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Improving the quality of public spending in Europe

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Improving the quality of public spending in Europe

A study on the methodology to compute and identify budgetary waste in Member States

The economic literature suggests that policy areas characterized by strong returns to scale, efficiency gains, relevant cross border spill-over effects and where heterogeneity of preferences is limited or could be sufficiently reduced, should be managed at higher levels of Government. When this does not occur, one could consider that there is a waste of resources. Building on these insights, we propose a methodology, based on Data Envelopment Analysis, to estimate "budgetary waste" in Member States' spending and to compute potential benefits that could be achieved by allocating resources at the EU level. Waste is therefore the amount of money that could be saved, by producing the same amount of output in the most efficient way. We apply our proposed methodology to Member States' spending in four areas: Health Care, Energy and Environment, Social Protection and Defence. For each area, we also compute the share of estimated waste due to unexploited returns to scale and the non-internalization of cross-border spill-over effects. We find large heterogeneity in efficiency across Member States and generally large average amounts of waste in current EU countries' spending.

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Executive summary

The subsidiarity principle states that policy areas should be assigned at the EU level only if it is proved that the desired objectives cannot be effectively achieved by means of actions taken at Member State (MS), regional or local level. In this Report, we interpret this principle as follows: **a policy should be assigned to the EU level only if the latter could offer the same services with less "waste" of resources than MS**, where waste is the amount of money that could be saved by producing the same amount of output in the most efficient way.

We propose to first identify and compute waste in MS spending by applying Data Envelopment Analysis (DEA) to MS production of public services; that is, by using a benchmarking analysis that compares the capability of the different MS to reach the highest level of desirable output with the least use of inputs. The economic literature suggests to move to higher levels of governments policies characterized by *strong returns to scale*, relevant cross border *spill-over effects* and limited heterogeneity of preferences across different constituencies. For this reason, we also propose to use *the same methodology* to compute the portion of estimated waste induced by the presence of returns to scale that are not being fully exploited, and by cross-border spill-over effects in the production function of MS. Unless there is evidence of strong heterogeneity of preferences across different countries, policy areas or sub-areas characterized by these two elements should then be assigned to the EU level, as this would arguably lead to exploitation of returns to scale and internalization of spill-over effects, thus minimizing waste.

We apply the proposed methodology to four highly relevant policy areas: Health Care, Climate and Energy Policy, Social Protection and Defence. For these policies, besides applying DEA to countries' production levels and estimating returns to scale and spill-over effects, we also check for differences in preferences across MS. Concerning the estimation of waste in national production of these services, our main results are summarized in Table 1. The Table reports the total estimated waste (in billion euro), the weighted average level of waste among MS in the production of services, and the average level of dispersion of the waste indicator across MS (using the coefficient of variation, the standard variation divided by the mean).

We find both a high average level of waste, ranging from 9% to 52% of MS spending and a large heterogeneity in the efficiency indicator across MS, with an average variation in efficiency with respect to the mean level that in some cases is close to or above 100%. More specifically, as can be seen by Table 1, our benchmarking analysis suggests that MS could save up to €175 billion in the provision of health care services, or 19% of total spending, if each MS produced the services in the most efficient way. Similarly, MS could collectively save up to €41 billion, or 26% of total spending, if each country were as efficient as the best performer in organizing its unemployment benefit system, €13 billion in military procurement or 52% of total spending, if each national procurement system was organized in the most efficient way and so on for all other services examined. In the case of Energy and Climate Policy, we particularly focus on the European Emission Trading System, and the relative inefficiency of each country is computed in each main regulated productive sector (Manufacturing, Transport and Energy Production) with respect to a production frontier where each sector produces simultaneously two outputs, a "good" one (GDP) and a "bad" one (CO_2 emissions). Thus, Table 1 says that, for example, in Manufacturing, national companies could save up to 47% of total inputs (labour, capital and energy) to reach the same combination of good and bad output if production in manufacturing in each country was organized in the most efficient way.

Table 1 Estimated waste in the production of services at national level

Policy areas	Targets	Estimated waste at the MS level		
		Rate on total expenditure	€ bn	Coef.Var
Health Policy	Aggregate spending	19%	175	0.73
	Of which: returns to scale related to procurement	12%	17	0.44
	Of which: returns to scale related to prevention	13%	3.5	0.51
Climate and energy policy	Manufacturing	47%	-	0.37
	Energy production	28%	-	0.70
	Transportation and Storage	8%	-	1.43
Social Insurance	Unemployment cash benefits	26%	41	0.54
	Active labour market policies	9%	1.6	0.57
Defence	Deployable troops	26%	32	0.63
	Procurement and R&D	52%	13	0.43

However, high levels of waste and large heterogeneity across MS in efficiency in the provision of services are not sufficient reasons for advocating common spending or common action at the EU level. MS might still learn from each other and the EU could still play an important role in attempting to inform and share the best practices, but there is no strong argument for supporting moving competences and resources on that policy area to the EU level. It has still to be proved that common spending or common action at the EU level might result in less waste of resources than MS spending. To this aim, we estimate whether the production function for these services exhibit relevant returns to scale or cross border spill-over effects. We generally find that only some sub-policy areas pass this test and exhibit a large amount of waste due to the presence of these two effects. On these bases, **Table 2 summarizes our recommendations** for the four policy areas.

Concerning *health policy*, while our results suggest both a high level of average waste and a large heterogeneity across MS, we also find that for health care as a whole, scale inefficiency is not much relevant and the role of spillovers limited. Specifically, for *curative care*, the largest component of health care spending in each MS, we do not find any evidence of increasing returns to scale or cross-border spill-over effects. There is therefore no efficiency argument in favor of EU common spending in this component. On the other hand, for specific sub-policies, in particular ***procurement* and *prevention***, we not only find a lower level of average efficiency, but also strong evidence of both *scale inefficiency* and cross-border *spill-over effects* (see Table 1). **According to our estimations, common spending at the EU level fully exploiting returns to scale, would imply for *procurement* an average increase in MS efficiency scores by 12%, saving €17 billion; and for *prevention*, an improvement in efficiency of 13%, saving €3.5 billion.** Clearly, these savings could be used to increase service provision, leaving the same level of spending but centralizing provision. Moving all current expenditure in procurement and prevention to the EU level would entail **an increase in common spending of up to 1,4% of current EU GDP**; but obviously, one could also consider intermediate steps. Data on R&D spending at the MS level are not sufficiently detailed to allow us to run a formal analysis; however, research is also a field that typically exhibits strong returns to scale. Managing it at the EU level is then also likely to be beneficial.

Concerning *climate and energy policy*, our analysis is on the whole supportive for the EU Emissions Trading System (EU ETS), which is a crucial part of the EU Climate Action and the European Green Deal programmes. Specifically, we do not find any negative effects of the regulation on the economic performance of European companies, not even in the more restrictive phase 3 (2013-20). On the other hand, we find evidence of an effect of the regulation on curbing CO_2 emissions, particularly for sectors and companies that had to buy emission allowances rather than receiving them freely. A back of the envelope computation of the advantages for the EU economy of **the introduction of the EH ETS system** suggests a **cumulated saving of approximately €42.5 billion**, where we use the market price of the EU emission allowances to quantify for each year the economic value of reduced emissions. A comparison with the more decentralized US system also suggests a better performance of the EU system due to a larger and thicker market, more able to internalize cross-border environmental externalities, and to larger savings in administrative costs. In our benchmarking analysis, we also find a general improvement through time in the efficiency of the companies in the regulated sectors, with **some convergence across MS in the Transport and Energy production sector but also some divergence for the Manufacturing sector**. Consequently, our policy recommendations are for a strengthening of the ETS mechanism, extending it to other sectors and decreasing the free allocation of allowances, while supporting the ecological transition of the least efficient firms particularly in the Manufacturing sector. Given the current debate on strengthening the role of autonomous funding for the EU budget, we also investigate the potential role of emission allowances in this respect. We estimate in the medium/long run **a potential revenue up to €50 billion per year from the auctioning of allowances**. Hence, this should be considered as a potential source of funding for the EU budget.

Table 2 Policy Recommendations and estimated savings by common actions at the EU level

Policy areas	Recomendations
Health Policy	- No common action at the EU level needed for *curative care* except diffusion of best practices to counteract the large heterogeneity in efficiency across MS. -Equity considerations also support a larger role of the EU level in the management of health care. - We recommend common EU spending for *procurement* (saving up to €17 billion) and *prevention* (saving up to €3.5 billion) in order to exploit returns to scale and properly take cross-border spill-over effects into account. A complete centralization of spending for these two functions would entail an increase in expenditure of about 1,4% of EU GDP at the EU level; intermediate steps could of course be considered. - R&D spending data are not sufficient to run a formal analysis; however managing research at the EU level is also likely to be beneficial.
Climate and energy policy	- Detailed analysis shows no evidence of negative effects of regulation on the economic performance of European companies. -Move towards Phase 4: Reinforce ETS mechanism, extend it to other sectors and decrease the free allocation of allowances. - Support the ecological transition of less efficient firms, particularly in Manufacturing where we detect some increasing divergence of performance across regulated companies of different MS. - In the medium to long run, we estimate *potential revenues up to €50 billion per year* from auctioning of emission allowances. This should be considered as a potential source of funding for the EU budget.
Social Insurance	- Large heterogeneity of preferences across MS does not support policy centralization in spite of the poor average performance and large heterogeneity in results.

	-However, imperfect correlation across MS GDP growth rates and relevant returns to scale in risk diversification strongly suggest the introduction of an European unemployment insurance scheme to complement national ones, supporting national systems in case of relevant economic shocks. -A simple exercise run on historical data suggests that such a scheme, entailing a contribution of max 0,2% of GDP per country per year, would have limited by 175 billion the huge GDP losses supported by MS during the 2009-12 international crisis.
Defence	- Duplication of projects and bias towards national markets in procurement strongly impair the efficiency of the EU defence system. - Common action for troop deployment could save up to €32 billion per year while common spending for procurement in military equipment could save up to €13 billion while still producing the same level of output in terms of R&D development. - We support allocating at least 25% of current spending in procurement to the EU level (saving 2,7 billions). -For troop deployment, our result speaks in favor of re-launching initiatives such as EU battlegroups.

Concerning *social insurance policy*, we find that **preferences and governance are highly heterogeneous across MS,** leading to an up-to ten-fold difference in per-capita expenditure levels. DEA analysis suggests that efficiency of unemployment benefits and active labour market policies expenditure in smoothing economic shocks and reducing long term unemployment is also very heterogeneous among MS. Depending on the specification, the average rate of waste across MS for unemployment benefits is between 26% to 53% of expenditure, leading to an estimated total waste between about €41 billion and €80 billion per year. The waste rate for active labour market policies is between 9% and 33%, leading to a total waste between €2 billion and €6 billion per year (see also Table 1). We also show that the correlation between economic cycles across EU countries is large but not perfect, creating **a strong economic rationale for *fiscal co-insurance* across EU countries.** Moreover, unemployment-related expenditure is more stable in larger countries and at the EU or EA level than in any Member State, suggesting the presence of strong returns to scale for risk diversification. On this basis, we run a simulation exercise using historical data postulating the existence of a simple EU unemployment co-insurance scheme built so as to avoid permanent transfers across countries and complementing national ones. **According to our estimations, a limited amount of co-insurance, with a maximum expenditure of 0.2% of GDP per annum per country,** introduced in the 2000s, while being roughly in equilibrium along the period, **would have reduced by €175 billion the GDP cumulative loss in 2009-12** (€44 billion per year)**.** Thus, our results clearly support the introduction of a European unemployment scheme to complement national ones, supporting national systems in case of relevant economic shocks.

Concerning *defence*, we confirm the existence of **large inefficiencies due to duplication of military projects**, lack of effective competition and largely non-integrated markets. An illustrative comparison with the more integrated US system is telling. Roughly speaking, for any large military project run in the US, three are run in the EU, each with a third of the funding, thus losing any potential benefits that could arise from exploiting returns to scale. Our benchmarking analysis on troop deployment and spending on procurement for military projects confirm the existence of large amounts of waste. In both cases, the estimated production function also exhibits very relevant returns to scale. Larger countries are always characterized by higher levels of efficiency. Our computations suggest that by coordinating troop deployment and by common spending in military procurement, so as to exploit the returns to scale, MS could save up **to €32 billion in military spending and up to €13 billion in military procurement** whilst still obtaining the same result in terms of deployable troops and investment in R&D. Specifically, common spending for at least 25% of military procurement, about 7 billion euro, a realistic target, would save 2,7 billion. Our results on troop deployment also support re-launching initiatives such as the EU battlegroups.

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1. Introduction

1.1. The general problem

The question of which policy areas – and related resources – should be assigned to the European level and which should instead remain, or return, to Member States (MS) or even sub-national governments, is central in the political debate. The assignment problem is also a long-debated question in the relevant scientific literature (see Chapter 2 for a discussion). On normative grounds, the fundamental difficulty in addressing this issue arises from the specific nature of the European Union (EU), somewhat a unique example in history. Although the EU has some features common to many other world federations (including a bi-cameral legislature made up by an elected Parliament, representing EU citizens, and a Council, representing the MS) the EU is not (yet) a fully-fledged federation, as MS have surrendered only very limited sovereignty to EU institutions and only in a limited subset of policies. On the other hand, the EU is much more than just a trade or a currency agreement among sovereign states. A set of shared and core values lies at its heart (like commitments to democracy, peace, human rights, rule of law and a common preference for a market economy tempered by strong welfare nets) which goes much beyond purely economic features. The stated long-term objective of the EU is still that of an "ever closer union" amongst MS. Clearly, the insights of the traditional fiscal federalism literature apply with difficulty to such a novel organization. This literature typically assumes the existence of a common sovereignty among constituent units and a potentially much larger role for the central government – all issues that do not represent the reality of the present EU.

Yet, the assignment question remains crucial. While historical developments have shaped both the size and the allocation of the present EU budget, the ability of the EU to reach its future goals and respond to the demands of European citizens in times of crisis crucially depends on its ability to expand and mobilize resources to support common goals. The recent COVID-19 pandemic has made this problem painfully clear. A Union aiming free mobility of people, companies, capital and commodities simply cannot work if the health crisis and the subsequent economic crisis are not addressed in a coordinated way. The EU has indeed taken some unprecedented and welcome steps to address the epidemic. For example, enforcing a stronger coordination in health matters among MS, forcing countries to keep their borders open for medical equipment, introducing temporary funds financed with European debt to support unemployment benefits and economic recovery, reallocating resources to invest more in research related to the pandemic and so on. However, it is certainly not the time for complacency as much more needs to be done.

1.2. Our approach

In this report, we address this fundamental issue by following a different route from the ones proposed by the previous literature. Rather than presenting just a theoretical discussion, based on some general normative principles, we attempt to ground the discussion on the results of an empirical analysis aimed at computing the economic benefits and/or costs that would follow from putting in common MS policies at the European level. Central to our approach is the notion of "waste" – how many resources could have been saved to reach the same output from a particular policy if this was provided at the European level rather than remaining in the hands of MS. To identify this waste, we rely mostly upon Data Envelopment Analysis (DEA) (see Chapter 3). The main idea behind DEA is to identify a "production frontier" starting from current observations of the production of services by different productive units and then computing the amount of waste in terms of the inputs that could be saved if all units produced the same total volume of outputs at the efficient frontier. For the aims of this report, the "productive units" are in most cases identified with the MS. The "inputs" used in the production are mostly the resources allocated in the MS budgets to produce that particular service. “Outputs” are alternatively identified as the general outcomes of the services (typically, some public good, such as health care or defence), or more specific outputs that can be thought of as intermediate production needed to produce those public goods.

Building on the theoretical literature surveyed in Chapter 2, we focus on sectors and policy areas where the existence of efficiency gains due to *increasing returns to scale* in the production of services and *relevant spill-overs* across MS is more likely. As argued in Chapter 2, both increasing returns to scale and cross border spill-overs provide strong prima-facie arguments for common spending at the European level. However, an important advantage of our analytical approach is that these two features – increasing returns of scale and spill-overs – rather than just being assumed, can be directly computed from the application of the methodology, thus offering a solid empirical basis for the discussion of common policy action at the EU level. As with any other technique, DEA has its own limitations, further emphasized in our case by the difficulties in collecting in some cases comparative data across MS. For this reason, we complement our main analysis with a large battery of robustness exercises, which use alternative definitions of inputs and outputs, and alternative methodologies (mostly regression techniques) to clarify important causality nexus between inputs and outputs.

Finding and quantifying the existence of waste in the MS production of some services with respect to a potential European production is not by itself enough to support common spending, as this potential benefit need be contrasted with the amount of shared MS sovereignty and the resulting increased difficulty in representing potential heterogeneity of preferences across MS constituencies. However, in line with the *subsidiarity principle*, it is an element to be taken into account in the debate, as it suggests that by allocating competences and resources to the European level, European citizens could save important resources for given outputs or they could receive more services (output) for given input. Focusing on “waste”, that is, on an input measure of inefficiency, has the additional advantage of avoiding the need to define the “counterfactual” of what would have been the output production in case that particular policy area, or sub-function, was allocated at the European level. In this sense, our approach is agnostic. It just limits itself to ask how many resources could be saved by moving that policy area to the EU level but keeping the output fixed, under the assumption that by offering that policy at the EU level the existing increasing returns to scale would be fully exploited and the spill-overs fully internalized. However, there is clearly a strict link between input and output measures of inefficiency, as the existence of “waste”, as we define it, implies that higher levels of output could be obtained by using the same inputs. As an exercise, we then also produce some estimations of the extra output that could be produced by allocating the function to the EU level at fixed inputs, again under the assumption of a full exploitation of returns of scale and full internalization of spill-over effects at the European level.

We are of course perfectly aware of the rather mechanical nature of our exercise. Should a particular policy area be allocated to the European level and the relative resources into the European budget, European institutions and politics will determine where and how this money is spent. The resulting level of “output” for that policy might then be very different from what we observe now, when the function is allocated at MS level. It is then better to think of our exercise as providing some empirical basis of the potential financial advantages of allocating a policy area to the EU level, rather than an attempt to predict how that function would be executed if indeed it were allocated to the EU level. Introducing a specific “counterfactual” for the European allocation would have made our analysis more precise, but also more arbitrary. However, as a robustness exercise, in order to confront this objection and in search of some external support for the results of our analysis, we also look at the experience of other federations, specifically to the US, to check whether the centralization of the functions we examine here indeed led to positive returns in terms of efficiency.

1.3. This Report

The report is organized as follows. Chapter 2 discusses the theoretical framework that supports our analysis, by discussing the relevant literature and its previous application to the European case. The aim of this chapter is to identify a set of criteria that might or might not support common spending on a given policy area, taking into account the specificity of the EU situation and the already large level of public spending in MS. These criteria are then used for guiding and interpreting our empirical analysis. Chapter 3 is a technical chapter that introduces and explain intuitively the methodology that we use, trying to make it understandable even for non-practitioners. Chapters 4 to 7 are the heart of this Report. For each specific policy field, these chapters discuss the current allocation of competences between the Union and the MS, illustrate the data collected, perform our analysis and draw our conclusions. The technical analysis that supports our conclusions can be found in the Annex to each chapter at the end of the Report and it is left to the more technically minded readers. Chapter 8 compares our results with the US experience in the same fields, to learn from this experience and find support for our policy conclusions. Chapter 9 briefly concludes by summarizing what we have learned and by suggesting avenues for future applications of our methodology.

2. Conceptual framework

2.1. Introduction

In this chapter we search for normative criteria to guide our empirical analysis, looking for arguments that can support or oppose the allocation of a given policy area to the EU level. We begin with an analysis of the fiscal federalism literature. Although this literature has been developed in different contexts from the EU, it provides plenty of theoretical and empirical results that can be useful to discuss the issues of centralization/decentralization at the EU level. We specifically conclude that for our aims, the original Oates' recipe for (de-)centralization is still useful, although in discussing its application to specific policy fields we will also make reference to the insights of the most recent literature ("second-generation" models). Building on this general discussion, we then present in detail the approach that we will follow in the next chapters to estimate the potential advantages of moving a function from MS to the European budget. Key to our research is the notion of waste; how much money could be saved if this function was moved to the EU level. We explain the methodology that we follow in the next chapters to measure this waste as well as the limitations of our approach. We also compare our approach with previous attempts in the literature, explaining the advantages and limits of our approach with respect to others. The chapter concludes with a road-map for the empirical chapters that follow.

2.2. Insights from the literature on fiscal federalism

2.2.1. "First generation" models

Economic theory justifies government intervention in the economy to redress 'market failures', i.e., cases where the market provision of goods/services does not deliver a fully efficient outcome (Pareto optimal allocation), either because of some specific, technological, characteristics of the good/services, or because the "market" does not exist or it is not competitive. In this study, we are particularly concerned with market failures related to the concepts of "public goods" (Samuelson, 1954) and "externalities", the two key features used by the literature to discuss issues of allocation of competences to different levels of government.

- A (pure) **public good** is a good that is *non-rival* and *not excludable* in consumption, meaning that the consumption of a good by a consumer does not reduce the consumption possibilities of others, and that no consumer can be excluded from its consumption (at reasonable cost). For these goods, market provision is usually thought to be impossible (since they are not excludable, no private producer could impose a price on the consumption of these goods) and therefore government needs to step in to fund its provision. Defence is the canonical example of a pure public good. However, many other goods and services, even if not strictly speaking "pure" public goods, have large public characteristics (Education, Health Care, etc.) so that by repeating similar arguments one can still find an efficiency rationale for government intervention, both in terms of funding and provision. In the following, we will use the term "public good" in this broader sense. Of course, particularly for these types of mixed goods, distributive considerations also play an important role in determining government intervention.
- **Externalities** are situations where economic agents affect others' utility or production functions without going through the market, that is, without receiving a price if they provide a benefit to other agents, or without paying a cost if they impose a damage. Because private and social costs and benefits do not match in the presence of

externalities, there is the presumption that market equilibria will not in general be Pareto efficient. Typically, we expect the good to be underprovided if externalities are positive and overprovided in the presence of negative externalities. Externalities might also occur because markets do not exist at all, as for some goods and services it is difficult or impossible to define and enforce property rights. Environmental issues and freely shared natural resources (commons) are typical examples of this form of externalities. Notice that the European Emission Trading System that we will discuss later on, it is an example of an attempt to solve an efficiency problem related to an environmental externality by creating a "market" (for emissions permits) that makes producers consider the external costs of their activity.

- In economics, **efficiency** is associated with the notion of Pareto efficiency – that is a situation where all mutual gains from trade and production are exhausted. It is therefore impossible to make someone, whether that is an individual, a company or a country, better off without making someone else worse off. Conversely, equilibria may be Pareto inefficient if, at least in principle, it is possible to find an outcome that makes someone better off without making someone else worse off. In turn, Pareto efficiency can be defined in many different ways depending on the context: producer efficiency, consumer efficiency, technical efficiency and so on.

The literature on fiscal federalism moves from the above discussion on the rationale for government intervention to propose an optimal attribution of competences among the different levels of government. In the *first-generation* of these studies, the government is assumed to act as a benevolent social planner (e.g., Boadway and Tremblay 2012; Oates 1972; Oates 2008; Tiebout 1956), maximizing some general function that captures the welfare of the citizens. In this setting, a crucial role in defining the optimality of (de-)centralization of public good provision is given by three arguments: 1) spill-over effects between jurisdictions, 2) preference heterogeneity across constituencies and 3) economies of scale.

The *spill-over effect* extends the notion of externalities between private agents to the relationship between governments. The basic idea is that policy actions taken by a given government level might have economic consequences even on the constituencies of other governments, therefore "spilling over" to other jurisdictions. Since, as one would expect, a particular government is only interested in the welfare of her/his own constituency, it has no incentives to take these spill-over effects into account when making policy decisions. Spill-over effects might be positive or negative; but in both cases, if they are relevant, there is the strong theoretical presumption that the choices taken by each government will not be efficient, meaning that all constituencies could in principle be made better off by agreeing to different governmental choices. For example, if spill-over effects are positive, governments might have a tendency to "free-ride" on each other, spending less on the good/service in question and waiting for others to provide it. In equilibrium, if every government behaves like that, the good/service will then be underprovided.

In a multi-tiered government framework such as the EU, where the economies of the MS are strongly interconnected by trade, common currency and agents' mobility, the possibilities for spill-over effects are very large. For instance, with open and well-integrated economies, is well known that the effect of a fiscal expansion in one country typically benefits other countries as well, as part of the additional aggregate demand created in a country becomes demand for imported rather than domestically produced goods. Hence, a fiscal expansion in one country might produce positive spill-over effects on others that are not necessarily internalized by that country. It follows that a purely decentralized allocation of fiscal policy might not be optimal, inducing too little support in the case of an economic slump. This is also the reason why traditional theory suggests moving fiscal and monetary stabilization policy to the highest possible level of government in a federation.[1] One lesson which was surely followed by Euro Area countries in the context of monetary policy (but not on fiscal policy), by immediately forming a European Central Bank following the adoption of a single currency. Another example, closer to our analysis here, is health protection: an efficient health care system in one country might benefit other countries as well. In the event case of an epidemic, illness will spread less to other countries. There are therefore positive spill-over effects that are not internalized by the single country in deciding how much to spend on epidemic prevention and this might lead to overall limited spending.

It is interesting to note that, analogous to what was proposed to solve the problem of externalities,[2] cross-border spill-over effects could in principle be internalized as a result of a bargaining across MS or local governments. Countries could acknowledge the mutual advantage of acting together, thus internalizing the effects of their choices on other countries. There would then be no need to move that policy to a higher level of government. However, this is a theoretical consideration without much practical usefulness. First, bargaining is generally costly ("transaction costs", in the language of Coase, are not zero; see note 2), both in terms of time and resources, particularly when the number of participants becomes large. Secondly, bargaining usually occurs in an environment where the consequences of one's action are uncertain, and asymmetric information between players (with some players having private information on some aspects of the bargaining) may prevent an efficient solution from being reached. The same type of reasoning can be extended to bargaining across governments. The suggestion of the traditional literature in this context is then quite clear: whenever a particular policy is characterized by relevant spill-overs across governments, that particular policy should be centralized at the highest possible level. This is because by centralizing the policy, the highest level of (benevolent) government would automatically internalise spill-over effects.

A second element considered by the traditional literature in defining the optimal allocation of competences across levels of government, this time in the opposite direction, concerns the presence of heterogeneity and stability in preferences across constituencies – where the term "preferences" must be interpreted as a catch-all term to define differences in economic conditions, culture, economic interests and so on. Either because a local government is benevolent (as assumed in this approach) or because it is interested in being re-elected, it needs to take into account local preferences when deciding policy choices. It follows that if preferences are very heterogeneous across localities, the optimal local policies can be very different. Assuming that preferences are stable and independent from on-going changes, there could then be a cost associated with centralizing this policy. A central government, even if well motivated, can only partially take in account these differences and the policy choice will tend to be uniform across territories. Under these assumptions, centralizing the policy might then lead to a Pareto inefficient allocation, where a significant proportion of the population is less satisfied than they would be with a decentralized equilibrium.

How important are differences in preferences across European citizens is an open question. Clearly, in a community that speaks 27 different languages and that comes from different histories, having also developed quite different institutions, one would expect these differences to be quite large. However and perhaps surprisingly, recent researches suggest that the preferences of EU citizens are already largely homogenous in many fields (European Commission, 1974-2019; Alesina et al., 2017). Alesina et al. (2017) use the results of different European and international social surveys to study the

[1] The opposite argument could be made for monetary expansion in a single country in the context of a common currency. In this case, spill-over effects are negative.

[2] We refer here to the so called "Coase Theorem": in the presence of zero "transaction" costs and well defined property rights all externalities could be internalized by rational agents through bargaining between themselves; see e.g. Dasgupta 1996.

differences in preferences (concerning economic issues but also cultural, social, religious etc.) across Europeans belonging to EU countries. They find that the dispersion in these preferences is much larger *inside* any EU country than *across* EU countries and that, for example, the heterogeneity across EU MS is not larger than that among US states. The measures of dispersion proposed seems also to suggest that on average, EU Europeans are closer to themselves than, for instance, to US Americans.

Furthermore, contrary to what assumed in the traditional literature, preferences are likely to be endogenous to social, environmental and economic developments, sometimes rapidly evolving when changes occur at a fast pace as demonstrated for instance by the emergence of a climate change consciousness. One could argue for instance that a stronger concentration of competences at the EU level, and the intensified democratic debate that would follow, could harmonise preferences across MS even further. We will discuss further potential heterogeneity of preferences with reference to the specific policy field analysed in later chapters.

A third argument considered in this literature when discussing (de)-centralization relates to *the technological properties* of the production function of public goods or services. The term *"economies of scale"* refer to cost-reductions that may result from the increase in the quantities produced, for instance due to the reduction of fixed costs per unit sold. This is typically due to the presence of large up-front investments; indeed, if these are too large, the good might simply not be provided at all if all costs are borne by a single government ("threshold effect"). Canonical examples of technologies with important returns to scale are net industries (utilities), where the cost of the service is very much concentrated in building infrastructures, while the marginal cost of providing the service is very low or even close to zero. However, important scale economy effects might also appear in the form of coordination and administrative savings.

There are many examples of policies in the EU context that present these technological characteristics across countries, such as infrastructures concerning electricity, gas, transportation, digital connections etc. There are also several examples of very costly common projects that no single European country could finance by itself because of a "threshold effect" (as examples, one could think to Galileo or CERN). In *latu sensu*, the regulatory activity performed by the Union can also be thought of as offering policies with returns to scale to MS. An EU standard, once reached, saves the costs that MS would face from deciding and co-ordinating standards necessary to facilitate international trade. From this point of view, the Single Market is the best example of an EU institution that has allowed large cost savings whilst also creating important benefits in terms of output growth (e.g. Campos et al., 2014). Moreover, and a theme that we will explore in the following chapters, important returns to scale might also appear from common spending in many policy fields, such as procurement (saving unitary cost and avoiding duplications), research (avoiding repetition and allocating resources to the more efficient researcher in a larger pool of potential ones) and so on.

Summing up, the first generation fiscal federalism literature provides a quite simple and clear message about how to optimally allocate policies (and therefore resources) at different levels of government. This is aptly summarized by the so called "decentralization theorem" (Oates, 1972) or even better in the Oates' (de)-centralization "recipe":

> *"Centralize policies with strong returns to scale and/or relevant spill-over effects and/or low heterogeneity of preferences; decentralize policies with limited returns to scale and/or limited spill-over effects and/or high heterogeneity of preferences".*

The fundamental insight of the first generation of fiscal federalism models is then quite sharp, although of course it might be difficult to apply it in practice. Measuring returns to scale, spill-over effects or heterogeneity of preferences is obviously neither simple nor uncontroversial. A further difficulty is that the Oates's recipe identifies *potential* Pareto improvements; starting from any specific allocation, centralizing or de-centralizing a particular function will generate different outcomes amongst MS. Moreover, although by definition Pareto improvement transfers could mean that all MS are still better off, this compensation needs to take place for a potential Pareto improvement to become effective. This is a crucial point; it is hard to think of any possible centralization/decentralization of policy at the European level that however potentially beneficial on efficiency grounds would not produce differentiated outcomes. This might then lead to resistance to change if not properly addressed. On the other hand, one would also suppose that the higher the efficiency gains the easier would be to find ways to solve this problem, ensuring interests' convergence.

The Oates' recipe only discusses efficiency reasons for (de)-centralization. Obviously, in any application of the theory to the real world, other criteria should be considered in deciding the allocation of policies to specific levels of government and this is true for the EU case too. For instance, in an important recent book, Inman and Rubinfeld (2020) in discussing the pros and cons of "democratic fiscal federalism" place at least as much importance on the ability of decentralized settings to stimulate citizens participation to the public debate and protect the rights of individuals and minorities than on economic efficiency considerations.

2.2.2. "Second generation" models

The Oates' recipe can also be criticised from a different point of view. The traditional model is based on an overly simplified view of governments; it also takes for granted a number of assumptions that deserve much more scrutiny. For example, the "informational" assumption, i.e., how much different levels of government really know about citizens preferences, or the implicit assumption that a central government could not differentiate policies at local level as well as local governments could do (Triesman, 2007). A large literature has grown to discuss these issues, collectively defined as the "second-generation" fiscal federalism models. Drawing from ideas already discussed in the literature (e.g., Brennan and Buchanan, 1980; Inman and Rubinfeld, 1997; Wicksell, 1896), these models depart from the assumption of welfare-maximising politicians to consider the fiscal and political incentives faced by sub-national officials/politicians in different institutional settings (e.g., Oates 2005, Weingast 2009; Triesman, 2007). Several studies analyse through this new lens the centralization/decentralization trade-off by investigating in this new institutional context the assignment of tasks in a multi-tiered government, the allocation of tax resources, the structure of intergovernmental transfers, the efficiency role of fiscal and yardstick competition across governments, the impact on the efficiency of good provisions etc. (e.g., Ambrosanio and Bordignon, 2015; Besley and Coate, 2003; Cremer and Palfrey, 1996; Lockwood, 2002, 2008). Building on the information revolution in economics (Tirole, 1988) and the new theory of the firm (Grossman and Hart, 1986), the informational assumptions of the traditional model have also been scrutinized in depth (e.g. Bordignon et al., 2001; Salmon, 2019; Bordignon et al., 2003, 2004).

Given our aims here, there is no need to enter into the details of this huge literature because many of these studies are specific to the financial and political organization of sub-national governments in national states, a framework that is very far from the EU present organization. However, three general observations are relevant to our discussion. First, when political mechanisms and other distortions are taken in consideration, policies tend to be more biased and inefficient under either centralization or decentralization, typically leading in all cases to sub-optimal outcomes. The choice between centralizing/decentralizing a particular policy area is then typically a comparison between a set of second best equilibria and it is a relative matter to decide what is best in any specific circumstance. Second, in spite of all the niceties introduced by this new literature, it is fair to say that the basic message of the Oates' recipe tends to be confirmed in these more complex approaches, although with various specifications (e.g. Besley and Coate, 2003; Lockwood 2015). In particular, the presence of relevant technological returns to scale and cross-border spill-over effects remain important arguments for centralization. Third, this more complex approach provides evidence on other important elements that directly concern our discussion here.

For example, in the traditional framework it is not possible to ask questions about the accountability of politicians and the perceived legitimacy of their decisions, because governments are supposed to be benevolent or in any case it is assumed the democratic system would force them to always behave according to citizen's interests.[3] On the contrary, an important result of this new literature is that the issue of centralizing/decentralizing a particular policy area, and of the tax resources needed to fund it, should also be examined in lieu of the incentives this provides to governments to remain accountable to their citizens (e.g. Ambrosanio and Bordignon, 2015). Accountability in turn increases citizens' participation and political legitimacy. This is an important insight that is of course relevant even for any discussion concerning common policies at the EU level.

Furthermore, once one acknowledges that governments might be subject to various political imperfections, the issue of common spending should also be addressed from a different perspective. For instance, one of the advantages of moving a policy area to the EU level might simply be that it reduces wasteful spending by MS, as countries otherwise could compete by offering subsidies and distorting tax systems in order to restrict competition. Given the diffusion of organized interest groups, particularly on the supply side of the economy (Grossman and Helpman, 2001), and the potential negative effects of lobbying on policy choices, it is also important to ask whether these distortions would become more or less severe if a policy was moved to the EU level. The theoretical literature suggests that this depends on whether the interests of different national interests are aligned or in conflict, and makes a strong point for centralization in this latter case (see Bordignon et al., 2008). Interestingly, and in line with this insight, Thomas Philippon (2019) has recently and convincingly argued that centralizing regulation and competitive policies at the EU level has resulted in more efficient allocation and a reduced role of lobbying with respect not only to maintaining these policies in the hands of MS governments, but also with respect to other federations, specifically the US (see also Gutiérrez and Philippon, 2018).

2.3. Our methodological approach

2.3.1. The measure of waste in Member States' budget

In this Report we attempt to offer a methodology, based on empirical analysis, of the relative advantages of allocating policy areas and relative resources to the EU or MS level. We only discuss the spending side of the EU budget, although similar analyses could be replicated for the funding side.

Central to our approach is the notion of "waste"; i.e., how many resources could have been saved if a particular policy area and relative funding was allocated to the European level rather than remaining in the hands of MS. A large "waste" suggests that there is an economic argument for moving this policy area to the EU level, as it implies that resources could in principle be saved by EU citizens by transferring this policy from MS to the EU budget. These saved resources could in turn be used to reduce taxes or to increase expenditure in a more efficient way. Given the already high level of spending and taxing in many EU countries, it is important that resources are allocated where they can be spent more efficiently. The notion of "waste" is in accordance with the EU *principle of subsidiarity*, which states that "action should only be taken at EU level when the desired objectives cannot be

[3] This is for example the result of assuming that governments commit to their electoral promises and citizens are informed enough to be able to check for these promises (see Persson and Tabellini, 2016).

effectively achieved by means of action taken at MS or regional level". It is also in accordance with the *principle of proportionality*, which states that the action of the EU must be limited to that necessary to achieve the common European aims as they are set up in the EU legislation. Finally, the notion of waste is strictly connected with the notion of the "cost of non-Europe" (European Parliamentary Service, 2019, hereinafter CONE Report), the benefits forgone for not having common spending in specific policy areas, and the sister notion of "European added value", which is indeed a measure of the collective gains that could be reaped by centralizing expenditure at the EU level in that specific policy field. Clearly, if EU provision can minimize waste more than MS provision then this is indeed a prima facie argument for moving that policy to the EU level, in line with the above principles.

In order to compute the level of "waste" in the MS production of services, we exploit the techniques developed in the economic literature to identify economic inefficiency in the production of goods and services by both the private and the public sector. Among the possible tools developed in the literature to this aim, for the reasons spelled out in detail in Chapter 3, we choose to use mainly Data Envelopment Analysis (DEA), a useful and flexible non-parametric method to estimate production inefficiency. The main idea behind DEA is to identify a "production frontier", starting from current observations of the production of services by different productive units and then computing the amount of waste in terms of the inputs that could be saved in the production of the same output if all units produced at the frontier.

In line with previous research (see Chapter 3 for a discussion) in most of our analysis we identify the "productive units" with the MS and the "inputs" used in the production with the resources allocated in the MS budgets to produce that particular "output". In turn, "output" is alternatively identified with the general outcomes of the services (typically, some public good, such as health care or defence), or more specific outputs that can be thought of as intermediate production levels needed to produce those public goods. In one case, (our application to the Energy Sector, where production is actually made by private firms that produce for the markets), "inputs" are the productive factors used in production (capital, labour, energy) while "output" is both a "good", the value added produced by each firm in each sector in each country, and a "bad" , the level of pollutant emissions.

For the sectors and the functions analysed in this report, we collect the relevant data for each MS for several years and apply our methodology. This empirical exercise provides a measure of the relative level of efficiency of the different MSAs the input in most of our applications is just money (measured at some reference year), we can then compute the level of waste, in monetary terms, for each country in producing the given service. As we have analysed several years, we can also study the evolution of waste across time; and as we have several potential proxies for both "outcomes" and "outputs" we can explore the robustness of our results to alternative definitions of "outcomes" and "outputs". When needed, we can also use alternative methodologies (mostly regression techniques) to clarify important causality nexus between inputs and outputs.

This empirical exercise is interesting by itself and to the best of our knowledge original, in the sense that for several of the functions we discuss in the next chapters this type of analysis has never been performed before. However, this does not respond to the question of which policy areas should be allocated to the EU level; it just measures the level of waste in the different countries with respect to the estimated frontier. To address this question, in line with the insights of the fiscal federalism literature discussed above, we exploit some recent advancements in the DEA technique (see Chapter 3) to check for each policy or sub-policy considered, whether the estimated production function exhibits *returns to scale* and *cross-border spill-over effects*. Somewhat more informally, when discussing the policy implications of our results, we also take into account the potential problem of heterogeneity of preferences and the political economy considerations emphasized by the "second generation" of fiscal federalism models.

If the estimated production technology for a particular policy or sub-policy does not exhibit significant returns to scale or cross-border effects, we conclude that there is no compelling economic argument for moving it to the EU level. MS might still learn from each other and the EU could still play an important role in attempting to inform and diffuse the best practices, but there is no strong argument for supporting the movement of that policy area to the EU level. To put it differently, the subsidiarity principle test for centralization is not passed according to our methodology for that specific function.

On the contrary, when it turns out that returns to scale and cross-border effects for the estimated production function are large, we conclude that there is an argument for centralization; i.e. a single policy maker that produced the *same output* with the *same technology* estimated for MS, could save considerable resources by internalizing the observed spill-overs effects and by exploiting the returns to scale. Indeed, we can do more. We can actually compute exactly how much money could have been saved for a given level of output if that policy had been allocated to the EU level to start with. Our computed "waste" is an *input* measure of inefficiency, not an output one; but of course if X money could be saved by MS by moving that policy to the EU level and the price of a particular good/ service is P, one can loosely say that by allocating that policy to the EU level X/P additional units of the good/service could have been bought.[4] To make this clear to the reader, we also present some simulations to this effect in the relevant chapters.

It is important to stress that our approach assumes that EU production would occur with the same technology (the production function) estimated from the observations on actual production by MS; and that we also assume that EU production would lead to an internalization of cross-border effects and the full exploitation of returns to scale. In a number of cases we consider, and where we do indeed find robust evidence of returns to scale/cross-border effects (procurement, research, investment in R &D in Defence and Health Care, co-insurance in Social Security, vaccination in Health Care and so on), these assumptions seem quite innocuous; in other cases they might be more questionable. But the point is that we do not really know how that particular policy would be executed once transferred to the EU level and trying to guess it, or producing some other artificial counter-factual, seems even more problematic that just keeping output and the production function fixed.

It is then important to stress the limits of our exercise; we attempt to provide some empirical bases of the potential financial advantages of moving a policy area to the EU level, we do not attempt to predict how that function would be executed if indeed it was allocated to the EU level. Should a particular function be allocated to the European level and the relative resources to the European budget, European institutions and politics will determine where and how this money is spent. The resulting level of "output" for that function, or perhaps even the production function, might then be different from what we observe now, when the function is performed at MS level.

In order to counteract the potential objections that this approach can generate, we present an extensive "robustness exercise". In Chapter 8 we look at the experience of another federation comparable to the EU, the US, to check whether in this case centralization of the policies indeed led to improved efficiency. The exercise is of course not conclusive because US institutions are different from those of the EU, but clearly if we find positive effects of centralization in the US case, this corroborates our findings for the policies we propose to move to the EU level.

Finally, it should be noted that, in spite of its limits, our approach has some advantages. First, given the quite rigorous test that we impose for concluding that a particular policy area or sub-function

[4] As explained in Chapter 3, input and output measures of inefficiency using the DEA methodology produce exactly the same results if the technology turns out to be characterized by constant returns to scale. Results however differ if the technology is characterized by increasing returns to scale, which however justify common spending at the EU level.

should be allocated to the European level (an empirical test supported by several robustness exercise), the estimated efficiency benefits for centralization turn out to be quite large. They should then be enough to guarantee an improvement of efficiency and ensure effective consensus among MS. Second, as only a limited subset of sub-functions pass our centralization test in the four policy areas considered, the amount of extra money one would have to allocate at the EU budget turns out to be quite limited. This of course does not mean that it would not be desirable to move other functions to the EU budget or return some of the existing ones to MS; it just means that in the context of the important policy areas we consider, large returns of efficiency could be gained by transferring overall limited resources to the EU budget.

2.3.2. Comparisons with alternative exercises

Several different studies have already discussed the issue of the optimal allocation of functions at the EU level and estimated the cost of non-Europe, in the sense of the economic benefits that are currently forgone by not allocating policies and competencies to the EU level. The Cecchini Report (1988) is an early example of an attempt to compute the cost for EU countries of not completing the Single Market and has been instrumental to the legislative progress made in this field. More recently, since 2012, the European Value Added Unit of the EU Parliament Research Services (EPRS) has been producing regular estimations of the potential economic gains, computed in terms of the additional GDP generated, that could be achieved through better coordination of spending at the EU and MS level in selected policy areas. In the last version of this report (CONE Report, 2019),[5] the study covers 50 policy areas, ranging from completion of the Single Market to the digital economy to Justice and Economic affairs to EU external policy. The study concludes that the overall “cost of non-Europe” in all these policy fields can be computed as above €2 trillion, or about 14% of the actual total EU GDP. In the same direction, many attempts have been made in the scientific literature to estimate the “European added value”, broadly defined as the economic advantage for a country to be a member of the EU, using a plurality of techniques and approaches. In an interesting recent example, Campos et al. (2014) builds a synthetic counterfactual to try to understand the benefits to countries for joining the EU, using in particular the sample of the countries that joined the EU in the subsequent rounds of enlargement from 1973 to 2004. They conclude that these benefits, mostly as a result of larger economic integration with the rest of the EU, have been considerable, at about 12% of GDP on average.

Closer to our own approach, other studies have instead tried to address the issue by starting from some broad normative principles, generally coinciding with the insights of the fiscal federalism literature or some political arguments, to propose an assignment of tasks, reforming or revising the present ones, to the EU and the MS. Most of this work is qualitative in nature but there have been already some more specific quantitative attempts. An early one is due to Alesina, Angeloni and Schuknecht, (2005). They use fiscal federalism principles, the preferences of Europeans as captured by Eurobarometer, data on the EU budget, and a measure of legislative incidence of the Union in the different policy areas to comment upon the correspondence between optimal and current allocation of tasks (see also Alesina, Angeloni and Etro, 2005). A much more ambitious work, commissioned by the Commission, the ECORYS, CPB and IFO (2008) report, reviews critically EU spending in fourteen policy areas of the EU budget, offering suggestions for improvement. Although institutionally very detailed and well argued, this work does not produce new empirical analysis of its own, but rather discusses qualitatively actual spending and actual allocations with a list of criteria similar to those

[5] But see also the previous studies published in 2014 and 2017 (European Parliament, 2019).

described in section 2.2 above. The work also does not cover potential functions that are not already funded in the EU budget.

The most ambitious study in the field to date is by Bertelsmann Stiftung (2017) which builds on an earlier work from the same authors (2013). This work also starts from fiscal federalism principles, but adds features that are perceived as specifically important for the EU context such as the coherence of reform proposals with the common market ("internal market consistence") and the maintenance of sufficient competitive impulses for both companies and countries ("competition"). The study also considers policy areas currently not funded by EU budget programs, but chosen for their general potential relevance (on the whole, 8 policy areas, including corporate taxation). The study is particular for the more rigorous approach used in the analysis, attempting to identify for each area currently covered by MS spending a precise counterfactual if this function were allocated to the EU level (and *vice versa*, in case the function was already covered at the EU level). The aim of the study is to define and compare the net benefit of spending at the EU level with the net benefit of spending at the MS level; if the difference is positive, the function should be allocated to (or remain at) the EU level; if negative, the function should be allocated (or return) to the MS level. In this way, the study also offers a precise meaning to the notion of "European value added" (which can then be negative) (see Stiftung Bertelsmann, 2013). The study also performs original econometric analysis to estimate returns to scale or heterogeneity of preferences, although not employing consistently a specific methodology as we choose to do in this Report.

It is worth stressing that in spite of the different methodologies and objectives, the basic message emerging from the literature is largely convergent. Alesina et al. (2005) finds that EU spends too much on Agriculture and Cohesion Policy and too little on "public goods" such as Defence or Border protections. The ECORYS, CPB and IFO (2008) report concludes that the EU should spend more on Research & Development, Environment, Network Industries and Foreign Aid (only slightly more for Defence), and less in Cohesion Policy and Agriculture. This study also does not think the EU should be involved in macro-economic stabilization policy, health care or social affairs, reflecting the leading opinions of the time. The Bertelsmann Stiftung (2017) study also concludes that the EU spends too much in Agriculture (payments to farmers should be nationalized), too little for Asylum and Refugee policy (Asylum Services should be harmonized at the EU level), Development Aid and Defence. They also find a rationale for a European unemployment scheme to complement national ones and for harmonization of corporate taxation.

The task of our analysis in the next chapters is slightly different from the one of these previous studies: computing the level of budgetary waste in a number of policies actually assigned to MS. Moreover, the policies considered only partially coincide with the ones analysed in the above studies. Still, in the concluding chapter we will briefly contrast our results with those of these previous studies.

2.4. Conclusions and a road map to the empirical analysis

As already anticipated in Chapter 1, we focus our analysis on four functions only, chosen together with the EU Parliament offices, for their policy relevance at the current political juncture and given the political agenda of EU institutions. The first function we discuss is health care. EU competences in this field are currently very limited (see Chapter 4), but the COVID-19 pandemic has painfully made clear the potential advantages of a larger role of the EU in this context, from procurements to research, to a better coordination of countries' policies and so on. Indeed, not only the Commission and the EU Parliament (European Parliamentary Research Service 2020a) but also several EU countries have already asked for a reinforced role of the EU in the provisions of health services. Chapter 4 then uses our methodology to study the relative efficiency of health care provisions in EU countries both for the whole function and for specific components, selected for their potential policy relevance in the EU context. In particular, we discuss in detail the procurement of medical machinery and drugs, and prevention policy.

In Chapter 5 we discuss environmental and energy policy. Environment is a key priority of the EU current political agenda and one where the EU has already made large progress (European Parliament DG IPOL, 2019). We analyse the EU Emissions Trading System (EU ETS), which is a crucial part of the EU Climate Action and the European Green Deal programmes. We are specifically interested in understanding the impact of the system on performance and emissions of companies, in particular after the tightening of regulations in 2013. Exploiting our results and those of the previous literature, we can also provide a rough estimation of the advantages that the introduction of the EU ETS system had on the EU economy. Concerning our benchmarking analysis, given the particular features of this policy field, we identify “inputs” as the amount of capital, labour and energy invested in each single sector (Transport, Manufacturing, Energy) and “outputs” as both a “good” (GDP) and a “bad” (CO_2 emissions) for each sector. The benchmarking analysis is performed across sectors/countries, and data allows us to study divergence and convergence of efficiency results for sectors/countries across time. Finally, given the current debate of allocating environmental tax revenues to the EU budget, we also discuss the potentiality of the EU ETS as a source of own revenues.

In Chapter 6, we discuss Social Insurance and Unemployment Benefits. In this field, EU competencies are currently very limited, but there has been already an extensive political debate to extend them for both the EU and the Euro Area. Political commitments by the EU Commission and EU Parliament to advance this debate -studying in particular the potential advantages of introducing an EU based unemployment co-insurance mechanism supporting EU countries’ national systems in the case of large shocks- have already been taken, but so far with little progress (CONE Report, 2019). Faced with the devastating economic effects of the COVID-19 pandemic, EU countries, following a proposal of the Commission supported by the EU Parliament, have introduced a special mechanism to support MS employment policy, the SURE initiative, financed with the issuance of European debt. However, this system is only a temporary measure and it only consists of loans to countries that ask for help. Confronted with this scenario, we use our methodology to assess the relative efficiency in MS social protection systems and the presence of returns to scale in the provision of unemployment insurance. We also perform a simulation exercise on historical data to examine the relative efficiency of a simple EU unemployment co-insurance scheme (built to avoid permanent transfers across EU countries) designed to support national ones.

Finally, in Chapter 7, we address the longstanding issue of providing a common defence policy to EU countries (CONE Report, 2019). After a discussion of the (limited) progress made so far in advancing a common EU policy, particularly with the PESCO initiative, and the results of several previous studies devoted to assess the efficiency of common spending in the defence sector, we apply our methodology to selected sub-sectors, where our methodology can be more fruitfully applied. Specifically, we discuss the potential advantages of common spending in troop deployment in international missions and in defence procurement, considering in particular its effects in increasing R&D expenditure.

3. Empirical methodology

3.1. Measuring efficiency in economics

Efficiency is one of the keywords in economics. As resources are scarce, research in economics is devoted to understanding which institutional mechanisms can allocate them efficiently. A central theme in this area is the measurement of the efficiency of production units operating in private markets. The topic is crucial in microeconomic theory and there is a huge literature on empirical applications in many different economic sectors, ranging from agriculture to electric power generation, and there has been a growing attention to the measurement of efficiency of government spending in the last decades (World Economic Forum 2019; OECD 2017).

Efficiency measurement is built on the microeconomic theory of production, using concepts including the "production function" and the "cost function". Efficiency can be simply understood as the ratio between inputs and outputs of the production process, where inputs are economic resources consumed in the process. Or, it can be expressed as the "distance" between the quantity of input and output characterizing a production unit, and the quantity of input and output that defines a comparable but fully efficient production unit.

But this is just one of the many concepts of efficiency identified and defined in the literature. First, *technical efficiency* rests on the relationship between inputs and outputs. According to Koopmans (1951, p. 60) "an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only decreasing some other output or increasing some other input". Second, *allocative efficiency* allows for the optimal choice of the input mix, considering the price of inputs and the behavioural assumption of cost minimization. In other words, allocative efficiency measures the ability of production units to choose the optimal set of inputs for a given set of input prices (Farrell, 1957). Third, another concept of efficiency is *cost efficiency*, defined as the ability of a production unit to produce a given quantity of output at the minimum feasible cost of production. To be cost efficient, a production unit needs to respect both technical and allocative efficiency. Finally, an additional concept defined in the literature is the concept of *scale efficiency*, namely whether a unit is operating at the optimal scale of production, or if increasing or decreasing the scale may lead to efficiency improvement.

Defining which concept of efficiency to investigate is the starting point; the next step consists in identifying a methodology to estimate efficiency. The first rigorous analytical tools to efficiency measurement were proposed by Koopmans (1951) and Debreu (1951), and then applied empirically by Farrell (1957). Both Debreu (1951) and Farrell (1957) introduced and developed an input distance function measuring the degree of inefficiency. Similarly, an output distance function introduced by Shepard (1970) characterizes the efficient production technology in the presence of multiple products and is used to construct output quantity and productivity indexes (Daraio and Simar, 2007). When applied to data, these measures of efficiency rely on the construction of a benchmark that defines the optimal frontier.

While it is easy to theoretically define the boundary of the production set and the measures of inefficiency, the empirical estimation of the production function (and the cost function) requires both appropriate data and statistical tools. Appropriate data allows the "best practice frontier" to be defined as the boundary of the production set, based on the best performing units in the sample (Daraio and Simar 2007). Two main approaches are followed by scholars to estimate the frontier using appropriate statistical tools. The first is a *non-parametric* approach that defines the optimal frontier by solving linear programming models (Førsund and Sarafoglou 2002). The second is a *parametric* *approach* that assumes a specific functional form for the frontier whose main parameters are estimated through regression methods, such as the COLS (Corrected OLS) model or MLE (Maximum likelihood estimators).

The two approaches have been refined leading to the development of two estimators that have become well established in the literature: *Data Envelopment Analysis* (DEA), initiated by Farrell (1957), developed by Charnes, Cooper and Rhodes (1978) and further extended to account for variable returns-to-scale by Banker, Charnes and Cooper (1984); and the *Stochastic Frontier Analysis* (SFA), discussed for instance in Lovell (1995). Compared to less advanced benchmarking techniques, both methods require very little *a priori* technological information and are able to cope with multiple inputs and outputs (e.g., Bogetoft and Otto 2011).

However, when studying efficiency *of public firms* or, even more, *governments' efficiency*, an additional issue needs to be discussed: while it is clear what resources are consumed (say, public spending), it is much less easy to define the *outputs* of the production process. Profit maximisation is not necessarily the sole objective for public firms; and government units often produce intermediate outputs that contribute to the production of *outcomes*, typically public goods, or goods with strong publicness characteristics. This is a problem that will be discussed at length in the empirical applications below. Our approach will be to consider a production set defined by outputs (or outcomes) that can be obtained consuming public resources, thus considering the concept of technical efficiency.

In this chapter, after describing in more details the two methodologies in section 3.2, in section 3.3 we define and motivate the approach that we will follow in the rest of the analysis. Section 3.4 describes the implementation of the empirical strategy to the study of the budgetary waste rate in the EU, particularly focusing on explaining the different techniques used to measure the potential added-value of reallocating some MS policies to the EU. Finally, section 3.5 describes some additional regression models applied to efficiency scores that we will estimate through the main analysis.

3.2. The tools for benchmarking

Following the definition of budgetary waste introduced in the conceptual framework (Chapter 2), the central issue in identifying a methodology for the empirical analysis is how to estimate the 'production frontier'. We define this here as the *minimum amount of public resources needed to achieve a fixed desired level of output/outcome* or, conversely, the largest possible amount of output/outcome that can be obtained given a fixed level of input (e.g. public spending).

Several benchmarking techniques exist in the literature for this purpose. In this section, we focus on the two most popular estimators: DEA and SFA. The former is a non-parametric technique that requires only mild assumptions on the production set, but it is more affected by measurement errors in the data. The latter is a parametric technique requiring the parameterization of the production set, but it can account for measurement errors in the data.

DEA is a linear programming technique. The basic DEA model solves a linear program to obtain either the maximum achievable outputs/outcomes given a fixed level of inputs, or the minimum level of inputs that each Decision Making Unit (DMU - a standard term used in this literature to identify the decision-taking unit) should consume in order to be on the efficient boundary (Daraio and Simar 2007). Once the efficient frontier has been defined, input-based or output-based technical (in)efficiency for each unit is measured by considering the radial distance from the observed point to its corresponding production or cost frontier (Daraio and Simar 2007).

In contrast to DEA, SFA is a parametric approach that requires the definition of the production set based on specific functional forms linking inputs with outputs, where the links are identified by the parameters to be estimated. The basic empirical framework for SFA is a regression model specification that relates observed outputs/outcomes to the production frontier, or observed costs to the input requirement function. Parameters defining the frontier are generally estimated via Maximum Likelihood Estimation (MLE), while output-based or input-based measures of technical (in)efficiency are identified from the error term by separating the inefficiency score from the usual random noise (Jondrow et al. 1982; Coelli et al. 2005; Cornwell and Schmidt 2008). Also, the identification of the inefficiency component of the error term requires parameterization of the distribution of the error term.

DEA and SFA have been extensively used to perform benchmarking analyses, mainly considering firms in many different sectors: from agriculture, where hypotheses related to competitive markets for inputs and outputs are more likely to be satisfied, to education and healthcare, where the role of public producers is very large and outputs have been combined with outcomes in defining the production set. As the benchmarking used in these techniques can be applied to any units that have to decide how to consume inputs, these approaches have also been used for the analysis of the performance of different levels of government. The techniques have been applied to many levels of government, from municipalities to entire countries, considering single services or the whole array of the public services supplied to citizens. For instance, the DEA approach has been followed by several authors to assess the efficiency of public spending for specific sectors, such as education and health (Herrera and Pan, 2005; Afonso and St. Aubyn 2005; Sutherland et al. 2007; St. Aubyn et al. 2009), or more generally to evaluate overall government performances (Afonso, Schuknecht and Tanzi 2005; Afonso and Fernandes 2008; Lin, Lee and Ho 2011; Afonso, Romero and Monsalve 2013; Afonso and Kasemi 2017). Most of these analyses focus on central government spending, while some look at the level of spending by local governments (Afonso and Fernandes 2008; Lin, Lee and Ho 2011). Similarly, using the SFA methodology, authors have investigated government efficiency both at the MS level (Greene 2004; Kumbhakar et al. 2010) and at the sub-national level (Kalb et al. 2012; Boetti et al. 2012; Piacenza and Turati 2014).

Among these papers, it is worthwhile to mention the recent contribution of Afonso and Kasemi (2017). In this study, the authors follow the DEA approach to assess public spending efficiency in 20 OECD countries. The study looks both at the general performance of governments and at performances in some specific functions such as: administration, health, education and public infrastructure. As input measures for DEA, they use governments' total and sector specific spending as a percentage of GDP, while as output measures they use either general performance indicators when using the total spending as an input, or more specific sub-indicators when using the sector specific spending as the input. Some examples of general output indicators used are: GDP per capita, the standard deviation of inflation and the Gini index. For sector specific indicators they use, for example: the level of corruption and judicial independence for administration, PISA scores and secondary school enrolment for education, the life expectancy for health, and infrastructure quality for public infrastructure. As we discuss in section 3.4, in our analysis we apply a similar approach to estimate the budgetary waste rate of Member States in some specific functions.

3.3. The pros and cons of DEA and SFA

There is a general consensus in the literature that there is no optimal methodology able to estimate efficiency across all situations. Unsurprisingly, both the DEA and the SFA approaches have pros and cons. Standard considerations suggest that while DEA is non-parametric, it does not allow a proper role for variables outside the control of the decision maker in each production unit, whereas SFA does allow for the impact of random noise but requires strong parameterization assumptions. In particular, SFA allows the estimation of standard errors and allows for a formal testing of hypotheses. For instance, using SFA, hypotheses on the technological properties of the production function and on the distribution of efficiency measures can be statistically tested (e.g., Kalirajan and Shand 1999). However, the main drawback of SFA is that it requires a specific functional form for the frontier to be imposed *a priori* on the production set, and it also needs to impose some particular distributional assumptions for the part of error term describing technical efficiency (e.g., Hjalmarsson et al. 1996).

DEA does not assume any functional form for the production frontier and does not impose any specific distributional form for the inefficiency scores. However, it produces results that are particularly sensitive to variable selection and data error (e.g., Kalirajan and Shand 1999). Moreover, with DEA, it is more difficult to implement statistical hypothesis tests. However, there are several different approaches that can be followed to overcome these limits. One possibility relies on a semi-parametric two-stage procedure that combines efficiency measurement by DEA with a regression analysis that uses DEA efficiency scores as dependent variables. In these analyses, the second stage is typically a censored (Tobit) or truncated regression to account for the bounded nature of efficiency scores (Badunenko and Tachmann, 2018). A second approach is to follow the parametric bootstrap procedure proposed by Simar and Wilson (2007). The advantage of this methodology is that it considers that efficiency scores are estimated from a common sample of data, and therefore, applying a bootstrap procedure, generates estimated standard errors and confidence intervals that account for the correlation between estimated efficiency scores and are therefore unbiased.

3.4. Using DEA for the analysis of budgetary waste in the EU

The methodology we follow in this report focuses on the DEA approach. When discussing governments' production, it is quite difficult to think about a specific form for the production function, or even to think of a "production function" as such; therefore a non-parametric approach is preferable since it avoids the need to parameterize the production set. However, to account for the drawbacks of DEA, we complement the analysis with the Simar and Wilson (2007) procedure that allows us to study the determinants of efficiency scores and implement some hypothesis tests.

The first step in applying the DEA approach is to define input and output measures. With output variables, following specifically Afonso, Schuknecht and Tanzi (2005) and Afonso and Kasemi (2017), we consider specific indicators that assess the performance of different government policies. For input variables, we collect data on public expenditure that should be appropriately linked to the related output indicator.

In the empirical applications, depending on the sector, we adopt both an input-based and an output-based approach. In the former case we define budgetary waste as the amount of public spending in excess of the optimal level to obtain a given level of output. This approach is particularly appealing in order to provide a measure of the amount of resources that could be saved or reinvested by acting efficiently. In the latter case we define budgetary waste as the difference between the maximum achievable level of output and the realized level of output for a given level of input. This approach is particularly appealing in all cases where outputs can be defined in monetary terms and we want to discuss the possibilities of expanding outputs keeping constant the level of spending. Nevertheless, input and output oriented measures are clearly related, being exactly the same in the DEA-model with constant returns to scale (CRS).

Building on the conceptual framework discussed above (see Chapter 2), it is particularly important for our analysis to account for and estimate scale and scope economies. As for scale economies, DEA may be adapted to different returns to scale specifications (e.g., Tsai and Molinero 2002; Daraio and Simar

2007; Hernandez Villafuerte et al. 2017). The original DEA model proposed by Charnes, Cooper and Rhodes (1978) was based on a constant returns to scale (CRS) assumption. Thereafter, Banker, Charnes and Cooper (1984) introduced the variable returns to scale (VRS) DEA model. Estimating and comparing the two models, it is then possible to separate total efficiency measure into pure *technical efficiency* and *scale efficiency*. Indeed, technical efficiency (TE) computed through the CRS-DEA model corresponds to the pure technical efficiency (PTE), while technical efficiency computed through the VRS-DEA model is given by the pure technical efficiency multiplied by the scale efficiency (SE) component (Marselli and Vannini 2004; Ji and Lee 2010). In other words, using a simple formula:

$$TE = PTE \times SE$$

Using this formula, we can derive the expression for computing SE, which is equal to the ratio between the technical efficiency calculated under the assumption of constant returns to scale and the technical efficiency calculated under the assumption of variable returns to scale. This analysis is needed to understand whether inefficiency is caused by inefficient operations or by a suboptimal scale of production. In our analysis, identifying the returns to scale characterizing the production set will help to assess the potential efficiency gains coming from a reallocation of competences from the MS to the larger scale of the EU level. Large returns to scale provide an argument for centralization, as by centralizing production at the EU level, returns to scale could be exploited to produce more outputs with the same inputs, or to reduce inputs (saving money) to produce the same outputs (Chapter 2).

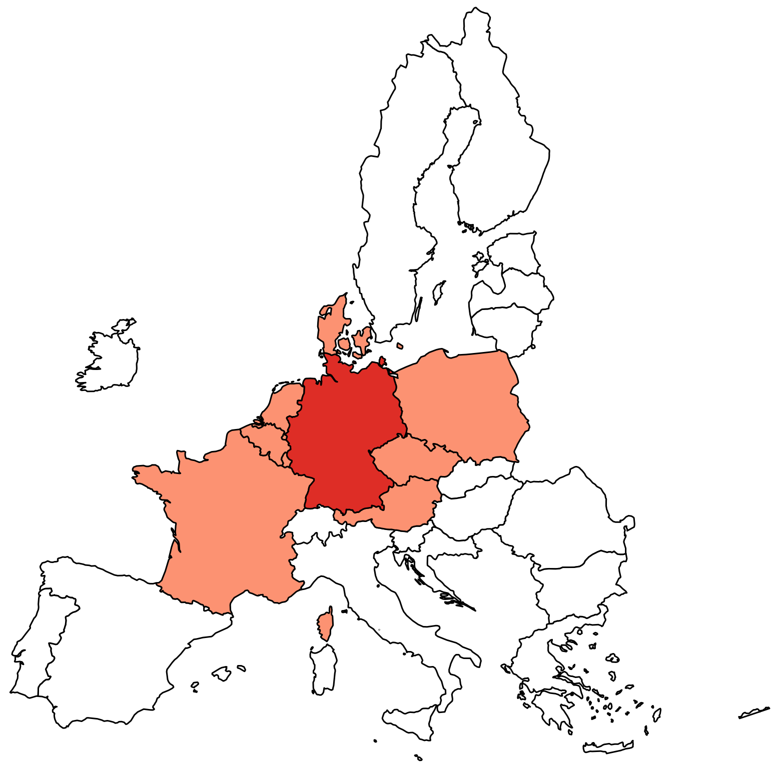
When applying DEA with variable returns to scale, the Stata routine “dea” produces as an output - in addition to efficiency scores - a further variable indicating whether the production function of each DMU is characterized by increasing, constant or decreasing returns to scale (Ji and Lee 2010). In the empirical analysis of the following chapters, we exploit this information and conclude that the reallocation of competences to the EU level will lead to: i) no changes of the SE when the production function is characterized by constant returns to scale, ii) an increase of the SE to the maximum value equal to one when the production function is characterized by increasing returns to scale, iii) an equivalent decrease of the SE when the production function is characterized by decreasing returns to scale. Calculating this measure for each DMU, we are then able to estimate the potential benefit/cost in terms of efficiency that could be obtained from shifting production to a larger/smaller scale. The implicit and important assumption here is that the production frontier (hence the production process) is the same between MS and the EU. This assumption is likely to be innocuous in a number of cases (e.g. public procurement); it might be more debatable in a number of other contexts (see the general discussion in Chapter 1 and 2 and the discussion in each empirical chapter). It is however the only possible assumption to make, as trying to predict how the production frontier would change if a particular function were allocated at the EU level would be highly arbitrary. Finally, it is important to note that in the following analysis, in order to test for the robustness of our results, we will also experiment with different definitions of inputs and outputs.

The DEA methodology can also be used to derive productivity indexes, such as the Malmquist productivity index (MPI), the Luenberger and the Bennet-Bowley indicators that we consider in Chapter 5 when discussing an empirical application on the energy and environmental sector. The MPI is generally used to evaluate productivity changes for a DMU between two periods in time. It is equal to the product of the “catch-up” and the “frontier-shift” components (Tone, 2004). The first component reflects the efficiency improvement experienced by a DMU over time, while the latter captures the shifts in the efficient boundary between the two periods of time. Technically speaking, the MPI is defined as ratios of distance functions that can be calculated through DEA models (Caves et al. 1982, Färe et al. 1994). In the analysis of Chapter 5, we measure the productivity change in the presence of undesirable outputs (like pollution). In this case it is more appropriate to use variations of the MPI index, such as the Luenberger indicator (Chambers 1996, Färe et al. 2010) or, when data on input and output prices are available, the Bennet-Bowley indicator (Chambers 2002, Färe et al. 2010), which is given by a simple formula and does not require any optimization.

3.5. Additional regression models

Starting from the efficiency scores estimated through the DEA model, we implement further regression analyses in order to investigate the role of *cross border spill-overs*, and to evaluate the effect of a specific program impacting the efficiency of governments. As discussed in Chapter 2, the presence of large spill-over effects constitute another important reason for centralization at EU level, as by centralizing at the EU level, it is more likely that these spill-over effects across countries would be internalized by the decision maker.

Figure 3.1: Contiguous countries and spill-over effects



Source: Eurostat.

DEA can account for spill-over effects by applying spatial regression models to the estimated efficiency scores (Ramajo et al. 2017). To apply the spatial analysis, we start from the GeoDist database (described in Mayer and Zignago, 2011) that includes geographical variables valid for pairs of countries, such as the bilateral distances for most countries across the world and a dummy variable indicating whether the two countries for each pair are contiguous. As a second step, we merge this database with the data used for the DEA model. Since each observation identifies a pair of countries (*i* and *j*), for each unit we include the efficiency scores and a set of control variables of both country *i* and *j*. Finally, we apply a regression analysis where the dependent variable is the efficiency score of country *i* (θ_i), while covariates include a set of controls for both country *i* and *j* (Z_i, Z_j), and our main variables of interest that are the level of spending of country *j* (S_j) and the interaction term between the level of spending of country *j* and the dummy variable indicating whether the two countries are contiguous ($contig_{ij}$):

$$\theta_i = \delta_0 + \delta_1 S_j + \delta_2 S_j \times contig_{ij} + \delta_3 Z_i + \delta_4 Z_j + \varepsilon_{ij}$$

Here the coefficient δ_1 captures the average effect of the level of spending of other EU countries on the efficiency score of each Member State, while the coefficient δ_2 captures the differential effect of spending by contiguous countries compared to the average effect of spending.[6] As an example, consider as single country *i*, Germany. Then the coefficient δ_1 captures the average effect of the level of spending of other Member States on the efficiency score of Germany, while the coefficient δ_2 captures the differential effect of the level of spending by contiguous countries, that in Figure 3.1 are indicated in orange (Denmark, Belgium, Netherland, Luxembourg, France, Austria, Czech Republic and Poland).

For the purpose of our analysis, a statistically significant coefficient (either negative or positive) indicates the presence of spill-over effects that, in the case of coordinated production at the EU level, could be internalized. The size of the coefficient measures the economic relevance of these spill-over effects; the larger the spill-overs the larger are the likely inefficiencies generated by MS production. As a consequence, centralization is more likely to generate an efficiency and social improvement compared to the production at the MS level.

As a further econometric tool, in some chapters we complement the DEA analysis with a Difference-in-Differences (Diff-in-Diff) model. This counterfactual technique relies on the comparison over time of two groups (the 'treatment' and the 'control' group) that are identified based on the (random) assignment of a treatment at a certain point in time to the 'treatment' group while leaving the 'control' group unaffected. The causal effect of the treatment is obtained by comparing the average change that occurred in the outcome between the post- and the pre- treatment period for the treatment and the control groups. The basic assumption behind this strategy is that, after controlling for observable differences, the control group is subject to the changes the treatment group would have experienced in the absence of the treatment, providing the counterfactual needed to evaluate the impact of the treatment. This strategy allows us to control for unobservable differences between groups that are constant over time and for other common (macro) time effects. Moreover, both parametric and non-parametric methods can be used in the estimation. Applying the Diff-in-Diff together with the DEA analysis facilitates the comparison of changes over time of efficiency scores of a treatment and a control group of countries. This will always be helpful in understanding the source of inefficiency in MS production.

[6] In some regressions we use alternative dependent variables, such as output or input data of country i to better investigate the direction of the spill-over effects.

4. Health policy

Main Findings

- Economies of scale and spill-overs cannot be used as efficiency arguments to justify a reallocation of core competences (curative and long-term care) at the EU level. However, the EU intervention may still be justified on equity ground since healthy life years across MS are still very heterogeneous.
- On the other hand, for the procurement and the prevention sub-functions, countries' average efficiency scores are much lower and this inefficiency is due to both scale inefficiency and cross-border spill-over effects. In other words, these competences could be better managed at the EU level.
- According to our estimations, a reallocation of competences to the EU level would imply for procurement an average increase in Member States' efficiency scores by 12%, saving 17 billion € and for prevention, an improvement in efficiency of 13%, saving 3.5 billion €. These estimates take into account differences in purchasing power among countries.
- In terms of budgetary consequences, allocating the entire current MS spending on procurement and prevention at the EU level would imply an additional spending at this level by 1.4% of GDP per year.
- Procurement and prevention spending also present important cross-border spill-over effects, which lead to inefficiency. For procurement, countries increase their spending if neighbouring countries are spending more; for prevention, a higher spending from neighbouring countries decreases the percentage of total internal deaths due to infectious disease, but also the percentage of people aged 65 and over that decide to vaccinate against influenza.
- The coordination of policies in the prevention and procurement fields would allow Member States to exploit economies of scale and internalize spill-overs, choosing more efficiently the optimal level of spending.
- For R&D spending, data are not sufficient to run a formal analysis. However, the COVID-19 pandemic has shown that managing research (especially when it concerns vaccines and new drugs) at the EU level may be beneficial for Member States and may help to reduce inequalities in access to health care.

The reduction of health disparities across gender and countries is one of the most important goals of current EU policy (CONE Report, 2019). While reducing inequalities is a long-run goal requiring changes in individual behavior (like adopting an healthier lifestyle), as the current pandemic crisis has shown, healthcare is a crucial tool in working towards this objective. EU MS are primarily responsible for organizing and managing their own healthcare systems, but the EU complements these MS policies and several actions have been undertaken to reduce disparities (European Commission, 2013). Our aim in this chapter is to understand whether EU citizens' welfare can be improved by increasing the current role of the EU with respect to healthcare spending. In terms of public spending, health care represents around 9.6% of the European GDP; however its relevance goes far beyond this number, as the quality and the effectiveness of health care systems increase the well-being of citizens, reduce inequalities and contribute to economic progress (WHO, 2019). Using the methodology discussed in Chapter 3, we find that MS can on average increase their spending capacity by about 20% by adopting common actions in healthcare. In addition, heterogeneity among countries in terms of efficiency scores is considerable. More precisely, we estimate that by spending more efficiently, MS could release approximately 175 billion € worth of resources (in PPP - Purchasing Power Standard adjusted); these resources could be used to improve health care provision and to reduce inequalities between and within MS.

To determine whether budgetary waste could be reduced by centralizing some health care expenditure, we study the presence of *economies of scale* and *spatial spill-overs*, and we find that - considering aggregate spending - the health production function is characterized by decreasing returns to scale in many MS, while spill-over effects among States are limited. Therefore, from this analysis we conclude that the allocation of health care expenditure as a whole to the EU level would likely *not be beneficial* in terms of efficiency. However, if we look at the composition of health care expenditure, around 60% is represented by *curative care*, a function for which we can expect decreasing return to scale and differences that may depend on local characteristics (in terms of population density, age profile, etc.). For this reason, we also study some sub-functions separately, especially those for which we may expect returns to scale and spill-over to produce efficiency improvements. In particular, we focus our attention on *procurement* and *prevention.*

We find that a reallocation of procurement competences to a larger scale, such as the EU level, may allow MS to increase their efficiency scores by 12%, thus providing around 17 billion € worth of resources to spend on medical equipment (in PPP). In the prevention sub-function, we estimate an improvement in efficiency by 13%, equivalent to around 3.5 billion €.

For these functions, spill-overs also play an important role: in fact we find that: a) MS increase their procurement spending if neighbouring countries are spending more, but this does not increase their level of efficiency; b) a higher spending from neighbouring countries decreases the percentage of total domestic deaths due to infectious disease, and also the percentage of people aged 65 and over that decide to vaccinate against influenza. Coordination at the EU level would allow governments to internalize these spill-over effects, meaning more efficient spending and better social outcomes. Common spending would also improve redistribution: medical devices and vaccination could be redistributed among MS with a view to reduce inequalities among MS, which is one of the primary objectives of the EU as concerns public health (European Commission, 2013).

The chapter is organized as follows. In section 4.1 we present the current allocation of competences in the health sector between EU and MS, and we provide a general picture about the organization of MS systems, health care spending, outputs and outcomes in the EU. In section 4.2 we describe our data and model estimations. In section 4.3 we present the results of the DEA methodology applied to public health care. In section 4.4 we use our data to study an efficient and plausible scenario of centralization that involves some specific functions. In section 4.5 we perform several robustness checks to the main analysis. In section 4.6 we conclude.

4.1. The current situation in EU MS

According to Article 168 of the Treaty on the Functioning of the European Union (TFEU), competences in 'public health care' are currently shared between the EU and each MS. MS are in charge of defining and delivering health services and medical care, while the EU seeks to complement MS policies to: prevent illness/disease by promoting healthier lifestyles; facilitate access to better and safer healthcare; contribute to innovative, efficient and sustainable health systems; deal with cross-border threats; keep people healthy throughout their lifetimes; and harness new technologies and practices. These are clearly broad goals which deal more with the determinants of health than with the provision of healthcare services per se, which are left to MS. The EU's Health program (2014-20) has a limited budget of about 450 million € compared to public spending for healthcare in MS,[7] and this budget is mainly used to support projects to improve Europeans' health via prevention campaigns and reduce health inequalities.

The organization and finance of MS healthcare systems is different along several dimensions across MS (Levaggi and Levaggi, 2020; Siciliani et al., 2017). For instance, competences in terms of healthcare services definition and delivery are shared between MS and subnational (in particular, regional) governments in countries like Spain, Italy, but also Denmark, while a single country-wide health insurance fund purchases services for all Greek citizens after the 2011 reform of the National Organisation for the Provision of Health Services (EOPYY) (Adolph et al., 2012; Costa-Font and Greer, 2016). A tax-funded national healthcare system characterizes countries like Spain and Italy, while social insurances characterize countries like France, Germany and Austria. However, with few notable exceptions, most healthcare expenditure is publicly funded in MS (OECD and European Commission, 2016; Paris et al., 2010). Figure 4.1 provides evidence: total health spending in EU MS accounted for 9.6% of the GDP in 2017, 72% of which was public funded. While these percentages were almost stable during the last seven years, variation across countries is significant.

Public health spending covers several types of services, from vaccinations (part of preventive care) to hospital services (part of curative care) to medical devices (a proxy for resources available for effective health care). Figure 4.2 shows the composition of public spending by sub-function for each MS (average value for the period 2011-2017). In all MS, curative care represents the majority: apart from Belgium, it represents more than half of total health care spending (over 70% for the Czech Republic and Poland). This is an important characteristic, since curative care is generally characterized by fewer spill-overs than, say, spending for prevention.

The goal of health systems is to improve the health of citizens, prevent the insurgence of disease and to cure illnesses whenever they occur. To measure health outcomes, most of the literature makes reference to measures of health at population level, utilizing measures such as Healthy Life Years (HLY, also called disability-free life expectancy), defined as the number of years that a person is expected to continue to live in a healthy condition; or (the inverse of) some measure of mortality. HLY is also the indicator the EU recommends to use (Robine et al., 2013). The health status of the population, besides the quality of the health system and the services it offers, depends on a number of other factors including: genetic characteristics, age and gender profile of the population, the social determinants of health (such as education and employment), the prevalence of healthy behaviors and the health literacy of citizens, and the quality of the environment (not only in terms of pollution, but also the

[7] This amount does not include investment and structural funds.

social environment) (Jagger et al., 2008). The contribution of healthcare systems to these final outcomes is made through intermediate outputs, which include all the services provided to citizens by spending public monies. Typical intermediate outputs in terms of curative care are, at the aggregate level, the number of hospital discharges or the number of bed-days produced by hospitals and other healthcare facilities. For preventive care, important indicators are the number of vaccinations out of the total population and the scale of screening programs. For procurement, the rate of medical equipment per 100,000 people in the total population is a possible output. Table 4.1 reports the average values for the period 2011-2017 of selected outcome and output measures for each of MS.

4.2. Data and model estimations

Our empirical strategy is based on the identification of input, output and outcome measures to define a 'health' production function. According to this interpretation, which is quite standard in the literature (e.g., Piacenza and Turati, 2014; Kumbhakar, 2010; Greene, 2004), inputs are consumed to produce intermediate healthcare services (output) which are used to improve citizens' health (outcome).

For input measures, we use the ratio of public health spending (PPP) to GDP (at market prices) for each MS. For (intermediate) output indicators, we use data on the number of discharges per 1,000 inhabitants and the self-reported percentage of met needs for medical examination by people within the lower quantile of the income distribution. Finally, for outcome indicators, we consider Healthy Life Years (HLY) and the inverse ratio of treatable and preventable deaths over total deaths (NPTM). Given the nature of healthcare services (an input itself in the production of health), output and outcomes cannot be considered together. Output measures help to understand the role of technical efficiency (i.e., the ability of MS to transform inputs into health care services) while the outcomes allow us to capture the 'appropriateness' of care in improving citizens' health. The distinction between output and outcome is typical of many public services, such as healthcare. Consuming services does not necessarily imply an improvement in outcome, because the relationship between output and outcome depends on several factors outside the efficiency of health care systems. In this respect, the two measures are per se interesting in understanding how to tackle the problem of reducing health disparities, which are related both to reducing disparities in healthcare access and disparities in, e.g., behaviours affecting health.

We use input-oriented DEA estimators to compute budgetary waste rates for MS. We then compute how budgetary waste rates can be translated into potential increase of outputs that could have been achieved by each MS using the same level of inputs, but acting efficiently.

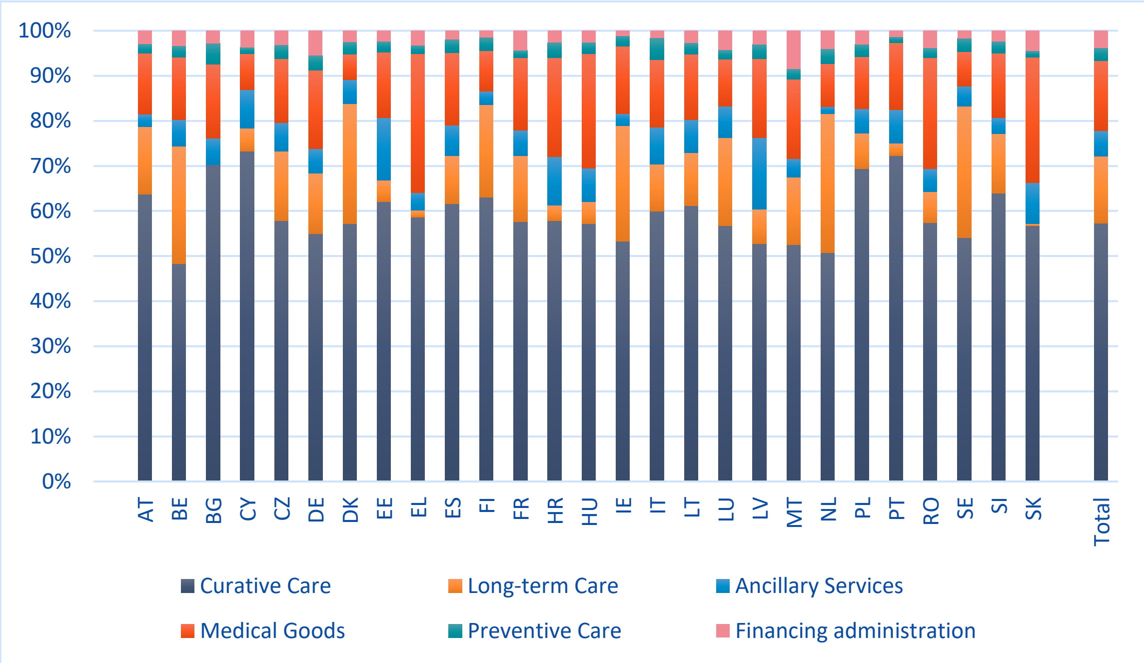
We specify two main general models: a model where all intermediate outputs are modelled as function of inputs, and a model where outcomes are modelled as a function of inputs. As robustness checks, we include an additional output (bed-days per capita) and we also estimate separate models for each output and outcome.[8]

As health outcomes are not only a function of healthcare services (the intermediate output) but also depend on health behaviours and the quality of the environment, we consider a second stage analysis in order to identify the determinants of the efficiency scores in the production of health outcomes.[9] In particular, as explanatory variables, following the institutional and the academic literature (Jagger

[8] In Annex A.4 we report the rank correlation between different models (Figure A.4.1 and A.4.2). We did not include bed-days per capita directly in the main analysis because of the lack of data for some countries.

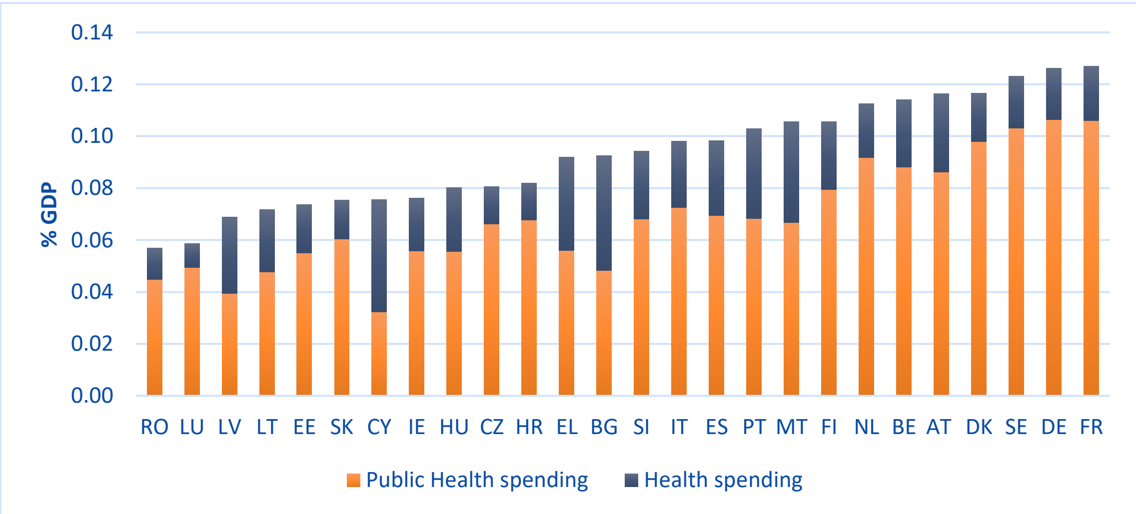
[9] Technically, this can be done in different ways. Here we consider the 'simarwilson' Stata module presented in Badunenko and Tauchmann (2019).

Figure 4.1: Public Health spending by function, average values 2011-2017



Source: Eurostat.

Figure 4.2: Health spending in 2017 by Member States (% GDP)



Source: Eurostat.

et.al, 2008; Fouweather et al, 2008), we include: a proxy for education (the percentage of the population with tertiary education), proxies for unhealthy behaviours (the percentage of daily smokers and people who are overweight), proxies for healthcare needs (the percentage of people over 70), and variables measuring private health care expenditure (the amount of voluntary health spending and household out-of-pocket health expenditure). Finally, we also consider the Gross Domestic Product and the number of doctors per 1,000 inhabitants as a proxy for possible supplier-induced demand.

Given the differences in spill-overs and the variance across MS, we will also discuss additional model specifications which consider healthcare spending on specific sub-functions such as prevention and procurement, i.e., those sub-functions for which we can expect higher returns from centralization according to the methodology defined in Chapter 3.

Table 4.1: Average values of outcomes and outputs

Country	OUTCOMES			OUTPUTS				
	HLY	PTM	IM	Discharges (‰)	Bed- days (‰)	UN (%)	MT	vacc. (%)
AT	58.70	0.23	9.14	245.17	1,584.71	17.00	8.49	20.30
BE	63.96	0.21	22.18	164.19	1,124.62	.	0.00	58.00
BG	64.26	0.28	8.07	.	.	17.30	9.33	2.40
CY	64.63	0.22	13.53	80.44	450.66	9.40	13.05	32.40
CZ	63.03	0.31	16.84	186.57	1,124.24	17.30	6.35	19.13
DE	61.21	0.21	22.21	233.58	1,790.81	30.30	6.61	40.08
DK	60.53	0.25	16.34	.	.	29.80	8.19	43.37
EE	55.67	0.32	9.66	154.79	911.51	38.80	5.24	1.93
EL	64.86	0.20	24.66	177.62	.	30.20	13.81	48.91
ES	65.67	0.18	14.43	110.62	660.98	25.70	6.70	56.34
FI	60.37	0.25	5.58	165.24	1,105.61	30.20	10.68	41.99
FR	63.49	0.19	17.02	158.28	901.71	.	3.41	51.31
HR	59.10	0.29	9.16	159.75	1,065.73	24.40	7.15	22.64
HU	59.53	0.37	8.13	174.12	981.33	22.50	4.98	27.87
IE	67.50	0.26	6.17	136.19	797.93	40.60	6.41	57.19
IT	63.59	0.17	21.92	109.13	744.91	31.00	12.27	54.73
LT	58.56	0.36	22.40	224.77	1,526.09	17.50	6.59	10.44
LU	63.04	0.24	14.34	141.24	1,039.52	37.30	8.61	40.85
LV	53.76	0.36	14.78	147.71	872.55	41.80	8.28	3.31
MT	72.24	0.25	6.34	146.57	773.56	23.00	9.55	54.60
NL	60.40	0.22	17.32	99.74	500.95	12.30	3.95	68.28
PL	61.56	0.30	5.77	167.66	1,134.57	32.30	5.30	9.70
PT	59.53	0.20	21.16	107.94	779.10	39.80	0.00	51.07
RO	58.54	0.36	13.52	196.73	1,235.03	15.50	3.28	10.56
SE	71.56	0.19	22.26	149.59	.	22.30	0.00	47.66
SI	56.93	0.27	5.82	164.93	1,096.56	26.10	6.27	12.30
SK	54.60	0.37	7.57	171.26	1,120.00	11.40	7.09	15.30
Total	61.73	0.26	13.94	158.95	1,014.03	25.75	6.73	33.43

OUTCOMES: HLY – Healthy Life Years, PTM – ratio between Preventable and Treatable deaths and total deaths, IM - deaths related to infectious diseases per 100.000 inhabitants ; **OUTPUTS**: discharges – n. of yearly hospital discharges per 1,000 inhabitants, bed-days – n. of yearly hospital bed days per 1,000 inhabitants, UN – self reported % of unmet needs for health care, MT – medical technology per 100,000 inhabitants (sum of Computed Tomography Scanners, Magnetic Resonance Imaging Units, Gamma cameras, Angiography units, Lithotriptors, PET scanners, Radiation therapy equipment, Mammographs), % vacc. – Vaccination against influenza of population aged 65 and over.

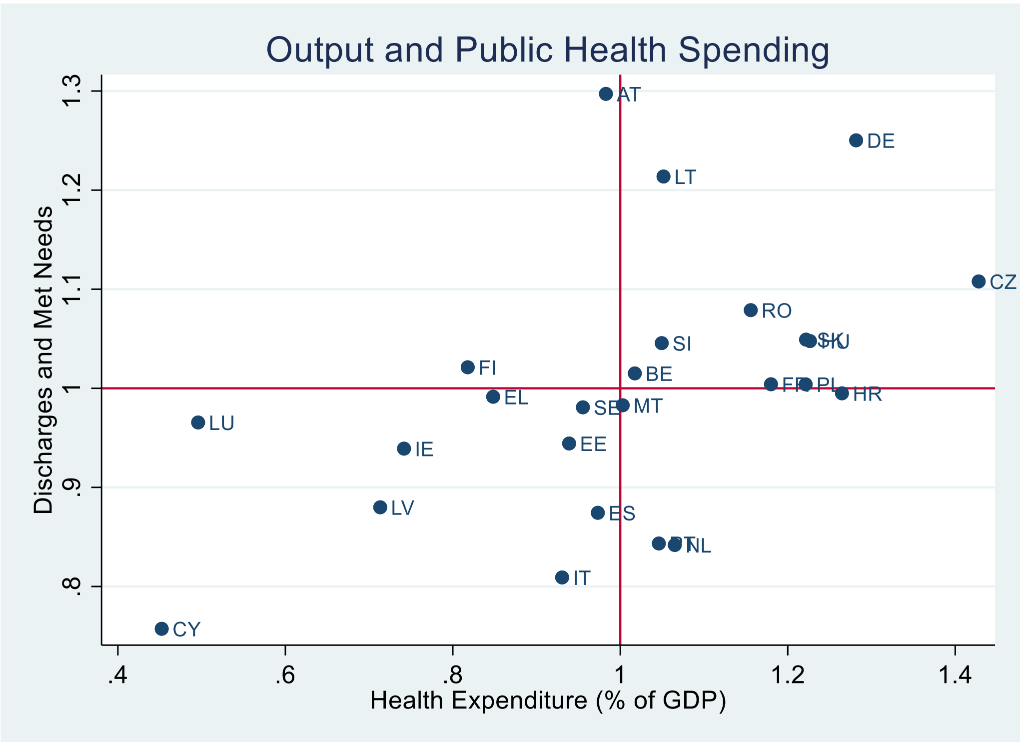
Source: Eurostat

4.3. The empirical exercise on total spending

To identify budgetary waste by MS, we first need to estimate the production frontier using the benchmarking techniques discussed in Chapter 3. As discussed above, the first model (model A) uses the ratio of total public health expenditure to GDP as an input, and two intermediate output indicators: the number of discharges per 1,000 inhabitants (discharges) and the percentage of self-reported met needs for medical examination by people within the lower quantile of the income distribution (MN), to account for a measure of (in)equality in the access to services. In the second model (model B), we consider the same input measure (total public health expenditure as a percentage of GDP), while as outputs we select two outcome indicators: Healthy Life Years (HLY) and the inverse ratio between preventable and treatable deaths and total deaths (NPTM).

Figures 4.3 and 4.4 show the relationship between total public health care expenditure and outcome/output, which easily allows us to determine the benchmark MS in each exercise. In both figures, input and outcome/output measures are represented as the ratio between the MS level for each MS and the average EU level. In the upper right quadrant, we find countries characterized by both spending and output/outcome higher than the average; while in the lower left quadrant we find countries for which both spending and output/outcome are below the EU average. The remaining quadrants are characterized by either input or output/outcome above/below the EU average. Benchmark countries can be identified by keeping constant spending and looking for those countries that obtain the highest output/outcome; or, alternatively, by keeping output/outcomes constant and

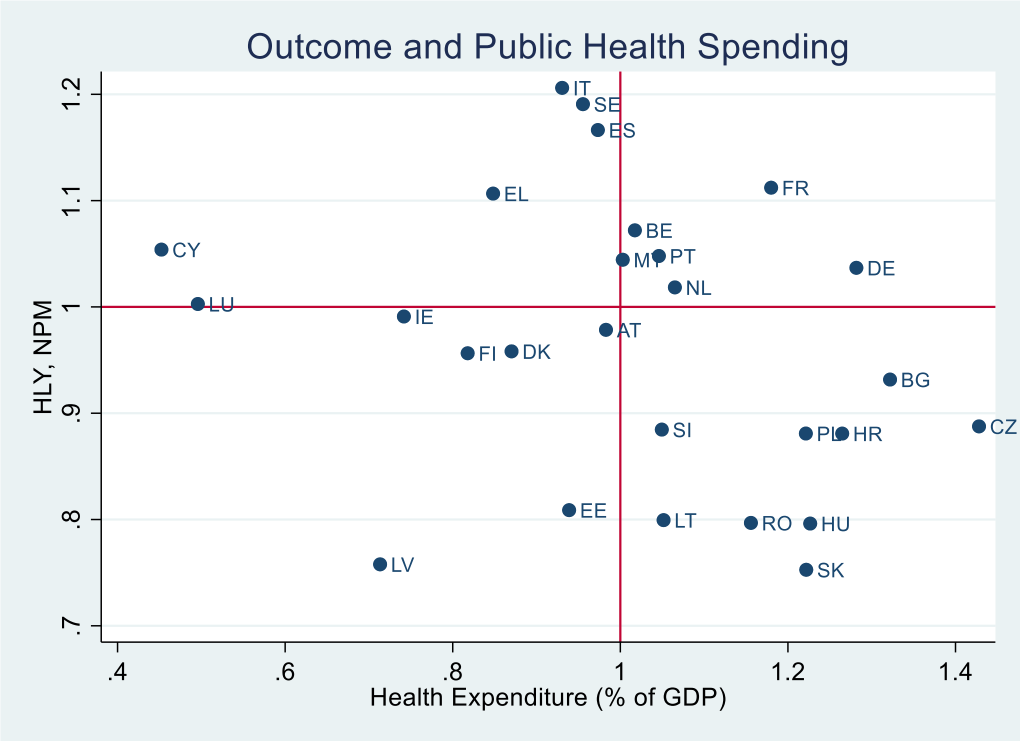
Figure 4.3: Output and Public Health Spending



In the graph the two outputs are equally weighted. The horizontal line 1 represents the average EU level of output indicator, while the vertical line 1 represents the average EU level of health expenditure.

Source: Eurostat

Figure 4.4: Outcome and Public Health Spending



In the graph the two outcomes are equally weighted. The horizontal line 1 represents the average EU level of outcome indicator, while the vertical line 1 represents the average EU level of health expenditure.

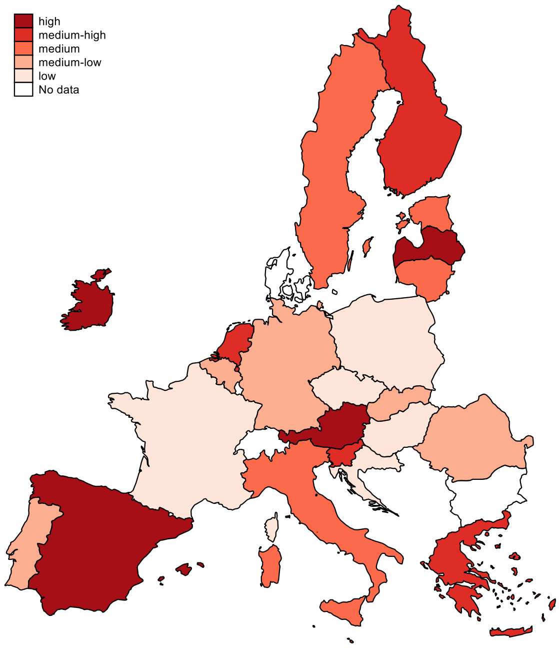
Source: Eurostat

looking for those countries that minimize spending (which is what we do in our exercises here to identify budgetary waste rate).

From Figures 4.3 and 4.4, we can identify a number of differences in the relationships between health expenditure and, respectively, intermediate outputs and outcomes. Figure 4.3 shows that the levels of outputs are generally positively related to the level of public expenditure. However, in Figure 4.4, we observe that several countries - although investing more than the EU average level - are underperforming in terms of outcomes, and vice-versa. This very simple and intuitive graphical analysis confirms the insights of a large theoretical literature suggesting that health outcomes depend on variables other than health spending, such as health behaviours and other specific characteristics of the population (Nixon and Ulman, 2006; Fouweather et al., 2015; Jagger et al., 2008) From these figures, we can also observe that there are two countries (Cyprus and Luxemburg) whose level of spending is significantly lower compared to other MS. Since DEA is very sensitive to the presence of outliers, we decided to exclude these countries when conducting our benchmarking analysis.

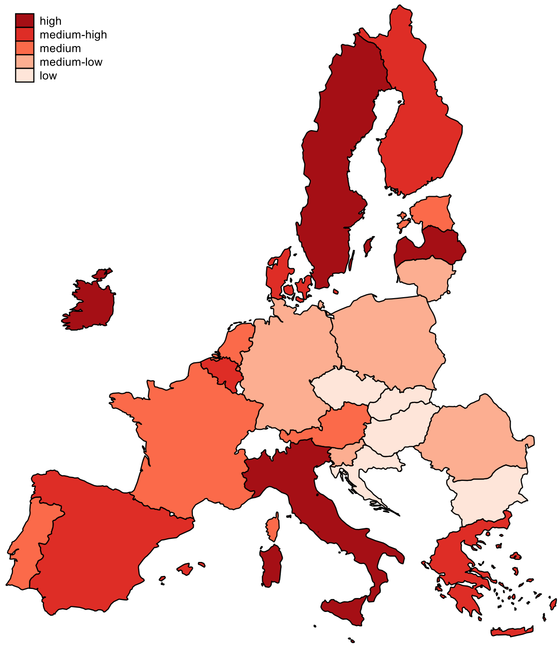
The estimated efficiency scores are reported in Figure 4.5 (model A, output=f[input]) and 4.6 (model B, outcome=f[input]). Both figures show a large heterogeneity among countries. Moreover, comparing the two figures we can also note that MS efficient in terms of outcomes are not necessarily as efficient in terms of outputs. The complete efficiency scores estimates are provided in Table A.4.1 Annex A.4. The average EU score is equal to 0.81 for model A and 0.78 for model B, meaning that MS could

Figure 4.5: Efficiency estimations, model: output=f(input)



Source: own estimates on Eurostat data

Figure 4.6: Efficiency estimations, model: outcome=f(input)



Source: own estimates on Eurostat data

increase their output available financial resources by 19% or 22% if able to reach the efficient boundary.[10]

These average values allow us to compute the extra resources that could have been obtained by spending more efficiently. Indeed, by eliminating waste, MS could obtain approximately an extra 175 billion € to use on services able to increase the number of discharges per 1,000 inhabitants and the percentage of met needs. In other words, spending more efficiently could result in more services and in more equal access to services. This increase in intermediate outputs will lead in the medium term to an increase in outcomes, i.e., an improvement in the health status of the population. As a general caveat, however, it is important to recognize that results in terms of outcomes depend also on other factors besides health services, such as the behaviour of individuals, which might outweigh the positive impact stemming from the availability of more services.

For this reason, we perform a second stage regression to study the determinants of the efficiency scores obtained from model B (involving the relationship between input and outcome). We find positive correlations between efficiency and education (scores improve by about 2% with a one percentage increase in the share of people with tertiary education), and efficiency and the availability of doctors (scores improve by 6.72% with a unit increase of doctors per 1,000 inhabitants). Other determinants such as the percentage of overweight, daily smoker or elderly people, GDP of the MS, the level of spending in voluntary health insurance schemes and household out-of-pocket payment are not significantly correlated with efficiency scores (Table A.4.3 Annex A.4).

[10] Average efficiency scores do not change substantially when considering the average value weighted for the level of spending of each MS.

Finally, we test whether economies of scale or spill-overs play a role in explaining the size of inefficiencies. This analysis is fundamental in understanding whether a reallocation of health care competences from the MS to the EU level may be beneficial in terms of reduction of budgetary waste.

As discussed in Chapter 3, identification of returns to scale characterising the production function is generally done by comparing DEA scores obtained with a Constant Returns to Scale (CRS) specification with DEA scores obtained with a Variable Returns to Scale (VRS) specification. In both models, the production function of MS exhibits in most cases the presence of increasing returns to scale, but the scale efficiency is particularly high for both models (0.95 and 0.93).

To analyze the role of spill-overs, we use a spatial model (technically, a spatial lag model) intended to check whether the level of efficiency of each MS is affected by the level of public health spending of neighbouring countries. In particular, neighbouring countries are defined as bordering countries. Applying a truncated regression model, which accounts for the fact that our dependent variable is bounded between zero and one, we find that there are some spill-over effects since the efficient scores estimated through model B are negatively affected by the level of public expenditure in neighbouring countries. However, the effect on scores is quite limited (Table A.4.4 Annex A.4).

Recalling that more than 70% of total spending is used for curative and long-term care (see Figure 4.1), we conclude that economies of scale and spill-overs cannot be used as arguments to justify a reallocation of core competences to the EU level. These results are not surprising and are in line with results of the empirical and theoretical literature suggesting that health services, especially curative care (which represent the highest share in health spending), should be decentralised to lower levels of governments, typically subnational governments in unitary countries.[11]

However, the recent pandemic has revealed some weaknesses in the national organization of health care systems and has emphasized the need for an enhanced coordination of specific functions within the health sector at the EU level. For instance, the Prime Ministers of Belgium, Denmark, Germany, Spain, France and Poland suggest "a wide range of measures, including accessibility of relevant and comparable data, stronger and more targeted research and development, common procurement and cooperation on critical stocks as well as some ideas to strengthen European resilience in certain, critical supply chains.". In the next section we focus on identifying areas where a reallocation of competences from the MS to the EU level may be beneficial for MS. Following the suggestion provided by the letter of prime ministers, we analyse the **prevention** and the **procurement** sub-functions and we discuss the potential development of **common R&D programs**.

4.4. Common action in prevention/procurement/R&D

As shown in Figure 4.1, the procurement and the prevention functions represent 15.6% and 2.9% of the total health spending respectively. They account for 1,2% and 0.2% of EU GDP respectively and they might be serious candidates for centralization at the EU level according to the theoretical framework developed in Chapter 2.

We start by analyzing **procurement**. Following the approach used in the previous section, we consider two models. Both models use the procurement spending in PPP as a percentage of the GDP at market prices as an input measure; as the output/outcome, we use an intermediate measure of output (the

[11] For instance, recent systematic reviews of the empirical evidence show that diseconomies of scale for hospitals emerge for small facilities under 200 beds and larger ones with more than 600 beds; these numbers suggest that economies of scale are limited for hospitals and justify the provision of these services at the local level (see, e.g., Giancotti et al., 2017).

'amount' of medical technologies - *MT*) in model A, and a measure of outcome (*HLY*) in model B.[12] To measure medical technology, we use as a proxy the number of Computed Tomography Scanners, Magnetic Resonance Imaging Units, Gamma cameras, Angiography units, Lithotriptors, PET scanners, Radiation therapy equipment, and mammographs per 100,000 inhabitants. The results of this exercise are summarized in Table 4.2.

In Table 4.2, θ represents the level of technical efficiency estimated using the DEA model. We can first note that the average levels of budgetary waste-rates for the procurement sub-function are much higher than for those calculated for the general health care function (see Table A.4.1 in Annex A.4). For instance, looking at the first model, the average level of budgetary waste rate is equal to 57%, while for the general model is equal to 19%. Part of this inefficiency is explained by the sub-optimal scale that, for most countries, should be increased as shown in Table 4.2. In the column "% change" we report the percentage change in efficiency that could be obtained by a change in technology from a crs (constant return to scale) to a vrs (variable returns to scale) production function. To assess whether a change to a larger scale (EU level) is beneficial for MS, we consider the percentage change to be positive when returns to scale are increasing and negative when they are decreasing. As a result, we can say that on average moving to a larger scale should imply an increase in efficiency of around 12%. MS could use these savings to reduce taxes, to spend in other fields, or to acquire more equipment. In this last case, as the total level of procurement spending is equal to 136 billion € (in PPP) and knowing that the unitary cost of equipment is between 500,000 € and 3 million €,[13] by increasing the production scale MS can potentially rise the total number of acquired equipment from a lower bound of 5,400 units to an upper bound of 32,500 units, with an average value of 19,000 units – that means around 700 more for each MS each year. Results are confirmed when considering model B, in which we note that the optimal scale should be increased, and the movement to a larger scale can potentially rise the average efficiency in the production of outcomes by 5%. These results are in line with the literature (e.g., Bandiera et al., 2009; Baldi and Vannoni, 2017). For instance, Bandiera et al. (2009) using Italian data show that when buying from a centralized procurement agency, public governments save on average 12 percentage points.

To analyze the role of spill-overs, we consider a spatial model that aims to check whether the level of efficiency of each MS is affected by the level of public health spending of bordering countries. We find that the level of spending by neighbouring countries negatively affects the efficiency scores derived from model A, while there is no significant effect on the efficiency scores derived from model B (see Table A.4.5, Annex A.4). To understand the causes of this result, we check whether the level of procurement spending or the level of outcome in one country is affected by the level of procurement spending in neighbouring countries. Although we find no significant effect on the level of outcome, we detect a positive and significant effect on the level of procurement spending (Beer et al., 2018).

For prevention, we consider as output both an intermediate output measure (the vaccination against seasonal influenza of population aged over 65 (*vacc*)), and an outcome measure (the inverse of deaths related to infectious diseases over total deaths (*IIM*)). Table 4.3 presents results from models using DEA estimation.

Similarly to what we observed for procurement, the efficiency scores are much lower than for the general function. Indeed, budgetary waste-rates are quite relevant and correspond to 44% for the first model and 34% for the second model. When looking at economies of scale we find that most countries exhibit increasing returns to scale, and potentially an increase of scale could lead to a rise in efficiency

[12] We consider measures that are more specific to the procurement function.

[13] These values largely depend on the type of machinery that is acquired: a Gamma camera may cost around 500,000 euros, while a Magnetic Resonance Imaging Units may cost around 3m euros.

of 13% when looking at the first model (considering output), and of 25% when looking at the second model (considering outcome). Knowing that in total the prevention spending in PPP corresponds to 26.975 billion €, and considering that the cost for vaccinating an individual throughout his life may vary between 400 and 3,400 € (Ethgen et al., 2016), we can estimate that, by saving 3.5 billion €, MS could increase the number of vaccinated people by somewhere between 1,020,000 to 8,750,000, with an average value of 4,890,000, or around 180,000 more people for MS. Alternatively, these extra resources could be used in a more targeted way to increase the provision of vaccines in those countries where the rate of vaccination is rather low compared to the EU average, redistributing resources (in kind) without any extra spending and reducing health inequalities across EU countries in terms of health outcomes.

As with spill-overs, applying our simple spatial analysis we find that (see Table A.4.6, Annex A.4): i) the efficiency scores of an MS are not affected by the level of prevention spending of other countries; ii) the rate of 65+ vaccinated against influenza is positively affected by the level of prevention spending of other countries, but negatively by the level of public spending in neighbouring countries; iii) the percentage of total deaths due to infectious diseases is negatively affected by the level of prevention spending in neighbouring countries.

Overall, our analysis suggests that both economies of scale and spill-overs are substantial arguments for improving common action in the procurement and prevention policies within healthcare. The case for a more substantial role in terms of prevention and procurement by the EU is emphasized also by the recent COVID-19 pandemic. For instance, during the pandemic the Commission has launched four joint procurements of personal protective equipment in order to help MS meet their demand for medical goods, and has mobilized a substantial amount of funds to develop vaccines, new treatments, diagnostic tests and medical systems to prevent the spread of the coronavirus and save lives (EU website, 2020).

For R&D a formal analysis is not possible because poor quality data and the multinational dimension of the health care industry make it rather difficult to determine the link between public expenditure in R&D and innovation (the main output of such activity). Furthermore, in recent years, most governments have outsourced R&D to private industries and prefer to pay for it through a higher product price (Lakdawalla, 2018). However, there might be more efficient ways to invest in innovation (Mazzucato and Roy, 2019). In this respect the EU could play an important role by developing models of risk-sharing between the industry and the EU in the development of new health technologies. The recent experience with the COVID-19 pandemic has shown the importance of acting at EU level. In particular, the EU is working together with MS for the development and distribution of a safe COVID-19 vaccine accessible for all (European Parliamentary Research Service, 2020a). European coordination is fundamental in order to collect funds, develop a common strategy for collecting data, promote knowledge sharing, and prevent ex-post inequality in the access to new COVID-19 treatments (Sturkenboom et al., 2019; European Parliamentary Research Service, 2020a).

Table 4.2: EU countries efficiency scores in both models (procurement)

Country	Model A: outputs=f(input)					Model B: outcomes=f(input)				
	θ_{vrs}	θ_{crs}	rts	SE	% change	θ_{vrs}	θ_{crs}	rts	SE	% change
AT	0.39	0.38	drs	0.98	-0.02	0.41	0.39	drs	0.96	-0.04
BE	.	.	-	.	.	0.44	0.41	drs	0.92	-0.08
BG	0.28	0.26	drs	0.93	-0.07	0.23	0.20	irs	0.88	0.12
CZ	0.24	0.19	irs	0.78	0.22	0.24	0.19	irs	0.81	0.19
DE	0.22	0.18	irs	0.81	0.19	0.27	0.25	drs	0.93	-0.07
DK	1.00	1.00	crs	1.00	0.00	1.00	1.00	crs	1.00	0.00
EE	0.36	0.23	irs	0.64	0.36	0.36	0.27	irs	0.76	0.24
EL	1.00	0.32	drs	0.32	-0.68	0.26	0.23	drs	0.90	-0.10
ES	0.31	0.26	irs	0.82	0.18	0.59	0.43	drs	0.72	-0.28
FI	1.00	0.87	drs	0.87	-0.13	0.67	0.66	irs	1.00	0.00
FR	0.26	0.11	irs	0.42	0.58	0.37	0.33	drs	0.89	-0.11
HR	0.18	0.18	drs	0.99	-0.01	0.18	0.15	irs	0.86	0.14
HU	0.16	0.10	irs	0.61	0.39	0.16	0.11	irs	0.67	0.33
IE	0.44	0.35	irs	0.78	0.22	0.44	0.42	irs	0.95	0.05
IT	1.00	0.53	drs	0.53	-0.47	1.00	0.52	drs	0.52	-0.48
LT	0.32	0.26	irs	0.80	0.20	0.32	0.22	irs	0.69	0.31
LV	0.40	0.40	drs	0.99	-0.01	0.39	0.27	irs	0.69	0.31
MT	0.35	0.32	drs	0.92	-0.08	0.28	0.27	irs	0.98	0.02
NL	0.49	0.24	irs	0.48	0.52	0.59	0.55	drs	0.94	-0.06
PL	0.35	0.22	irs	0.65	0.35	0.35	0.28	irs	0.82	0.18
PT	.	.	.	.	.	0.42	0.38	drs	0.91	-0.09
RO	0.17	0.07	irs	0.40	0.60	0.17	0.12	irs	0.69	0.31
SE	.	.	.	.	.	1.00	0.88	drs	0.88	-0.12
SI	0.32	0.25	irs	0.77	0.23	0.32	0.29	irs	0.91	0.09
SK	0.14	0.12	irs	0.87	0.13	0.14	0.10	irs	0.66	0.34
Total	0.43	0.31		0.74	0.12	0.42	0.36		0.84	0.05

The columns are: θ_{vrs} - total technical efficiency with variable return to scale, θ_{crs} - total technical efficiency with constant return to scale, rts- returns to scale, SE- Scale efficiency, % change- % change in total efficiency moving from crs to vrs (+ for irs, - for drs).

Source: Eurostat.

Table 4.3: EU countries efficiency scores in both models (prevention)

Country	Model A: outputs=f(input)					Model B: outcomes=f(input)				
	θ_{vrs}	θ_{crs}	rts	SE	% change	θ_{vrs}	θ_{crs}	rts	SE	% change
AT	0.63	0.25	irs	0.40	0.38	0.76	0.59	drs	0.78	0.22
BE	0.73	0.56	drs	0.76	-0.17	0.49	0.20	drs	0.40	0.60
BG	0.20	0.01	irs	0.05	0.19	1.00	0.35	irs	0.35	-0.65
CZ	0.29	0.11	irs	0.37	0.18	0.30	0.16	irs	0.54	0.46
DE	0.30	0.24	irs	0.78	0.06	0.30	0.14	drs	0.45	0.55
DK	0.52	0.44	irs	0.85	0.08	0.53	0.27	crs	0.50	0.50
EE	0.55	0.02	irs	0.04	0.53	0.70	0.61	irs	0.87	0.13
EL	0.78	0.75	irs	0.96	0.03	0.83	0.46	drs	0.55	0.45
ES	0.59	0.48	drs	0.83	-0.10	0.46	0.24	drs	0.53	0.47
FI	0.52	0.43	irs	0.82	0.09	1.00	0.84	irs	0.84	-0.16
FR	0.68	0.68	drs	0.99	-0.01	0.68	0.31	drs	0.46	0.54
HR	0.30	0.13	irs	0.44	0.17	0.41	0.40	irs	0.97	0.03
HU	0.40	0.22	irs	0.55	0.18	0.64	0.59	irs	0.92	-0.08
IE	1.00	0.81	drs	0.81	-0.19	0.88	0.70	irs	0.80	0.20
IT	0.35	0.30	drs	0.87	-0.05	0.28	0.12	drs	0.43	0.57
LT	0.48	0.10	irs	0.20	0.38	0.51	0.27	irs	0.54	0.46
LV	0.56	0.04	irs	0.06	0.52	0.66	0.49	irs	0.75	0.25
MT	0.70	0.61	drs	0.87	-0.09	0.74	0.66	irs	0.89	0.11
NL	1.00	0.48	drs	0.48	-0.52	0.36	0.17	drs	0.45	0.55
PL	0.37	0.07	irs	0.19	0.30	1.00	0.62	irs	0.62	-0.38
PT	1.00	1.00	crs	1.00	0.00	1.00	0.44	drs	0.44	0.56
RO	0.53	0.11	irs	0.21	0.42	0.63	0.47	irs	0.74	0.26
SE	0.43	0.41	irs	0.93	0.03	0.43	0.17	drs	0.38	0.62
SI	0.48	0.11	irs	0.24	0.36	0.83	0.73	irs	0.88	-0.12
SK	0.72	0.21	irs	0.30	0.50	1.00	1.00	irs	1.00	0.00
Total	0.56	0.34		0.56	0.13	0.66	0.44		0.64	0.25

The columns are: θ_{vrs} - total technical efficiency with variable return to scale, θ_{crs} - total technical efficiency with constant return to scale, rts- returns to scale, SE- Scale efficiency, % change- % change in total efficiency moving from crs to vrs (+ for irs, - for drs).

Source: Eurostat.

4.5. Robustness checks

We performed several robustness checks to the main analysis modifying the variables used in our DEA models.

1. *Alternative outputs – general analysis*. Model A in the analysis of section 4.3 includes as output variables met needs and the number of discharges, while as input variable includes the public health spending as a percentage of GDP. As a robustness check we consider each output separately and we include the number of bed days as an additional output measure. Figure A.4.1 in the appendix shows that the rank correlations among the different models are always above 0.65.
2. *Alternative outcomes – general analysis*. Model B in the analysis of section 4.3 includes as outcome variables HLY and NPM, while as an input variable the public health spending as a percentage of GDP. As a robustness check we consider each outcome separately and we show that the rank correlations among the different models are always above 0.88 (Figure A.4.2).
3. *A composite indicator*. Despite the arguments discussed above, we also tested for completeness, a model in which we consider a production process producing a composite indicator that includes all outputs (met needs and discharges) and all outcomes (HLY and NPM) with equal weight, while as an input we consider the level of public spending (in PPP) as a percentage of the GDP. The rank correlations between this model and our two benchmark models is respectively equal to 0.85 with model B and 0.88 with model A.
4. *Alternative outputs – procurement function.* As an alternative output we use a proxy for the value of machineries (a weighted sum that considers the cost of each machinery). Figure A.4.3 in the appendix show that the rank correlations between all procurement models are always above 0.80.
5. *Rank correlation – prevention function.* Figure A.4.4 in the appendix shows the rank correlation between prevention models. We can observe that the rank changes significantly when moving from model 1 to model 2. This result is not surprising and is explained by the difference between output and outcome measures. Indeed, countries where the deaths related to infectious diseases are numerous due to, for instance, the geographical or social proximity among individuals, are also countries with a strong need/demand of vaccination against seasonal influenza. The result confirms how important it is to distinguish between output and outcome measures.

4.6. Conclusions

In this chapter we discuss a benchmarking exercise focused on spending for healthcare, a function largely in the hands of MS. We first estimated DEA efficiency scores on aggregate spending, and then we repeat a similar exercise for two sub-functions, prevention and procurement. When looking at aggregate spending, our results do not support the view that centralizing spending for healthcare will provide improvement for the welfare of EU citizens. However, we do find supporting evidence for centralizing both spending for prevention and spending for procurement.

The COVID-19 pandemic has already mobilized a European response for enhancing the cooperation that EU countries were not able to achieve when the outbreak started. For instance, in a letter addressed to the president of the EU commission, six countries (Belgium, Denmark, Germany, Spain, France and Poland) asked for an EU strategy to avoid shortages of critical medicines, medical devices, PPE, and vaccines needed to face future pandemics. This strategy needs: i) efficient monitoring and data sharing at the EU level, with an increased role of ECDC; ii) a better distribution and coordination of supplies, which starts from an optimization of EU production and the consideration of common strategic stocks of critical medicines and devices; iii) a strong investment in R&D, for a joint vaccine development, for developing better diagnostic testing procedures, and for sharing research data on treatments; iv) to ensure resilience by guaranteeing the free flow of trade across borders, define Antitrust guidelines relevant during crises and to develop joint procurement agreements; v) provide incentives to invest in production capacity in Europe of selected critical active ingredients, raw materials and medicines. Our results support this strategy, suggesting that coordination at the EU level is required in the presence of spill-overs and scale economies that can be better exploited on procurement, prevention, and R&D at the EU level.

5. Climate and energy policy

Main Findings

- The EU Emissions Trading System (ETS) is the largest greenhouse gas emissions trading system in the world. It allows for maximal thickness of the market, minimal administrative costs and an overall higher allocative efficiency compared to systems based on local/regional/national markets for emissions.
- The estimated reduction of CO_2 emissions obtained by means of more stringent regulation in phase 3 (2013-20) with respect to phase 2 (2008-12), equals about 150 thousand tonnes, 5.7% of emissions in 2008, and has a (lower bound) value using EUAs prices of about €1.15 billion.
- Relying both on our results and those presented in previous empirical literature on phases 1 and 2, we calculate that the total reduction on emissions induced by the EU ETS since its introduction (in 2005) to the last available year (2018) is roughly 3350 $MtCO_2$. Using EUAs prices, *this amounts to about €42.5 billion of gains for the EU economy.*
- We find no evidence of any adverse effect of the stricter regulation implemented in phase 3 on companies' performance in different sectors, a result that confirms the literature's findings for the less strictly regulated phases 1 and 2.
- Our benchmark analysis suggests that the current amount of waste (for the last available year, 2018) – that is the increase in GDP and/or reduction in CO_2 emissions which could be obtained by a more efficient use of inputs (capital, labour and energy) – is, *on average across MS, 8%, 28%, 47% in the Transportation, Energy and Manufacturing sectors respectively*. However, all three sectors have experienced a rise in average efficiency between 2008 and 2018, with the Manufacturing sector outperforming the other two thanks to the strong dynamics of the best performers.
- Our results also suggest that incentives from the EU ETS are much stronger when companies *need to purchase the allowances* instead of having them freely allocated. This evidence sheds a favourable light on the progressive tightening of free allocation programmed for the upcoming phase 4, and calls for a careful consideration of any instance where exceptions are made.
- We characterize the role played by the EU ETS as a source of revenues so far. Our estimates of revenues follow the price dynamic of the emissions allowances and prove to be sizeable: €6 billion in 2012-2017, €16 billion in 2018 and €20 billion in 2019.
- Due to the increasing efforts of the EU to fight climate change, prices of EAUS are expected to rise in the future suggesting that *potential revenues* from EU ETS in the medium-long term can be expected to be *above €50 billion per year*. (Part of) these revenues could then become an important source of autonomous funding of the EU budget and would be able to cover up to one-third of the current EU budget.

5.1. Introduction

Climate change is one of the main challenges of our time and European citizens support EU action in this field (European Commission 2017). Addressing the problems posed by climate change is complex, but the rewards are also considerable: creation of jobs, improved competitiveness, economic growth, development of new technologies, etc. For example, the CONE Report (2019) estimates that the economic loss that could be avoided from limiting the raise in temperature to below 2 degrees Celsius by the end of the century,[14] is about €160 billion per year while achieving a target of 20% renewable energy by 2020 would create 400,000 jobs. EU action in this field is also likely to generate substantial EU Value Added given the gain/losses at stake and the relevant negative externalities characterizing emissions of greenhouse gases (GHG). Indeed, such externalities would lead to sub-optimal results if uncoordinated efforts by MS were implemented.

With the 1997 Kyoto Protocol, 37 countries agreed on legally binding emissions reduction targets of GHG to be met in the period 2008-2012. The EU Emissions Trading System (ETS), the main tool devised by the EU Commission to meet the agreed commitment, was established shortly after with the 2003 EU ETS directive. The "pilot" phase 1 was launched in 2005.

The energy sector is clearly one of the most important for reaching the emissions targets, accounting for more than 35% of CO_2 emissions. It has been estimated (CONE Report 2019) that a more integrated energy market could generate potential benefits equivalent to €231 billion per year. In 2009 the EU set the 2020 package to meet its energy policy objectives of developing a sustainable, secure and competitive energy system. The 2020 package is a set of binding legislation identifying three key targets (20-20-20):

- 20% cut in **GHG** emissions compared to 1990 levels;
- 20% of EU energy from **renewables**;
- 20% improvement in **energy efficiency** (compared to baseline projections).

These measures had a substantial impact on the EU energy system. The share of renewable energy in EU gross energy consumption rose from 9.6% in 2004 in 18.9% to 2018 and most MS are expected to meet their 2020 renewable energy targets. The distance between final energy consumption and the 2020 target halved between 2006 (6%) and 2018 (3%).

Following the Paris Agreement (2015), the EU set the new 2030 Climate and Energy Policy identifying three key targets:

- At least 40% cuts in **GHG emissions** compared to 1990 levels;
- At least 32% share for **renewable energy;**
- At least 32.5% improvement in **energy efficiency.**

A core objective of the European Green Deal is to generate a climate-neutral EU by 2050, and the GHG emission target is a necessary step towards this goal. Increasing efforts towards this end are represented by the upward review of the renewable energy target in 2018 (from 27%), and by upward revision clauses for 2023 for both the renewable energy target and the energy efficiency target.

In the wake of the COVID-19 crisis, the efforts of the EU towards a greener, sustainable, economic model has intensified. As reported in European Parliamentary Research Service (2020a), at a time when private-sector investment in climate-friendly technologies is likely to be reduced due to economic hardship, the publicly funded recovery packages represent an opportunity to kick-start the European Green Deal and advance the transition towards a greener economy. The policies

[14] See IPCC (2018).

implemented to fight the coronavirus outbreak led to high costs and financial stresses for companies and citizens. However, on the environmental side, CO_2 emissions dropped substantially (by up to 17%) worldwide. Most of the reduction in CO_2 emissions can be explained by the lower social and economic activity, but also adaptation strategies and behavioural shifts have played an important role. The flexibility allowed by this moment of change offers an opportunity to induce a long-lasting modernization of working practices and reduce the impact on traffic-related CO_2 emissions. More so, the pandemic has demonstrated the importance of international cooperation, a renewed awareness that might be exploited in the environmental setting to foster the development of low-carbon and clean energy technologies, adaptation practices and joint responses to risks.

5.1.1. The EU ETS

The EU ETS is the largest multi-country, multi-sector GHG emissions trading system in the world. It was the first of its kind and covers more than 11,000 heavy energy-using installations and the aviation industry in 30 countries (about 45% of total EU GHG emissions). The system sets a cap on the total amount of GHG that can be emitted by the regulated companies. The cap is split in individual European Union emission Allowances (EUAs), which give the right to the holder to emit GHG equivalent to a ton of CO_2.

Each year installation/operators under the EU ETS must surrender allowances to cover for their reported emissions.[15] The EU ETS Registry keeps track of EUAs holders and ensures an effective enforcement of the regulation by identifying and imposing heavy fines on non-compliers.

Allowances can be obtained either through free allocation, auctions or on the secondary market.[16] The carbon price is determined through the auction/market of EUAs and arises at the equilibrium between the demand of EUAs from companies and the supply, as determined by the cap. The market for EUAs, by allowing the free trade of allowances and identifying a carbon price, ensures that effort to reduce emissions is undertaken at the lowest possible cost, and incentivizes investment in low-carbon technologies. Evidence from the US SO_2 cap-and-trade system (see the discussion in Chapter 8) shows that this market-based policy instrument, when correctly implemented, reduces policy costs from 15% to 90% compared to traditional command-and-control programs such as production taxes or emissions fees (Carlson et al., 2000; Ellerman et al., 2000, Keohane, 2006, Schmalensee and Stavins, 2017, 2019).

The EU ETS has gone through different phases. Phase 1 (2005-2007) acted as a trial stage to set up the monitoring, reporting, verification, and market infrastructure of the EU ETS, ensuring its functionality by the start of phase 2 (2008-2012), which coincides with the first commitment period of the Kyoto protocol. Progressively stringent and improved emissions' regulation has been implemented over time, with phase 3 spanning 2013 to 2020 (second Kyoto protocol commitment period) and phase 4 ranging from 2021 to 2030.

5.1.2. Phase 1 (2005-2007)

In phase 1, the EU ETS regulated the CO_2 emissions of the most emissions-intensive industries of the EU-27 countries.[17] The cap set by the EU ETS is a hard constraint ensuring the reduction of total

[15] Limited (qualitatively and quantitatively) amounts of international credits, ERUs and CERs, established by the mechanisms of Joint Implementation and Clean Development Mechanism can also be used to this end.

[16] Allowances not surrendered by a company can be used in the future or be sold on the market.

[17] Power stations and other combustion plants ≥20MW, oil refineries, coke ovens, iron and steel plants, cement clinker, glass, lime, bricks, ceramics, pulp, paper and board.

emissions and it was set to 2.058 Gton of CO_2. EUAs distribution in this pilot phase was almost completely done by means of free allocation (≈98% of the total).

5.1.3. Phase 2 (2008-2012)

In phase 2, the EU ETS expanded to Norway, Iceland and Liechtenstein and aviation was added to the sectors regulated.[18] The cap set for CO2 emission was lowered to 1.859 Gton of CO_2 and MS could opt in for the regulation of some emissions of N_2O and PFC. Even in phase 2, the main channel of EUAs distribution remained free allocation (≈96% of the total). When a company is allocated EUAs freely, it is not burdened with the cost of complying with the regulations but it might still have an incentive to curb emissions so as to profit from selling the EUAs at the carbon market price.[19] However, with free allocation, lower capital is needed to comply with the EU ETS in terms of EUAs purchasing or emissions abatement investments. Hence, the urgency to reduce emissions is lessened, especially if the future evolution of the regulation is uncertain. Finally, free allocation might result in windfall profits to companies able to pass through the cost of allowances to their customers (due to limited competition in the market they operate). Evidence from phase 1 and phase 2 shows that this indeed occurred with companies in the energy industry (Lise et al., 2010; Joltreau and Sommerfeld, 2019).

5.1.4. Phase 3 (20013-2020)

In phase 3, Croatia joined the EU ETS and the sectors covered expanded to further industrial ones.[20] The cap on CO_2 emissions was set at 2084 Gton for 2013 and will diminish each year by 1.74% until the beginning of phase 4, when the decreasing step will be set to 2.2%/year. The regulation is also extended to N_2O emissions from all nitric, adipic and glyoxylic acid production and PFC emissions from aluminium production.

In this phase, reflecting the above-mentioned drawbacks, the proportion of freely allocated EUAs was reduced to 43%. This result was achieved by imposing 100% auctioning for power generation installations and by setting a progressively higher target of auctioning for industrial installations, increasing from 20% in 2013 to 70% in 2020 (the target for 2030 is 100%). The main purpose of free allocation in phase 3 is to prevent the relocation of emission-intensive internationally-competing industries towards countries with laxer environmental regulation, causing loss in jobs and market shares, and potentially offsetting improvements in EU’s emissions via carbon leakage. Targeted free allocation allows the support of investment in emissions reductions and energy efficiency technology while pursuing emissions reduction objectives.

As a part of the increased effort against climate change, the determination of the quantities of freely allocated EUAs was also improved in phase 3, moving from being based on historical emissions (“grandfathering”), to using benchmarks based on the release of GHG by the best performers for a given production process. As a result, for firms subject to free allocation, the least polluting companies have their EUAs needs entirely covered by free allocation, while heavily polluting companies need to

[18] The cap on aviation emissions is separate from the one of the other sectors and for phase 3 it has been set at a constant level equivalent to 95% of the historical aviation emissions. From 2021 onwards the linear reduction factor of 2.2% that applies to stationary installations will also apply to the aviation cap.

[19] While the Coase theorem (Coase 1960) showed that in theory the initial allocation of permits, while having distributional impacts, should not be expected to influence the incentives, its strong assumptions are seldom met. For example, in presence of taxes (Goulder et al. 1999).

[20] Aluminium, petrochemicals, ammonia, nitric, adipic and glyoxylic acid production, CO2 capture, transport in pipelines and geological storage of CO2.

purchase EUAs for their extra emissions and are therefore incentivised to improve their environmental performances.

A well-functioning EUAs market is pivotal for the effectiveness of the EU ETS. However, since 2009, the EUAs market has been characterized by a temporary oversupply, reaching a 2 billion surplus by the start of 2013, largely due to the economic crisis of 2008, unexpectedly high imports of international carbon credits and, to some degree, the significant increase in the use of renewables. The large surplus led to low carbon prices in the period 2012-2017, lessening the incentive to reduce emissions. It has been argued (Martin et al. 2016; Joltreau and Sommerfeld, 2019) that the proper functioning of the carbon market was hindered during phase 2 and the initial part of phase 3 by the free allocation of allowances and the considerable over-allocation (Joltreau and Sommerfeld, 2019; Klemetsen et al., 2020). The EU Commission short-term response to postpone the auction of some allowances ("back loading") effectively reduced the surplus to 1.78 billion by 2015. The long-term response was the implementation of the Market Stability Reserve (MSR) that began operating in 2019. Working on pre-defined rules, the MSR adjusts the supply of allowances based on circulating EUAs. Carratù et al. (2020) show that, while in phases 1 and 2 most of the sectors display an over-allocation of allowances, this problem was reduced in the period 2013–2016. Using our data, we confirm this dynamic up to 2018 (see the next section).

The purpose of this chapter is three-fold. First, we investigate the impact of the EU ETS on performance and on CO_2 emissions across countries and sectors. Specifically, given the significant regulatory changes occurring between phase 2 and phase 3, we provide a *causal* estimation of the impact of the regulatory changes in 2013 on emissions and performance. As this change affected both the intensity of the regulation (the sectors covered by the ETS systems) and the share of EUAs that companies need to buy on the markets, we provide different estimates for the effects of the two regulatory changes. We emphasize that for phase 3, to the best of our knowledge, we are the first to perform this analysis. Combining our results with those of the previous empirical literature on phase 1 and 2 we can also provide a rough estimation of the overall effect of the EU ETS system on the EU economy since its implementation. Second, we perform our benchmarking analysis using DEA methodology across MS and sectors, focusing in particular on Transportation, Energy and Manufacturing. Given the specificity of the field analysed in this chapter, we postulate a production function where in each sector inputs (capital, labour and energy) are used to produce two outputs, a "good" one (GDP) and a "bad" one (pollution). We derive the efficiency frontiers across countries and sectors and study the dynamic of efficiency across different periods. Finally, given the current debate on using EU ETS as a source of revenues for the EU budget, we compute the revenues that could have been obtained at the current allocation prices and study its potential for the future.

The rest of the chapter is organized as follows: in Section 5.2 we present the dataset that we collected for this analysis; in Section 5.3 we study the impact of the EU ETS on emissions and performance; in Section 5.4 we perform our benchmarking analysis; in Section 5.5 we study the potential use of the EU ETS as a source of revenues. Finally, we draw our conclusions in Section 5.6.

5.2. The Data

We consider yearly data with the unit of observation consisting of the sector of a given country. Analysing each sector separately allows us to account for the peculiarities (market, technology, etc.) characterizing each sector regulated under the EU ETS. We consider six different sectors according to the NACE classification (see the Section 5.3 for details). Given the relevant changes undergone by the EU ETS, the use of yearly data (from 2008 to 2018, phases 2-3) allows us to investigate the evolution of the effects of the policy through time. The production function we postulate is a standard production function in which capital, labour and energy are used to produce an output, which is however characterized by a negative externality (pollution).

In more detail, to analyse the performance of each sector we **use five variables, three inputs: capital (fixed asset at current replacement cost in 2015 PPP €), labour (thousand hours worked) and energy (in tera joule)**– and **two outputs** – the **desirable GDP (in 2015 PPP €) and the undesirable CO_2 emissions (in thousand tonnes).** All data comes from the Eurostat database. For capital, labour and emissions, we use the original data to perform the analysis. The energy data (from energy balances dataset) was imputed to sectors in accordance with the Energy Balance Guide (Eurostat 2019), the Manual for Air Emissions Accounts (Eurostat 2015) and the Validation rules for Air Emissions Accounts (Eurostat 2020).[21] Eurostat national accounts do not directly report GDP at the sector level; therefore we computed it by first identifying taxes and subsidies and then subtracting them from the sectoral gross value added. The representativeness of our dataset is high, with only 1.4% missing values, and we obtain a balanced panel by imputing the closest observation from the past.

We further extend our dataset with data on verified emissions, surrendered EUAs and freely allocated EUAs from the Union Registry database. To match the Union Registry data, that is reporting information at the installation level, with the sector of activity that we are using in the analysis, we use the proceedings of the stakeholder meeting on the results of the preliminary carbon leakage list for phase 4 of the EU Emissions Trading System (European Commission 2018). Using this imputation method, the resulting dataset covers 88% to 94% of emissions in the period 2008-2018 (91% on average). Data on the EUAs market spot price comes from the International Carbon Action Partnership (ICAP) database.

5.3. Impact of EU ETS on Emissions

In this section, we investigate the effectiveness of the EU ETS regulation in attaining its main goal, namely to reduce CO_2 emissions. Several studies discuss this issue, focusing on phase 1 and phase 2 (see Table 5.1 for a summary of results).

Ellerman and Buchner (2008) and Anderson and Di Maria (2011) shows a 3% reduction in emissions in phase 1 while Abrell et al. (2011) finds that the growth rate of emissions was 3.6% higher in 2005/06 vs. 2007/08. Egenhofer et al. (2011), using macro-data at country level shows a modest 1% CO_2 reduction for each year in 2006-2008 and of 5% in 2009. Petrick and Wagner (2014), using German data, finds that regulated manufacturing plants reduced emissions by 18% more than non-regulated firms in phase 1 and by 20% in the first years of phase 2. A similar study undertaken by Wagner et al. (2014) on French manufacturing plants identifies a reduction of emission intensity (emissions/gdp) of 8–12% in the first three years of phase 2 but not before. Bel and Joseph (2015), using data at the country level for 2005-2012, argue that emissions reduction in the first two phases was mainly due to the impact of the economic crisis. Focusing on a panel of 5,000 Lithuanian firms in 2003-2010, Jaraite and Di Maria (2016) finds that ETS participation did not lead to a reduction in CO_2 emissions and only induced slight decreases in emission intensity for the year 2007. Dechezleprêtre et al. (2018), using firm level data in France, Netherlands, Norway and UK finds a statistically non-significant emission reduction of 6% in phase 1 but a significant reduction of 15% in phase 2. Similarly, the study by

[21] As a robustness check we also developed a less-conservative specification of energy data by following the International Recommendations for Energy Statistics (United Nations Statistical Commission 2018) to impute residual items. The results of the analysis are not significantly affected by the imputation method and are available upon request.

Klemetsen et al. (2020) on Norwegian manufacturing installations reports a statistically significant 30% reduction of emissions in phase 2 but insignificant effects in phase 1.[22]

Table 5.1: Impact of EU ETS on CO_2 emissions - Evidence from the Literature

Study	Geo	Sample	Method	Impact of EU ETS on CO_2 emissions
Ellerman and Buchner (2008) *Environ Resource Econ*	24 EU countries	Analysis at country level	Difference between Business as Usual (BAU) estimate and observed emissions. BAU computed as historical emissions corrected by GDP growth and emissions intensity dynamics	CO2 emissions were about 3% (60 $MtCO_2$) lower than the allocated allowances of 2005-2006
Anderson and Di Maria (2011) *Environ Resource Econ*	EU-25	Analysis at country level (some sectorial heterogeneity considered)	Difference between BAU and observed emissions. BAU computed using flow adjustment model (dynamic panel) forecast of emissions accounting for lagged emissions, sector, energy prices and weather	2.8% net CO_2 emissions abatement in 2005-2007, 84.2 (2005), 61.7 (2006) and 27.6 (2007) $MtCO_2$
Abrell et al. (2011) *Bruegel WP*	18 EU regions or countries	2101 firms (3608 installations), ≈59% of total verified emissions	Diff-in-Diff regressing (third difference of) emissions over turnover and labour accounting for country and sector. Effect is captured by time dummies at the change in phase. The ETS impact on emissions from the first to the second phase is identified by time dummies	Reduction of growth rates of CO_2 emissions is 3.6 pct. points in 2005-2008
Egenhofer et al. (2011) *CEPS report*	EU-25	Analysis at country level	Difference between BAU and observed emissions. BAU computed as historical emissions corrected by GDP growth and emissions intensity dynamics	Reduction of CO_2 emissions is 1% 2006-2008 and 5% 2009
Petrick and Wagner (2014) *MIMEO*	Germany	400 regulated firms matched to 1600 unregulated firms	Semiparametric conditional Diff-in-diff using nearest-neighbour propensity score for matching. Propensity score is computed using a probit entailing sector and state dummies and accounting for levels and squares of: CO_2 emissions, gross output, export share of output, number of employees, and the average wage	Not statistically significant increase of CO_2 emissions in phase 1 and statistically significant ≈25% reduction in phase 2
Wagner et al. (2014) *Fifth World Congress of Environmental and Resources Economists*	France	287 regulated firms matched to 4302 unregulated ones	Semiparametric conditional Diff-in-diff using nearest-neighbour propensity score for matching. Propensity score is computed using probit entailing the carbon intensity in the announcement year of the EU ETS (2000) while matching exactly on the 2-digit sector	No reduction of CO_2 emissions in phase 1, 13.5-19.8% reduction in phase 2
Bel and Joseph (2015) *Energy Economics*	EU-25	Analysis at sector-by-country level	Difference between BAU and observed emissions. BAU computed using flow adjustment model (dynamic panel) forecast of consumption and prices of emissions accounting for lagged emissions, sector, energy prices, weather, GDP growth, crisis (2008), differences between ETS and non ETS firms	Reduction in CO_2 emission from ETS is 33.78 - 40.76 $MtCO_2$ (≈12%) of 294.5 $MtCO_2$ total reduction in 2005-2012

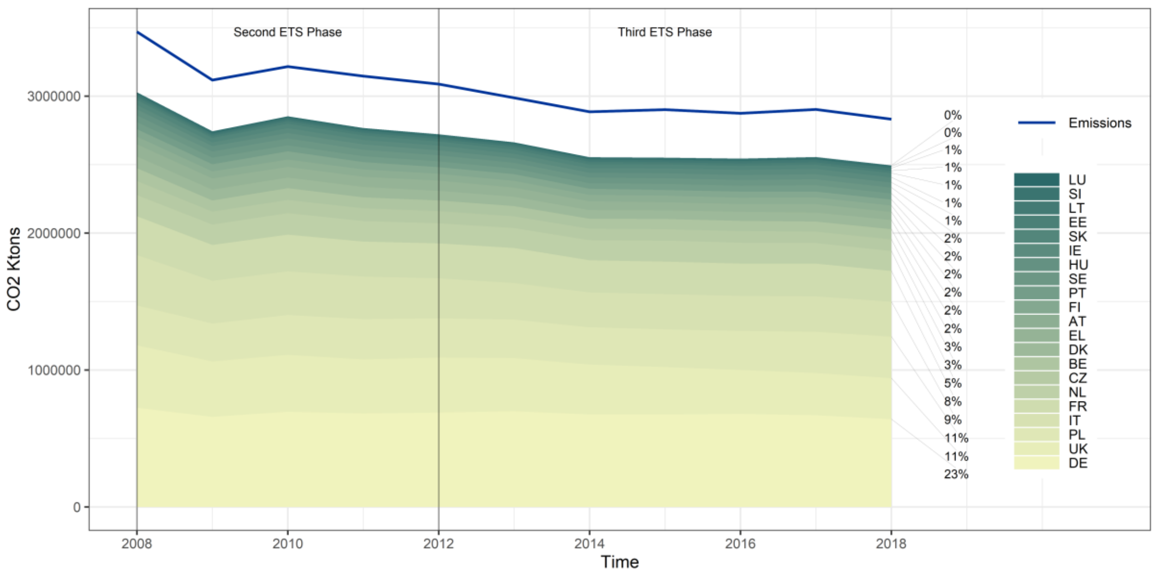
[22] Albeit not always significant in the robustness checks.

Jaraite and Di Maria (2016) *The Energy Journal*	Lithuania	205 regulated firms matched to ≈2800 unregulated firms	Semiparametric conditional Diff-in-diff using nearest-neighbour propensity score for matching. Propensity score is computed using probit entailing the amount of fossil-fuel-based energy used, the stock of tangible capital, turnover, and a sectoral dummy for NACE 40 industry	No reduction of CO_2 emissions in phases 1-2, slight decrease of emissions intensity in 2007
Dechezleprêtre et al. (2018) *OECD WP*	France, Netherlands, Norway and UK	240 regulated installations matched to ≈ 1200 unregulated ones	Conditional Diff-in-diff using nearest-neighbour propensity score for (full) matching. Propensity score is computed accounting for log of average pre-ETS emissions, emissions growth rate and, exactly, country and the 3-digit NACE sector	Statistically insignificant emissions reduction of 6% phase 1 and a significant 15% reduction in phase 2
Klemetsen et al. (2020) *Climate Change Economics*	Norway	152 regulated installations and 513 unregulated ones	Diff-in-diff using nearest-neighbour propensity score for matching and fixed effects specification. Propensity score is computed accounting for predetermined levels of emissions (as proxy for capacity limit) and number of employees while exact match is performed on type of pollutant and on plants' type of activity (2-digit level)	Negative but not statistically significant effect in phase 1 and 2013. Statistically significant 30% reduction of emissions in phase 2

Source: Own elaboration based on the scientific literature.

The effects of Phase 3 of the EU ETS have not yet been considered in the literature (except for the year 2013 in Klemetsen 2020). To fill this gap, in this section we provide what is, to our knowledge, the **first assessment of the impact of the increased stringency of phase 3 relative to phase 2 of the EU ETS regulation on CO_2 emissions**. As outlined in the introduction, there are several reasons to believe phase 3 was more effective in curbing emissions, chiefly due to the more stringent cap enforced, but also as a result of other aspects of the tighter regulation it implements, such as the reduction in freely allocated EUAs and the switching from grandfathering to a benchmark-based quantification of the freely allocated EUAs.

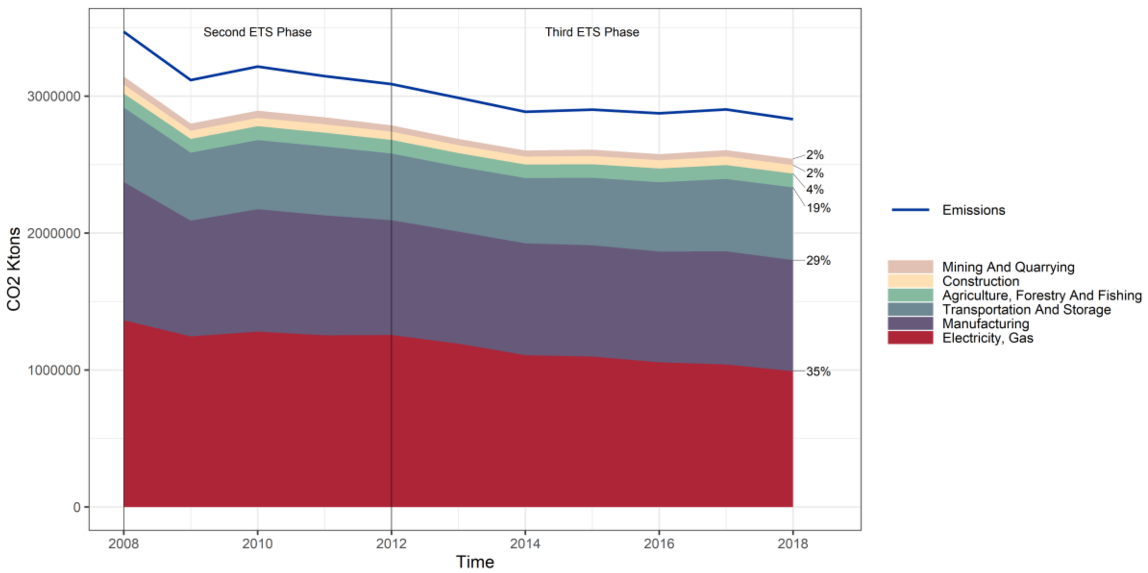
Figure 5.1: Emissions by Country



Source: Own elaboration based on Eurostat data.

We start our discussion by illustrating how representative is our sample, in terms of countries and sectors covered. Figure 5.1 reports the evolution of CO_2 emissions by country during the period 2008-2019. The blue line represents the total emissions from EU-27. Notice that our sample does not include (in order of CO_2 contributions) Spain, Romania, Bulgaria, Latvia, Cyprus and Malta, due to data availability issues.[23] Total emissions follow a downward trend for the whole period considered. The distribution of emissions displays some degree of concentration among countries, showing that Germany, UK, Poland, Italy, France, Netherlands, and Belgium, account for 70% of emissions in 2019.

Figure 5.2: Emissions by Sector



Source: Own elaboration based on Eurostat data.

Figure 5.2 illustrates the contribution of each sector in our sample to the total emissions and highlights a marked sectoral concentration. The most polluting industry is Energy, accounting for 35% of emissions, followed by Manufacturing (29%), Transportation (19%), Agriculture, Forestry and Fishing (4%), and Construction and Mining contributing 2% each.

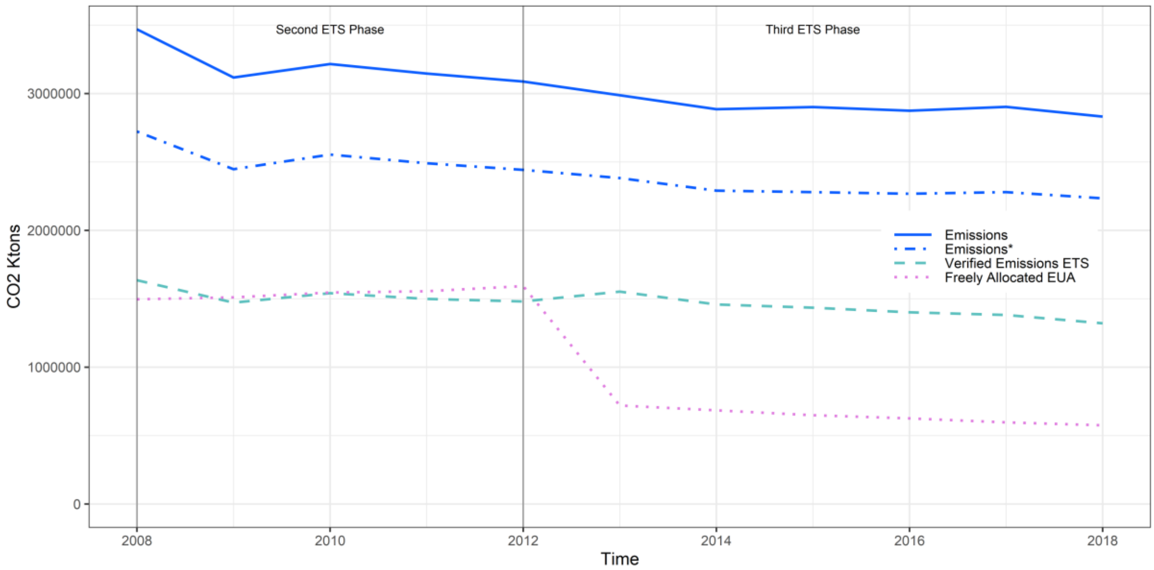
Despite dropping some countries due to a lack of data, our sample obtains good coverage, equal to 79% of total emissions. More importantly, as shown in Figures 5.1 and 5.2, the evolution of our sample closely resembles that of total emissions so we can be reasonably confident that our analysis is considering an undistorted representation of the real dynamics.

To properly address the possible impact of EU ETS on CO_2 emissions, it is crucial to identify to what extent the emissions dynamics has been driven by the change in regulation and/or is a result of changes in the economic environment. Ideally, we would like to estimate the difference between observed emissions as compared to the (counterfactual) emissions that would have been observed whether the EU ETS stayed the same between phase 2 and phase 3. While this counterfactual is obviously unobservable, in the econometric literature several techniques have been developed to this end.

[23] See the Annex for a complete break-down of the CO2 emissions contribution by country and by sector.

The first technique that we will use is an event study,[24] a method that allows the investigation of how a policy change has affected a variable of interest. In our setting, the variable of interest is CO_2 emissions while the policy change is the implementation of phase 3, which occurred at the end of 2012. To identify if the policy change has had an impact on the effectiveness of the regulation, we exploit the differences in how intensely sectors have been subject to the EU ETS. Intuitively, the emissions of two sectors that are regulated by the EU ETS to a different extent will respond differently to the shifting regulation and we can use this difference for the identification of the switching impact on emissions. Using Eurostat and Union Registry data, we develop *two measures* of how strong are the incentives that the ETU ETS regulation is imposing on companies.

Figure 5.3: Verified Emissions and Freely Allocated EUAs



Source: Own elaboration based on Eurostat and Union Registry data.

The first, that we call **EU ETS intensity**, is the share of emissions regulated under the EU ETS relative to the total emissions of that sector. The idea is that the larger the share of emissions covered by EU ETS, the stronger the response to the regulation incentives. The best measure to quantify the share of emissions that are regulated under the EU ETS would be the surrendered EUAs, because verified emissions might be affected by non-compliance. Unfortunately, the Union Registry only reports the cumulated surrendered allowances for phase 2. However, compliance under the EU ETS is almost perfect. The share of the verified emissions under EU ETS that are met by surrendered EUAs is between 98.9% and 99.5% in 2013-2018 and >99.9% for the cumulative period 2008-2012. Given that data on verified emissions are available for the whole period 2008-2018, in the analysis we then use verified emissions to compute the measure of EU ETS Intensity.

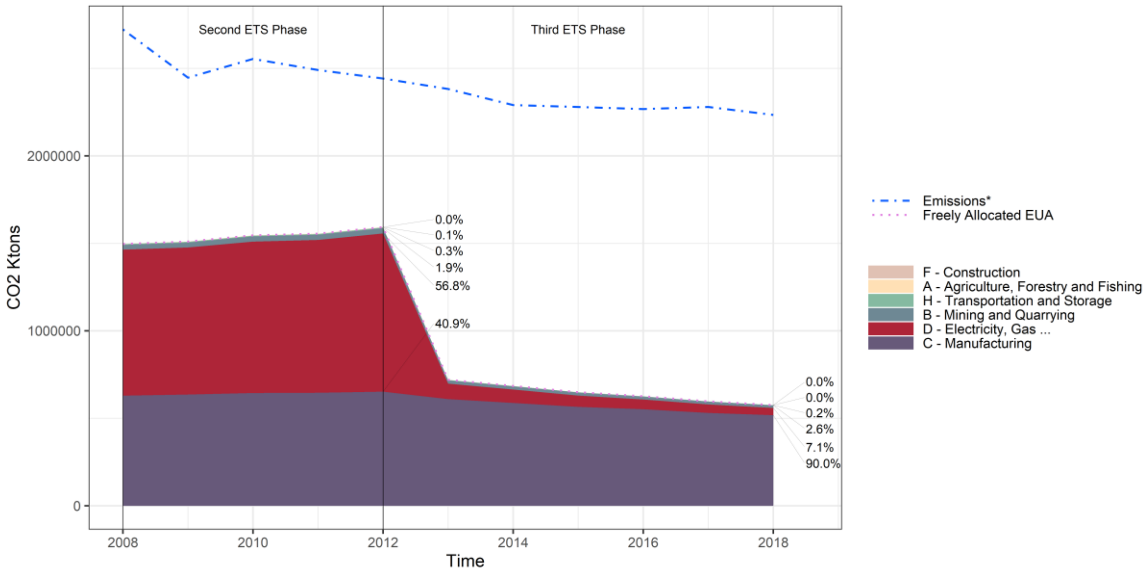
However, a more relevant measure of the incentives induced by the EU ETS on regulated companies might be represented by the amount of EUAs that they have to purchase, since as we discussed above, the part of their emissions that are matched by freely allocated allowances would provide companies with only minor incentives to change their behaviour.[25] Following this line of thought, we define a

[24] See the Annex for technical details.

[25] The idea of exploiting the variation between emissions and freely allocated EUAs is not new in the literature, see i.e., Anger and Oberndorfer (2008), Abrell et al. (2011), Carratù et al. (2020).

second measure, **the purchased EUAs intensity**, which is the difference between the verified emissions and the freely allocated emission divided by the total emission of the sector. In some instances, especially in phase 2, freely allocated emissions are larger than the verified emissions resulting in negative purchased EUAs intensity. In such cases, we set at zero the value of the variable.

Figure 5.4: Freely Allocated EUAs by Sector



Source: Own elaboration based on Eurostat and Union Registry data.

Before proceeding with the event study, we present some descriptive evidence. Figure 5.3 reports the main variables from the Union Registry used in the analysis. The solid blue line and the blue dashed-dot line denote, respectively, total emissions and the emissions of the sectors/countries in our sample (emissions*), the green dashed line represents the verified emissions, and the freely allocated EUAs are in dotted pink. While a slight and smooth downward trend can be observed for total emissions, emissions* and the verified emissions, the freely allocated EUAs has a sharp decline in 2013. Figure 5.4 illustrates the sector composition of the freely allocated EUAs, showing that the drop of 2013 is driven by the huge decrease in the amount of freely allocated EUAs assigned to the energy sector that took place between phase 2 and phase 3.[26] In 2018, 90% of freely allocated allowances were attributed to the manufacturing sector, 7.1% to the energy sector and 2.5% to mining and quarrying industry.[27] The sectoral composition of the verified emissions closely resembles that of the freely allocated emissions in 2012, with about 57% belonging to the energy sector, about 41% to the manufacturing sector and about 2% to the mining and quarrying sector.

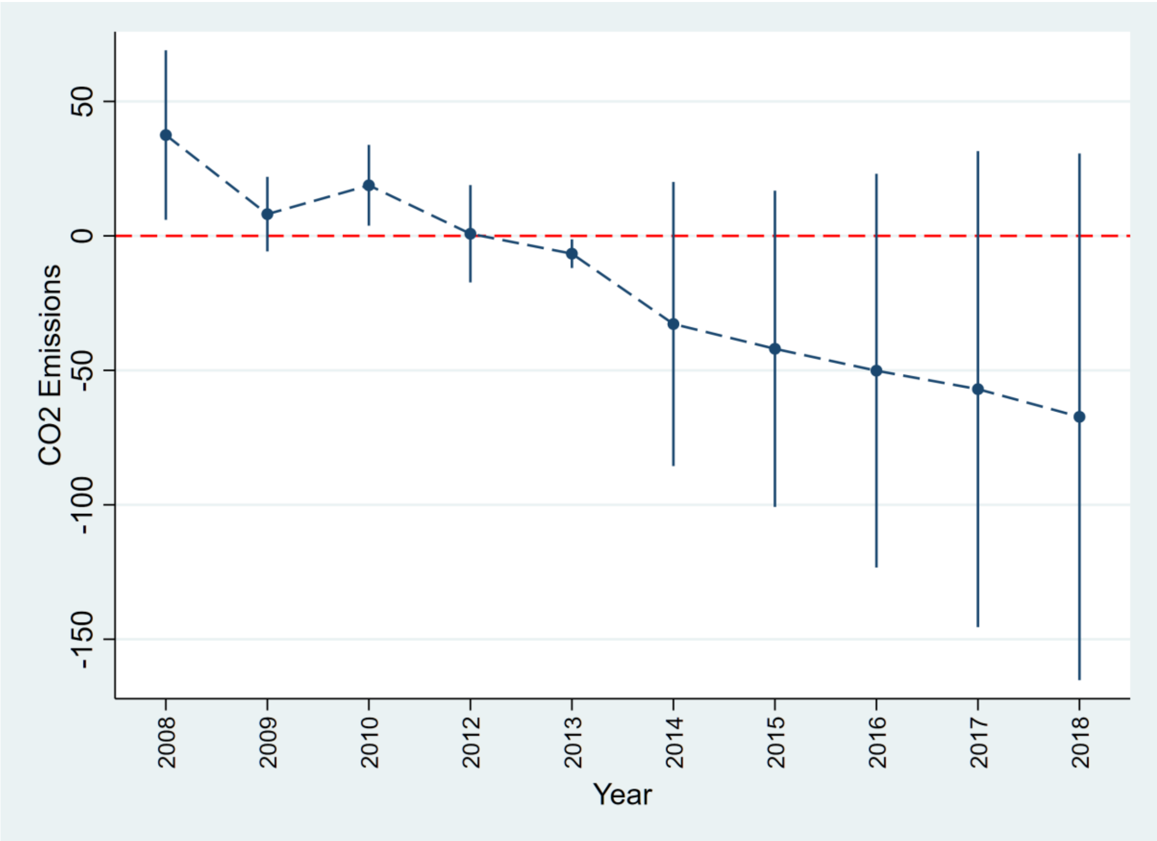
The strategy used in the event study to identify the impact of the change in regulation consists of a panel (multi-year) regression of sector-by-country total emissions in our sample (emissions*) over a measure of the treatment (the EU ETS intensity or the purchased EUAs intensity) while controlling for other variables that might affect emissions.

[26] Country breakdown of freely allocated EUAs along with the sector and country breakdown of verified emissions can be found in the Annex.

[27] Mainly used to support innovation projects.

Given that the treatment in different years might in principle be endogenous (i.e., being determined by the regulators based on the results of previous years), we fix the treatment variable for each year as the one of 2008. Notice that due to the reduction in the freely allocated allowances taking place between phase 2 and phase 3, the *purchased EUAs allowance* measure increases through time. Hence, using the value in 2008 as a treatment likely underestimates the impact of regulation. Our results should then be considered as a lower bound for the actual effect. However, using the 2008 value entails an implicit assumption of proportional treatment across years. While this assumption is reasonably met for the EU ETS intensity, it becomes more questionable in the case of the purchased EUAs intensity given the drop in freely allocated allowances occurred in phase 3. Further research is needed to tackle this issue. Given the underlying solid economic rationale, the insights provided by this investigation are however relevant, although exploratory.

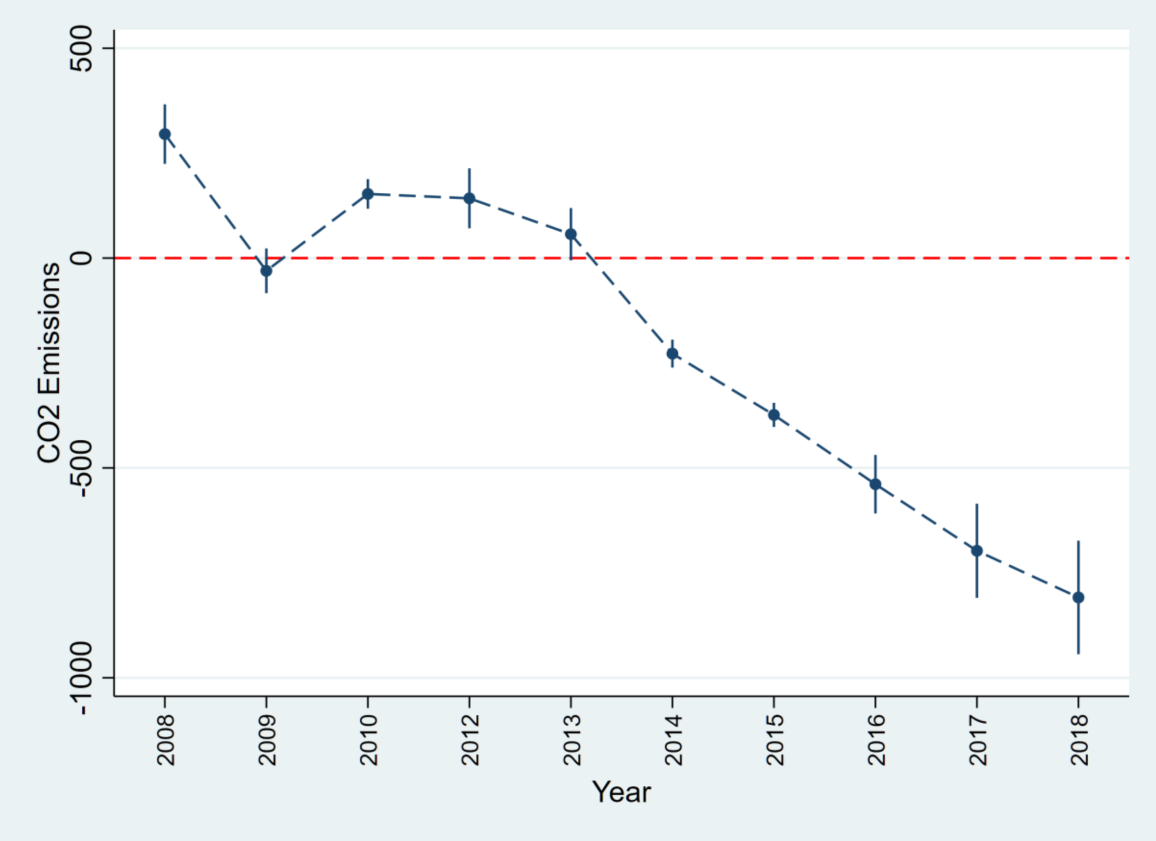
Figure 5.5: Event Study – EU ETS Intensity



Source: Own elaboration based on Eurostat and Union Registry data.

Many other factors might impact on emissions, e.g., the changing economic conditions might have induced some companies to alter their emissions behaviour for reasons unrelated to the EU ETS. We consider the effect of these confounding variables by controlling for capital, energy, labour, GDP plus a set of indicators at the year level that allows us to account for temporal shocks (e.g., the 2008 economic crisis). The fixed-effects panel approach used in the analysis also removes from the estimates any effect stemming from differences occurring at the sector-by-country level, such as regulation, social capital, etc.[28] The result is a set of coefficients, one for each year, where coefficients of a given year estimate the impact of the treatment on emissions. In our analysis, 2011 is taken as our baseline so its coefficient is equal to zero and a coefficient below zero means that in that year the reduction in emissions associated with the treatment has been higher than in 2011 (and vice-versa).

Figure 5.6: Event Study – Purchased EUAs Intensity



Source: Own elaboration based on Eurostat and Union Registry data.

In Figure 5.5 we present the results of the analysis comparing emissions dynamics for countries and sectors characterized by their different degrees of *ETS intensity*.[29] We observe that the results provide only weak evidence of an effect of EU ETS on emissions. Point estimates until 2012 are all positive or close to zero, while the ones after 2012 are all negative. Such evidence could be interpreted as a sign of the increased effectiveness of the more stringent regulation of phase 3. However, the figure also shows that all the estimates after 2012 (except for 2013) are not statistically different from zero at the 95% confidence level, with increasing imprecision in the point estimates (testified by larger standard errors). As argued above, this might arise from using a treatment variable that is just a noisy proxy of the incentives provided by the regulation.

To investigate further this point, in Figure 5.6 we present the results of the event study using the *purchased EUAs intensity* as the treatment variable. In this case the confidence intervals are much

[28] Given this strengh of our methodology, we do not need to perform some of the robustness checks that are instead provided in the other empirical applications of this report (as for example where the analysis is performed on subsamples not including year 2008 to check for the potential impact of the economic crisis).

[29] The complete table of result and robustness checks for all the analysis in this section can be found in the Annex.

narrower, suggesting a tighter relationship between the treatment variable and the emissions. More so, almost all the coefficients before 2013 are now statistically higher than zero (at the 1% level) as opposed to the ones after 2013 that are all statistically lower than zero (at the 1% level). The point estimates after 2013 are also larger in magnitude, implying a sizable impact of purchased EUAs allowances on emissions. Notice that in both event studies a lag in response seems to be present, with a change in the emission behaviour starting just in 2013, one year after the implementation of phase 3. This might be an indication of the failure by companies to anticipate the evolution of regulation before its implementation, with a response taking place only after the consequences of the reform took place.

To quantify the impact of the tightening of the regulation between phase 2 and phase 3 on emissions, we adopt a difference-in-differences (Diff-in-Diff) empirical strategy.[30] This method involves a panel regression of emissions* over an indicator function equal to one from 2013 onward (treatment dummy) and a measure of the treatment (again using its 2008 value) from 2013 onwards (treatment intensity) plus the usual control variables. The main coefficient of interest in this method is the one of treatment intensity that measures the change in emissions stemming from a unitary increase of the treatment variable.

The treatment intensity coefficient is highly statistically significant (1% level) and its value implies that for a 1% increase in the purchased EUAs intensity of 2008, the average reduction in emissions (across the sector-by-country groups) for the period 2013-2018 stemming from the tighter regulation of phase 3 is about 540,000 tonnes.[31] This figure represents a lower bound of the real effect since it accounts for the reduction in emissions deriving from different levels of purchased EUAs intensity but does not include the baseline effect arising from the observations being under EU ETS regulation (an effect that is most definitely sizable).

The coefficient of the treatment intensity can be used to estimate the total amount of CO_2 reduction achieved during 2013-2018 across all sectors/countries (in the sample) as a result of the switch from phase 2 to phase 3**.** Using a 5% confidence interval, **the CO_2 reduction ranges between 1.41 and 1.70 $MtCO_2$ with a point estimate of -1.55 $MtCO_2$. The reduction is sizeable,** around -9.5% of the (2008) emissions we observe under EU ETS in our sample and **-5.7% of the total EU-27 emissions in 2008.** To provide an economic evaluation of the reduction in CO_2 emissions, we compute the average price of EUAs in the period 2013-2018, that is ≈€7.45, **suggesting an estimated value of ≈€1.15 billion** (with a lower and an upper bound of €1.05 billion and €1.27 billion). This is a conservative appraisal since it is just accounting for the differential impact of ETS intensity (excluding the baseline) and is also based on understated market prices (an extended discussion of the latter point is provided in Section 5.5).

Using our results and those from the previous literature we can also attempt a rough, back-of-the envelope quantification of the reduction of CO_2 induced by ETS. Following Ellerman and Buchner (2008), Abrell et al. (2011) and Anderson and Di Maria (2011) it seems plausible that phase 1 induced a 2-3% reduction in ETS emissions, equivalent to a net reduction of ≈150 $MtCO_2$. Using EUAs prices to evaluate the social value of this reduction, this amounts to about €3.5 billion (in 2015 terms) of benefits for the EU economy. For phase 2, the studies of Petrick and Wagner (2014), Wagner et al. (2014), Bel and Joseph (2015), Dechezleprêtre et al. (2018) and Klemetsen et al. (2020) find a reduction in the range of 10-30%, with lower levels when a bigger set of countries is considered. Given this evidence, it seems plausible to assume that, at the whole EU level, emissions have been reduced by at least 10% as a result of the EU ETS phase 2. This corresponds to a reduction in CO_2 emissions of

[30] See the Annex for details.

[31] The complete results for the Diff-in-Diff analysis can be found in the Annex.

around 1500 $MtCO_2$ for a value of €25.5 billion. To evaluate the impact of phase 3, we assume its baseline effect to be the same of phase 2 and increase it by our estimate that accounts for the tougher regulation of phase 3. The resulting figure for phase 3 emission reduction is around 1700 $MtCO_2$ for a value of €14 billion. Summing over the whole time frame in our study, **the total reduction on emission induced by the EU ETS from 2005 to 2018 is 3350 $MtCO_2$ for a value of €42.5 billion**.

This (rough) computation of the economic benefits of the EU ETS regulation implicitly assumes a counterfactual where in the absence of the EU ETS regulation no other environmental regulation would be implemented. Arguably, in order to compute the true "European value added" of the EU ETS one would like to compare the effect of the EU ETS with a counterfactual where instead national or local regulations were implemented. This is obviously impossible. However, to shed some light on this aspect, in Section 8 we compare the emissions dynamic in the EU with the one in the USA, where emission trade is performed in local markets and where US states programs are not coordinated at the federal level. **We find that the EU framework outperforms the US one and generates additional benefits that in the 2008-2017 period amount to €29.7 billion**. While the better performance of the EU might also be due to a variety of economic/industrial/social/etc. reasons, it seems plausible that the EU coordination has played an important role in determining this outcome by inducing a larger and thicker market for emissions that lowered administrative costs and fostered the internalization of cross-border environmental externalities.

To sum up, the empirical literature shows a limited emission reduction effect of EU ETS in phase 1 and more sizeable ones in phase 2 and 3. The analysis presented in this section provides weak evidence that higher levels of EU ETS intensity had an effect on emission reduction moving from phase 2 to phase 3. Conversely, we find that differences in the purchased EUAs intensity have sizeable and highly statistically significant impacts. **This suggests that incentives from the EU ETS are much stronger when companies need to purchase the allowances instead of having them freely allocated. This evidence sheds a favourable light on the progressive tightening of free allocation programmed for the upcoming phase 4**.

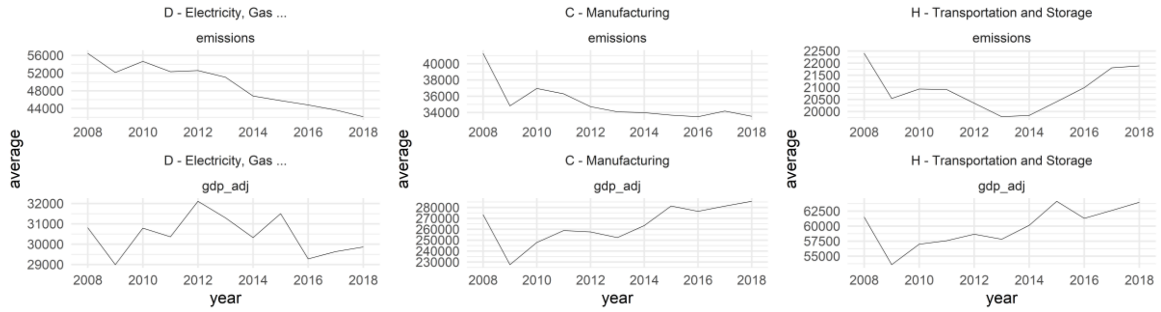
5.4. Benchmarking analysis

The evidence presented in Section 5.3 suggests that the EU ETS has been effective in reducing CO_2 emissions, particularly in the stricter phase 3. In this section we complement this evidence with a benchmarking analysis, using a DEA methodology (see Chapter 3) that accounts for both desirable (GDP) and undesirable outputs (CO_2 emissions). The main objective of this section is to investigate whether the EU ETS, besides leading to a reduction of emissions, also influenced efficiency in output provision.

Economic theory shows that environmental regulations could have an adverse effect on firm's productivity (Jaffe et al. 1995) by distorting investment (Rose 1983) or reducing operating flexibility (Joshi et al. 1997). A related concern, peculiar to the EU ETS and stemming from its non-global nature, is that emission-intensive companies in tight competition markets could relocate to jurisdictions with more lenient carbon regulation. However, the Porter hypothesis, (Porter 1991) argues that stiff environmental regulations could foster productivity by stimulating innovation and efficiency – see, among others, Ambec et al. (2013), Mazzuccato (2015), Wang et al. (2019), Martínez-Zarzoso et al.

(2019). In this section we will briefly review the results from empirical studies and then use our methodology to characterize the performance of different sectors during phases 2 and 3 of EU ETS.

Figure 5.7: Outputs of Energy, Manufacturing and Transports sectors



Source: Own elaboration based on Eurostat data.

In the empirical literature, Abrell et al. (2011) find a slightly negative but not statistically significant impact of EU ETS on the value added, profit margin and employment of 2000 European firms between 2005 and 2008. Jaraite and Maria (2011), using data on the power generating sector of 24 European countries in 1996–2007, shows that carbon pricing had a positive impact on technological change during phase 1. Chan et al. (2013) uses firm-level data to study the effect of ETS regulation on the three most polluting sectors, power, cement, and iron and steel. The study finds a positive effect on the material costs and revenues for the power sector in 2005–2009. Marin et al. (2018), finds that firms under the EU ETS have performance gains relative to ones not regulated, with positive effects on turnover, markup, investment intensity and labour productivity in phases 1 and 2. Carratù et al. (2020) finds no significant effects of participation in allowance auctions on the profitability indicators of ETS firms in phase 3 of the EU ETS, excluding that windfall profits are currently being obtained. Finally, Guo et al. (2020), exploiting the whole set of transactions of allowances in the first two phases shows that emission abatements and trading profits are generally positively correlated, pointing towards a positive effect of EU ETS on performance.

Overall, the results of the empirical literature do not seem to provide evidence of a significant negative impact of the EU ETS on competitiveness and profitability during phase 1 and phase 2. As already noted, however, the first two phases were characterized by more lenient regulation relative to phase 3; it is then of interest to provide evidence on its impact on performance. The analysis undertaken in this section represents, to our knowledge, the first evidence available of the impact of EU ETS phase 3 on performance.

As in the rest of this study (and, in the literature, to Jaraite and Maria, 2011), we are interested in an aggregate measure of efficiency, able to account for both the inputs used and the outputs produced. However, given the focus on the environment in this chapter, in this section we use a modified version of the DEA.[32] When considering processes entailing the production of both desirable outputs, such as goods, and undesirable outputs, such as pollutants, an efficiency/productivity measure that does not take into account the asymmetry between both types of outputs would result in biased assessments of performance. In our setting, we need to account for the fact that the outputs of a Decision Making Unit (in our case, a specific sector of a country) consist in both desirable ones, the GDP produced, and undesirable ones, CO_2 emissions. To incorporate this distinction between desirable and undesirable

[32] See Chapter 3 for details about the DEA methodology.

outputs, we use the concept of *directional efficiency* developed by Chambers et al. (1996) that, in its output orientation, states that an observation is inefficient when, for a given level of input, it is possible to increase desirable outputs and/or reduce undesirable ones (while an observation is efficient -on the frontier- otherwise). This concept of efficiency allows us to characterize the performance of each sector in each country relative to others at a given point in time. However, to understand whether phase 2 and phase 3 had different impact on performance, we also need to study the *dynamics of efficiency* through time, and we will do so by employing the Malmquist-Luenberger (ML) Index (Chung et al. 1997) that allows us to measure the growth of efficiency relative to a base year (2008 in our case).

Table 5.2: Cumulative productivity growth 2008-2018

Sector	Mean ML	Std. Dev ML	Mean MLTEC	Std. Dev MLTEC	Mean MLTC	Std. Dev MLTC
C - Manufacturing	1.112	0.172	0.821	0.124	1.374	0.229
D - Electricity, gas, steam and air conditioning supply	1.033	0.100	1.018	0.072	1.013	0.092
H - Transportation and Storage	1.026	0.106	0.995	0.101	1.031	0.048

Source: Own elaboration based on Eurostat data.

For each sector/country, the outcome of the benchmarking analysis evaluates the degree to which it would be possible to increase GDP and/or decrease emissions while keeping the inputs used in production fixed. For the sake of brevity, in the following, we will mainly focus on the energy, manufacturing and transportation sectors (cumulatively accounting for 63% of emissions, see Figure 5.2).[33]

Table 5.3: Waste rates - 2018

Sector	Mean Waste	Std. Dev Waste	Weighted Mean Waste
H - Transportation and Storage	0.253	0.363	0.077
D - Electricity, gas, steam and air conditioning supply	0.536	0.376	0.276
C - Manufacturing	0.599	0.222	0.472

Source: Own elaboration based on Eurostat data.

As a preliminary step, it is interesting to look at the average behaviour of outputs in isolation from the inputs, so to understand the overall sector dynamic. In the upper panel of Figure 5.7, CO_2 emissions are depicted while in the bottom panel GDP is reported. The leftmost graph shows that, in the energy sector, emissions underwent a marked downward trend while the GDP has mainly remained constant throughout the 2008-2018 period. The central panel refers to the manufacturing sector and shows an

[33] Results for the remaining sectors (Agriculture, forestry and fishing, Construction and Mining and Quarrying) can be found in the Annex.

even more pronounced decrease in emissions accompanied by a strong upward trend in GDP (after the fall due to the 2008 economic crisis). Finally, the rightmost panel reports information on the transport sector, showing a U-shaped dynamic for emissions and a GDP pattern analogous to the one observed in the manufacturing sector. Overall, the outputs dynamic seems to point into the direction of an improvement of efficiency during time.

To rigorously investigate the performance dynamic, we use the ML Index, that is equal to 1 in case of constant productivity, bigger than 1 in case of increasing productivity and smaller than 1 in case of decreasing productivity. Following Aparicio et al. (2013), it is possible to decompose productivity changes into efficiency change and technical change. The former corresponds to the catch-up effect (MLTEC); i.e., the change of the observation's technical efficiency between two periods. The latter corresponds to the frontier-shift effect (MLTC), i.e. the change of the reference frontier between the two periods. The interpretation of the MLTEC and MLTC is analogous to the one of the ML index (increase if >1 and decrease if <1).

In Table 5.2 we report the cumulative productivity growth that occurred in the three sectors considered in the period 2008-2018. Both a measure of the average and of the dispersion across countries is provided for ML, MLTEC and MTEC. While all the sectors have experienced an increase in productivity, a marked heterogeneity in its components can be observed. Manufacturing, the industry with the highest productivity growth, is characterized by negative performances in terms of catch-up effect and by a positive frontier-shifting effect. A similar but less pronounced pattern can be observed for the worst performer, the transportation sector, where a slightly negative catch-up is associated with positive frontier-shifting. Finally, the energy sector displays moderate improvements in both dimensions. Countries' performances were more heterogeneous in the manufacturing sector as reported by the relatively higher dispersion of its indexes. A very low heterogeneity can instead be observed in the frontier shifting of the transportation sector and, to a lesser extent, on the catching up effect within the Energy sector.

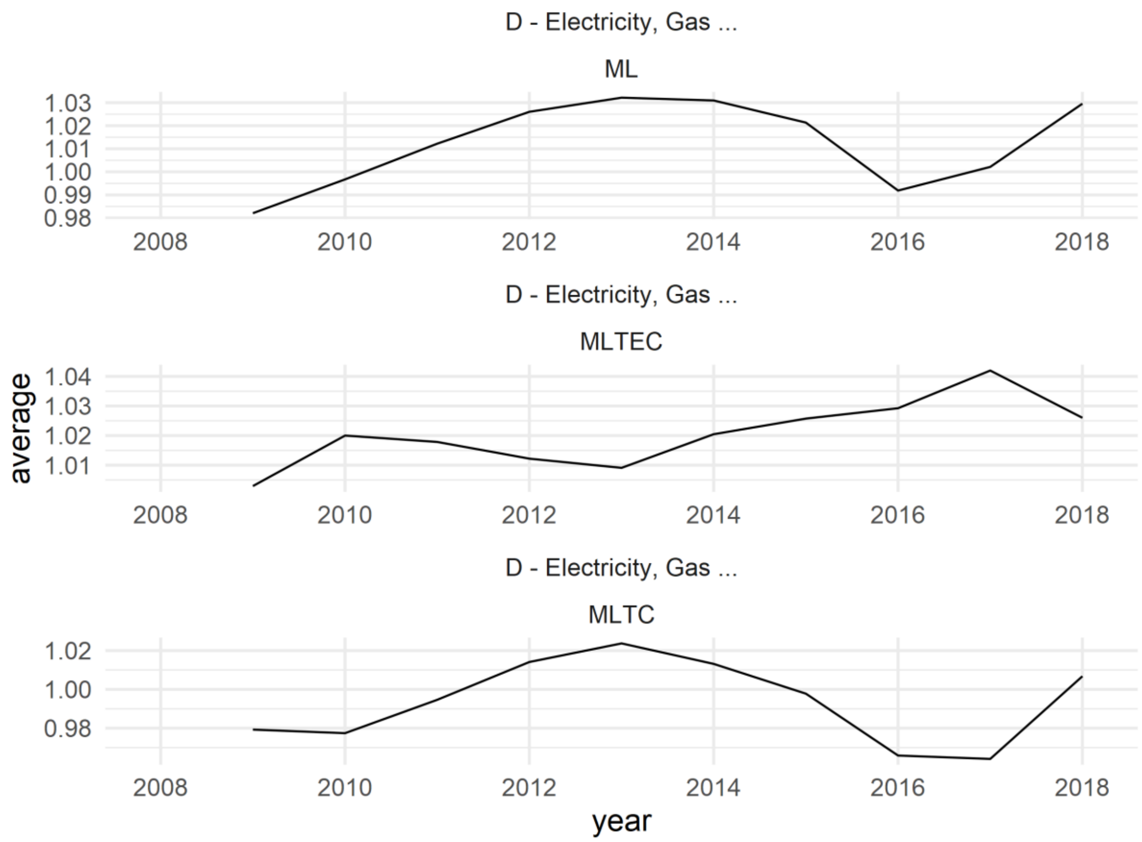
Some information on the current performances are reported in Table 5.3 that illustrates the average and dispersion of waste rates across countries for the last year in our sample (2018). The results show that the transportation sector is the more efficient one, with an average of just 25% improvement achievable (in terms of increase in desirable outputs or decrease in undesirable outputs) while Energy and Manufacturing have improvements above 50% achievable (54% and 60% respectively). The sector with the higher dispersion of mean waste rate is the energy one, closely followed by transport. Manufacturing displays instead a lower level of dispersion.

The measure of average waste we report, however, does not account for the relative importance that the different countries have to each sector. Given that our results show some degree of dispersion, this could lead to an overestimation of the impact of the least important countries and vice-versa. To address this potential issue, we also compute *the weighted average waste* weighting the (sector) waste rate of a given country for its (sector) share in the (sector) EU GDP. In Table 5.3 we show that the resulting weighted mean waste measures are significantly lower than the unweighted ones for each sector considered. For the transportation sector the measure of waste is reduced to a third of our previous estimate, from 25% to 8%, it halves for the energy sector, from 54% to 28% and is reduced by one fifth for the manufacturing sector, declining from 60% to 47%. This conveys a more favourable picture of performance and implies that countries accounting for a bigger share of a sector's GDP tend to be more efficient.[34]

[34] A detailed investigation of the dynamic of each country-level evolution of performance for each sector is reported in the Annex.

The ML Index also allows us to decompose long term productivity into changes taking place in sub-periods and we use this feature to closely investigate how the different phases of EU ETS affected this dynamic.

Figure 5.8: Productivity Growth - Energy

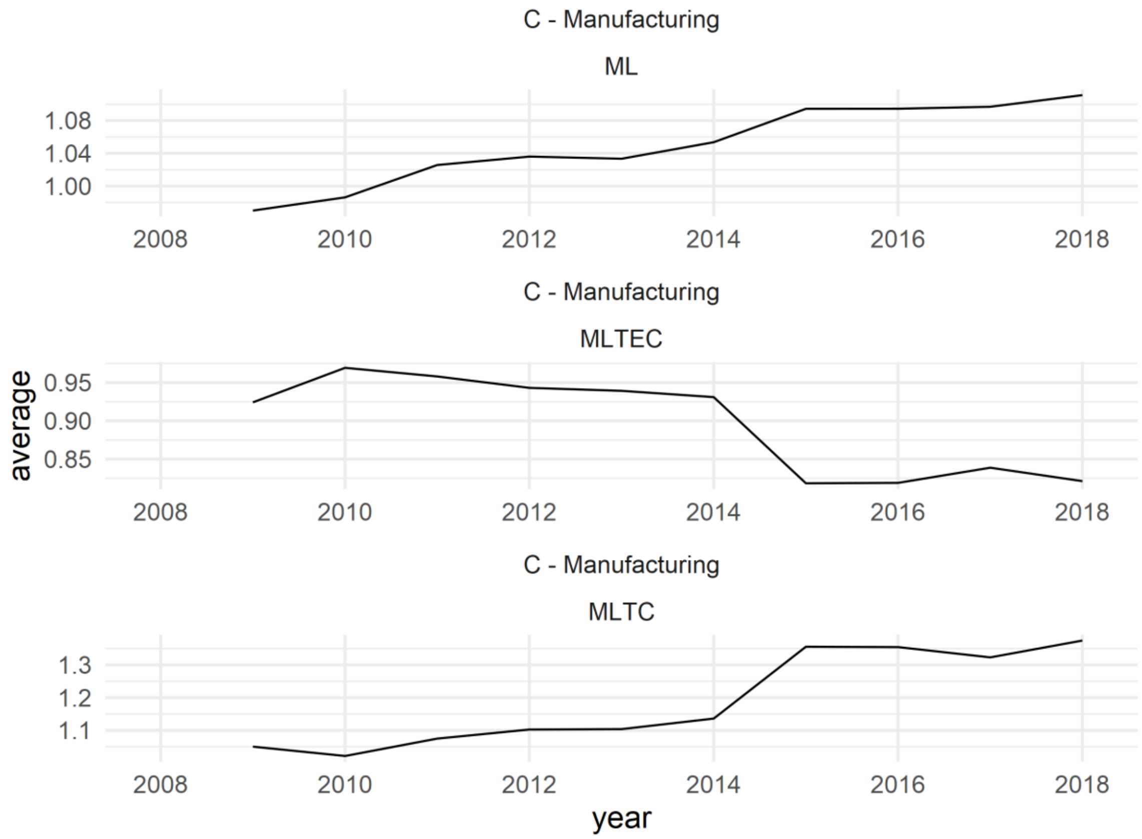


Source: Own elaboration based on Eurostat data.

Figure 5.8 illustrates the ML results for the Energy sector, averaged across countries, the top panel reports the overall ML index, the central panel is relative to the its catch-up component (MLTEC), while the bottom panel shows the frontier-shift component (MLTC). The ML displays an overall efficiency growth, more pronounced in 2010-2013 and less marked in 2015-2017. The inverse U-shaped ML dynamics are mainly driven by the frontier-shifting effect that entails a retreat of the frontier in 2015-2017. The MLTC behaviour is however more than offset by a moderate but steady catching-up effect that persists for the whole timespan.

Figure 5.9 shows the evolution of productivity for the Manufacturing sector. The picture it conveys is one of steady efficiency growth, mainly driven by frontier improvements (especially after 2014) but associated with a worsening in the catching-up that becomes marked after 2014. What the evidence suggests is that, in 2014, the best performers started to considerably improve their efficiency, while the countries at the back have been lagging increasingly farther from the frontier. This evidence implies an increase in the spread of the distribution of efficiency through time. A possible explanation is that the introduction of more stringent environmental regulation, by imposing more demanding requirements, benefitted the best performers that were more able than other countries to react positively to the challenge, but it had a detrimental effect on the least efficient. This is in line with the evidence provided by Guo et al., (2020) for phase 1 and 2. They argue that "…the participating firms' trading profits and their emission abatements are positively correlated…" and "… we observe that non-linearity exists in the correlation; higher firm-level emission abatements can realize larger trading profits".[35] In the presence of big differentials in the ability of firms to respond to regulation, important policy implications would follow on the need to adequately sustain the technological change for the least efficient firms.

Figure 5.9: Productivity Growth - Manufacturing



Source: Own elaboration based on Eurostat data.

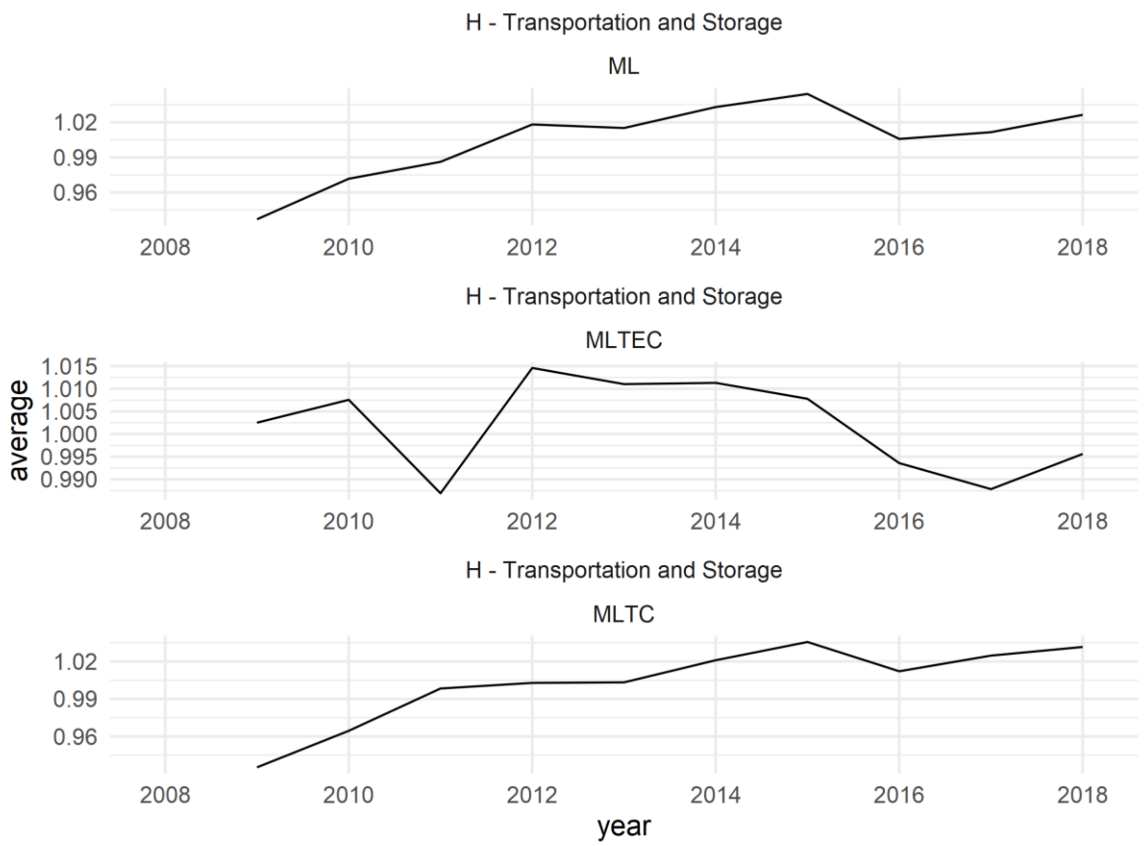
The evolution of the ML Index for the transport sector is depicted by Figure 5.10. The ML index follows an upward trend with efficiency improving since 2012 (when the index crosses the 1 threshold). Note that aviation, responsible for a sizable part of the emission of the transport industry, started being regulated under the EU ETS precisely in 2012, which suggests that regulation had no adverse effects on performances. The ML dynamics are mainly driven by frontier-shifting changes while the catching-up component hovers around one.

A related question is whether the EU ETS is effective in encouraging environmentally friendly innovation and the adoption of innovative technology to improve companies' environmental performance. This question assumes also an important role given that a considerable part of the

[35] Also known as the Matthew effect, i.e., the rates of return are positively correlated to profit levels.

revenues currently collected with the EU ETS system is used for promoting innovative technology to combat climate change and to encourage the adoption of environmentally friendly processes. A part of EUAs (€450 million) is not allocated to MS but managed by the European Investment Bank for the Innovation Fund (which replaced the previous New Entrant Reserve). The Innovation Fund focuses on highly innovative technologies and big flagship projects able to generate significant value added for Europe. To foster the adoption of emissions reduction technologies in lower-income EU countries, 2% of the allowances are used to finance the Modernization Fund, which supports investments for increasing energy security, expanding the use of renewable energy sources and promoting exchange of best practices among MS. The EU ETS Directive states that MS should inform the Commission on the use of revenues and, in 2008, the Heads of State committed that at least 50% of the revenues will be used to reduce emissions and combat climate change. The latest Report on the functioning of the European carbon market (European Commission, 2019) shows that ≈80% of revenues in 2013-2018 were used for climate and energy related purposes.

Figure 5.10: Productivity Growth – Transports



Source: Own elaboration based on Eurostat data.

The actions undertaken by the EU to recover from the pandemic crisis are currently under consideration also as means to foster low-emission technology. In a recent report, the European Parliamentary Research Service (2020b) states that the recovery package set-up by the EU amounts to more than €3 trillion. The planned 'Next Generation EU' instrument consists of €750 billion in grants and loans complemented by an EU multiannual financial framework for 2021-27 with a budget of almost €1.1 trillion. As stated in the report

"A focus on the European Green Deal in the EU recovery funds and a similar approach in national recovery packages presents a unique opportunity to prevent a rebound in emissions, promote low-carbon investment in industry and households, accelerate the transition towards a climate-neutral economy and promote European leadership in key green technologies".[36]

Whether the incentives and support of EU ETS to innovation have been effective so far is a question of major importance that has spurred interest in the empirical literature.[37] However, the scarcity of data from institutional sources on "green" R&D hinders the production of empirical studies.[38] Löfgren et al. (2014) find that being under EU ETS regulation has no statistically significant effect on investment in low-carbon technologies using data of ≈700 Swedish companies between 2000 and 2008. Borghesi et al. (2015), focusing on 2006-2008, show that Italian manufacturing firms in the EU ETS have been more likely to make climate-related investments than companies not under regulation. Calel and Dechezleprêtre (2016), in a study covering 80% of EU ETS installations, show that the regulated firms increased low-carbon patenting up by 36% over 2005-2009, an effect mainly driven by energy prices. Calel (2020), in a study on UK firms (400 under ETS and 400 not under ETS), reports a 25% rise of low-carbon patents and low-carbon R&D expenditure for regulated firms. However, no significant difference is observed between regulated and non-regulated firms in emissions intensity, suggesting that the EU ETS has been effective in stimulating innovation of low-carbon technologies but not in their diffusion. Bel and Joseph (2018) use data for 28 countries for the period 2005-2012 and find a negative correlation between country-level oversupply of free allowances (freely allocated allowances exceeding verified emissions), and number of filed low-carbon patents.

To sum up, the investigation of productivity growth shows no sign that EU ETS regulation has had a negative impact on the performance of the sectors most heavily polluting and most intensely regulated by EU ETS.[39] Instead, if anything, it seems to coincide with the periods of fastest growth for the Manufacturing and Transports sectors. When considering the ability of the EU ETS to foster "environmentally friendly" technological innovation and adoption, the empirical literature shows strong evidence of positive effects on low-carbon innovation, weak evidence of a positive effect on low-carbon technology adoption and a negative effect of free allocation on low carbon investment. While the effect on investment of the reduction of free allocation of phase 3 might have been partially offset by the low price of EAUs,[40] with the implementation of MSR, prices have started rising again and a strengthening of ETS impact on the investment on low-carbon technology should be expected in phase 4.

5.5. EU ETS as a Source of Revenues

The price of EUAs is crucial to the functioning of the EU ETS. As mentioned in the introduction, it directly provides an incentive to companies to invest in low-carbon technologies. Too low a price and investments in emission reduction technologies will be modest, as in most cases it would be cheaper to just pay for the emissions. With a high price the cost to comply with the regulation increases and

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[36] See European Parliamentary Research Service (2020b) for all the potential initiatives under consideration.

[37] Here we focus on the econometric literature not targeted on single sectors and using activity data (no interview, expert opinions, etc.). The reader interested in a broader review should refer to Teixidó (2019).

[38] We used OECD data to investigate the effect of EU ETS of Gross domestic expenditure on R&D by sector using a methodology of Section 5.3. However, the data used presents serious limitations that restrict its ability to provide a reliable answer to the question: i) "green" R&D are only a part of total R&D, ii) nearly half of observations are missing in the period 2008-2018. We find no statistically significant impact but, due to the data limitations, the informative content of this result should be considered minimal.

[39] See Section 5.5.

[40] On the EUAs price dynamics see Section 5.5.

also firms with low emissions might be forced out of the market. More so, as Section 5.3 suggests, there are also financial and behavioural channels through which carbon prices might affect companies' choices (i.e., Lise et al., 2010; Joltreau and Sommerfeld, 2019, Marin et al., 2018; Martínez-Zarzoso et al. 2019; Guo et al., 2020). Given the centrality of the carbon market price, in this section we illustrate its dynamic since the start of EU ETS. We will then extend our investigation to the value of the EUAs market and consider its possible exploitation as a source of revenues for the EU budget.

Figure 5.11: Price of EUA

Source: ICAP.

Figure 5.11 shows the spot price dynamic for EUAs in the secondary market during the period 2008-2020. The price was at around ≈€27/ton in 2008, declined in 2009 to ≈15€/ton (economic crisis) until 2012 when a further drop led to prices ≈€5/ton (≈ 1 billions of EUAs surplus) until 2018 when prices started to rise again to the current ≈€25/ton. The moderate upward trend from 2014 to 2016 has been likely due to the back-loading of allowances implemented to reduce surpluses. The return to price levels of 2008, however, started in 2018, just before the beginning of operations of the Market Stability Reserve in 2019. This dynamic suggests a remarkable effectiveness of using EUAs supply adjustments to improve EU ETS resilience to shocks (Joltreau and Sommerfeld, 2019). It is likely that the low prices of the period 2012-2018 reduced the incentives to emissions reduction,[41] since allowances could be cheaply bought on the secondary market (e.g., Koch et al., 2014) and effectiveness of the ETS system can be expected to improve as a result of the current, higher price.

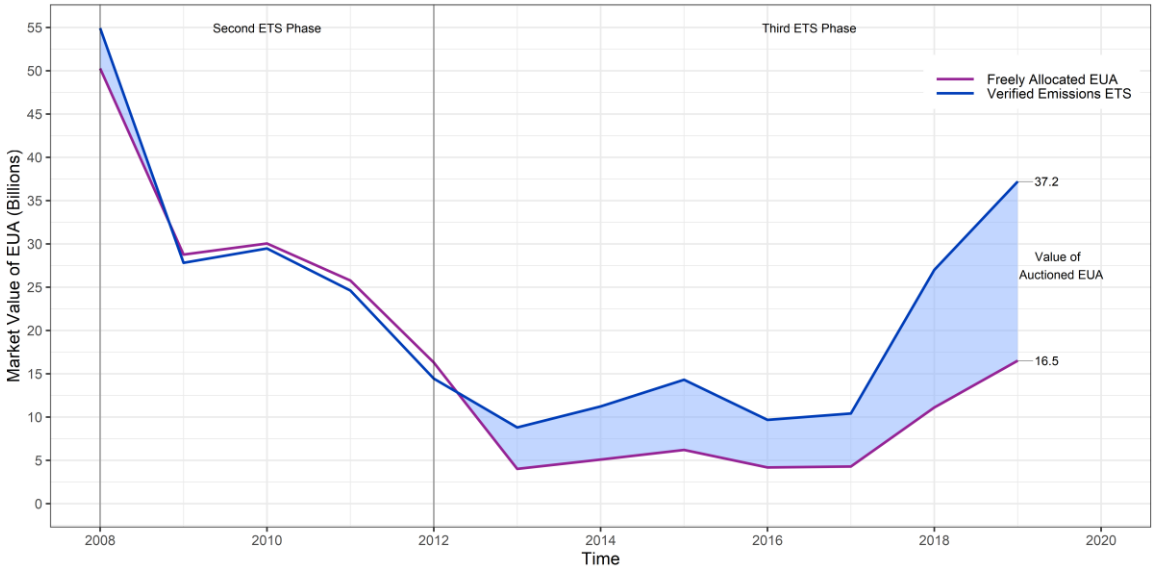
We can quantify the market value of EUAs by using market prices. However, given the price dynamic just described, our appraisal should be taken as a conservative lower bound. Figure 5.12 reports the value in billion of euro (2015 PPP) of both the freely allocated EUAs (purple) and of the verified emissions (blue), which can be used as a proxy of the surrendered allowances (see Section 5.4). When verified emissions are higher than the freely allocated EUAs – i.e., the blue line is above the purple one – companies' need of allowances was not entirely satisfied by free allocation and actual purchasing of EUAs took place. In that case, the vertical distance between the two lines represents

[41] The auction prices, not reported here because unavailable during phase 2, largely overlap with the spot prices during the period 2013–2016.

the value of the purchased EUAs, shaded in light blue in Figure 5.12. Given that firms' primary source of EUAs is auction, if we are willing to neglect discrepancies that might arise in time (e.g., banking, the carrying of EUAs from one compliance period to the following), we can make a further step and consider the value of the purchased EUAs as a measure of the value of the auctioned EUAs.

During the whole timespan 2008-2020, the value dynamic closely follows that of the price. The evolution of freely allocated EUAs and verified emissions almost overlap in phase 2. A drop between 2008 and 2012 brings the two measures from ≈€52 billion to ≈€10 billion. At the beginning of phase 3, freely allocated allowances are reduced and a stable wedge of about €5 billion between the value of verified emissions, hovering around €10 billion, and the one freely allocated EUAs, at ≈€5 billion, characterize the period 2013-2017. In 2017 the value of auctioned EUAs started to increase due to a notable rise of the verified emissions' value that is only partially mimicked by freely allocated EUAs. In 2019 the market value of verified emission is at ≈€37 billion while that of freely allocated emissions is ≈€17 billion, implying a value of auctioned EUAs of ≈€20 billion. The values of auctioned EUAs that we compute are not far off the ones actually collected, €3.5 billion on average in 2012-2017 (our estimate is €6 billion), €14 billion in 2018 (€16 billion), €14.6 billion in 2019 (€20 billion).

Figure 5.12: Value of EU ETS



Source: Own elaboration on Eurostat, Union Registry and ICAP data.

Given the EU's political commitment to be climate neutral by 2050, and the more general European Commission's Green Deal proposal, led by the president of the Commission Ursula von der Leyen, long-term and upward pressure on the carbon price is to be expected. Indeed, prices of EUAs are forecast by numerous analysts to rise substantially above €30/Kton (i.e., ICIS 2019, Schjølset 2014) in the medium to long term. In the long term it is not unreasonable to expect prices in the order of €50/Kton, which would imply revenues that, at the level of emissions of 2019,[42] are above €70 billion.

The EU Commission is currently proposing to increase the role of its own tax resources to fund the EU debt raised to finance Next Generation EU. The revenues from the EU ETS auctioning are one of the possible sources of additional resources under consideration.

[42] We are here abstracting from the expected emission's reduction that the EU ETS will attain in the future.

As we outlined above, the revenues already collected through the EU ETS are in the order of €15 billion. The number of EUAs in the medium to long-term will decline following the reduction imposed to the emissions cap (-2.2% in phase 4). However, during phase 4 a contraction of the freely allocated EUAs will also take place and a significant part of their value, currently around €15 billion, might then be available for collection.

Currently[43], 88% of the auctioned allowances are distributed to MS based on emissions in phase 1, 10% are given to MS with low per-capita income and high growth prospects to support their investment in emissions reduction and climate change adaptation strategies, and the remaining 2% is allocated as "Kyoto bonus" to the MS that reduced their emissions by more than 20% by 2005. As noted above, most of the revenues collected in phase 3 were used for climate and energy related purposes. In phase 4, 90% of the allowances to be auctioned will be distributed to the MS based on their share of verified emissions while 10% will be given to EU MS for solidarity, growth and to foster interconnections.

Auctions of EUAs takes place through the European Energy Exchange (EEX) for twenty-eight countries (plus Germany that relies on EEX as an opt-out platform, and Poland, that uses the EEX as an interim until the appointment of its opt-out platform). The auctioning of allowances by MS is governed by the EU ETS Auctioning Regulation that ensures predictability, cost-efficiency, fair access to auctions and simultaneous access to relevant information for all operators. Such a regulation allows for the thickest market possible while reducing to the minimum the administrative and compliance costs as compared to a set of national markets. More so, the EU ETS Auctioning Regulation also maximizes the depth of the market enhancing its allocative efficiency.

As we previously observed, the market price of the EUAs has been markedly understated in phase 2 and part of phase 3 possibly due to oversupply in the market. However, imbalance problems in the EUAs market seem to have found a solution with the institution of the Market Stability Reserve that allows the adjustment of supply so as to prevent undesirable price dynamics and ensure improved resilience of the system. Moreover, given the European Commission's Green Deal and the overall stance of the EC against climate change, prices of EAUs are expected to rise in the future. **This suggests that reasonable estimates for the revenues obtainable through the EU ETS in the medium-long term can be expected to be above €50 billion /year.**

5.6. Conclusions

The EU ETS is the cornerstone of the European Union strategy to meet reduction targets in GHG emissions set by the 2020 package and the 2030 Climate and Energy Policy. In this chapter we have focused on three main research concerns: i) to identify and estimate the impact of EU ETS on CO_2 emissions; ii) to assess the impact of EU ETS on performance at the industry level across MS; and iii) to characterize the role played so far by the EU ETS as a source of revenues and shed lights on its potential as a source of funding for possible future expansions of the EU budget.

The emission reduction effect of the EU ETS has been modest during phase 1 and more pronounced in phase 2. In our study, the first one in the literature so far involving phase 3, we find weak evidence that higher levels of EU ETS intensity had an effect on emission reduction when passing from phase 2 to phase 3. Conversely, we find that differences in the purchased EUAs intensity have highly statistically significant and sizeable impacts. This seems to suggest that incentives from the EU ETS are much stronger when companies need to purchase the allowances instead of having them freely

[43] European Parliament and the Council of the European Union Directive 2009/29/EC.

allocated. The estimated reduction of CO_2 emissions obtained by means of more stringent regulation is of ≈150,000 tonnes, that is 5.7% of emissions in 2008 and has a (lower bound) value of ≈€1.15 billion at market prices.

The empirical literature shows no evidence of a significant negative impact of the EU ETS on performance and profitability during phase 1 and phase 2, possibly resulting from positive innovation developments. Recent evidence indicates also that profitability has not been affected by the ETS regulation during the first years of phase 3. The analysis presented in Section 5.4 represents, to our knowledge, the first effort to investigate the impact on performance induced by the tightening of the EU ETS regulation between phases 2 and 3. Our results suggests that the stricter regulation of phase 3 has had, again, no adverse impact on performance.

The EU ETS, by means of its mechanism of allowances auctioning and of the stabilization mechanism of the relative market, consists of a reliable policy framework. The size of the revenues that could be collected through it matches the funding needs of the projects currently under consideration by the EU and could be scaled up in the future. Our estimate of the potential revenue to be collected through EUAs' allocation is considerable: €6 billion in 2012-2017, €16 billion in 2018 and €20 billion in 2019. Moreover, given the increasing efforts of EU against climate change, prices of EAUs are expected to rise in the future, suggesting potential revenues above €50 billion/year in the medium to long term, about one-third of the current EU budget. The evidence proposed in this chapter identifies it as a strong candidate to become a source of revenues in a possible future expansion of the EU budget.

The present study leaves open some interesting avenues for future research, mostly related to the effect of ETS on efficiency dynamics and their drivers, and to the identification of the impact that allowances prices have on emissions and performance. Moreover, due to the continuous reform of the EU ETS regulation, it is certainly of interest to follow the future evolution of both the impact of EU ETS on emissions and performance. Indeed, the impact of EU ETS can be expected to be strengthened by the reduction in free allocation of EAUs, by the rise in EAUs price that is forecasted due to the progressively stricter carbon targets and by the establishment of the Market Stability Reserve.

6. Social Insurance

Main findings

- Structural, active and passive, market policies are currently almost exclusively responsibility of MS.
- Preferences and governing institutions are highly heterogeneous in the different countries, leading to ten-fold differences in per-capita expenditure levels.
- Empirical evidence in the last 20 years shows that MS are hit by both symmetric and asymmetric economic shocks. Correlation between economic cycles across EU countries is large but not complete. There is then a potential role for fiscal co-insurance across EU countries.
- Unemployment-related expenditure is more stable in larger countries and at the EU or EA level than in any MS. Hence an EU unemployment insurance mechanism would allow the smoothing of expenditure.
- DEA analysis suggests that efficiency of unemployment benefits and active labour market policies' expenditure is very heterogeneous among MS.
- Depending on the specification, the average rate of waste across MS for unemployment benefits is between 26% to 53% of expenditure, leading to an estimated total waste between about €41 billion and €80 billion per year. The waste rate for active labour market policies is between 9% and 33%, leading to a total waste between €2 billion and €6 billion per year.
- A simulation using historical data shows that a simple EU unemployment co-insurance scheme built so as to avoid permanent transfers and complementing MS ones would have benefited all MS and allowed a stabilization of consumption growth and a smooth unemployment-related expenditure.
- Countries' contributions to the fund would be of 0.2% of GDP per year, with a maximum cap at 1.2% of GDP.
- An EU unemployment insurance scheme with borrowing capacity could also be helpful to tackle a large symmetric shock such as COVID-19.

In this chapter we discuss the potential benefits or costs of moving social insurance competences to the EU level, focusing in particular on unemployment benefits and active labour market policies. In Section 6.1 we provide an overview of the current distribution of competences between the EU and MS and summarize the quantitative level of expenditure in the different countries. In Section 6.2 we explain the reasons for which pooling part of the unemployment risk, henceforth smoothing unemployment-related expenditure, would be beneficial for all MS. In Section 6.3 we perform the DEA analysis for unemployment benefits, identifying the related waste rate, and active labour market policies. In Section 6.4 we run a simulation for a simple EU-level unemployment insurance scheme, highlighting the positive effects for all MS and discussing its role during an economic crisis like the one related to COVID-19.

6.1. Unemployment benefits expenditure in the EU: an overview

Structural, active and passive, market policies are currently almost exclusively under the responsibility of the MS, if we exclude the part of the European Social Funds that are devoted to support active labour market policies in MS. As part of the process to build a more resilient Union, the newly created 100-billion SURE fund is designed to provide a temporary safety net to mitigate unemployment risks related to the COVID-19 crisis. In general, there is an ongoing discussion about the creation of a common insurance and re-insurance mechanism for unemployment at the EU level, possibly in the spirit of the one provided in the US (see Section 8.3 for details). This discussion has been revived by the Commission led by Ursula von der Leyen, who explicitly mentioned an European Unemployment Benefit Reinsurance Scheme during her Opening Statement in the European Parliament Plenary Session. Moreover, recent recommendation and directives have focuses on social security systems; in particular, the Council recommendation on access to social protection for workers and the self-employed and the Directive on transparent and predictable working conditions aim at extending social protection to working categories, like the self-employed, that are currently underprotected.

Between 2008 and 2017 the expenditure per inhabitant for unemployment benefits in the EU ranged between €355 and €460 in Purchasing Power Standard (PPS) – about 2% of GDP.[44] However, given that each country has his own insurance mechanism, the expenditure level has been quite heterogeneous among MS: some countries, as Bulgaria, Poland and Romania, never spent more than €100 PPS per capita in one single year, while others, such as Belgium and Ireland, have reached peaks above €1000 PPS per capita. Moreover, country-level unemployment benefits are heterogeneous in the length of the benefit, in the replacement rate, in eligibility requirements and in the funding scheme (Del Monte and Zandstra, 2014; Asenjo and Pignatti, 2019). This substantial degree of heterogeneity reflects the heterogeneity in preferences among different countries for the strength of social safety nets and also the differences in the institutions governing the labor markets. Hence, a potential common mechanism should couple the advantages of moving part of this competence at the EU level with the aim of preserving as much of the specific MS preferences as possible.

6.2. The advantages of risk pooling

For a single person it may be cumbersome to bear the risk of an event that could cause an huge economic loss (e.g. home fire). For this reason, one hundred households may decide to pool the risk of their one hundred houses, in such a way that each household bears 1% of the risk that each of the one hundred houses catches on fire, rather than 100% of the risk that one single house catches on

[44] Source: Eurostat.

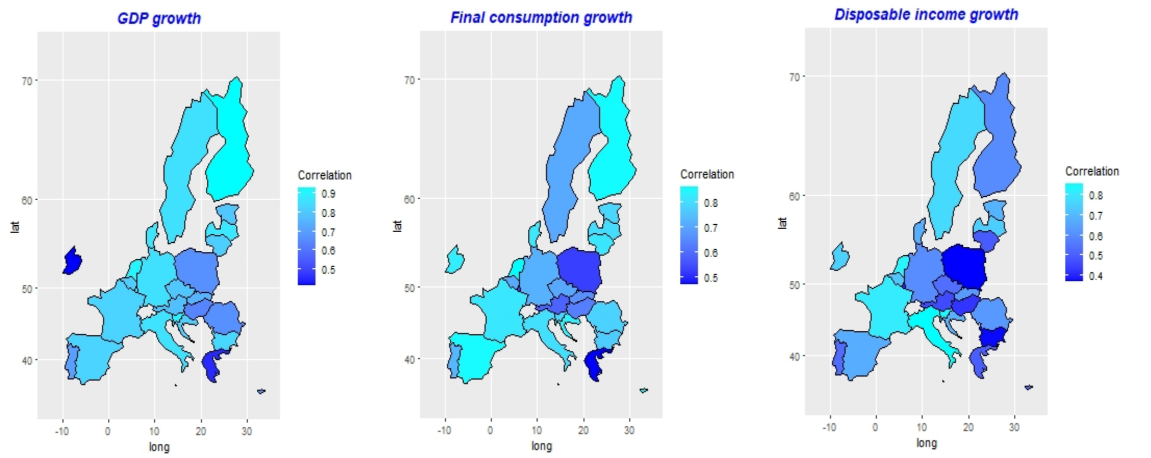
fire. Unless all the houses catch fire at the very same moment, the first risk is easier to bear than the latter.

The intuition for the potential advantages of risk pooling at a supranational level, like the EU or the Euro Area (EA), is similar. Although European countries have strong economic relationships, countries are hit by asymmetric shocks or even by symmetric shocks but with asymmetric effects (as, for example, COVID-19). Countries that face an huge economic shock may find it difficult to absorb the shock on their own, and the long-term costs are higher if the effort is borne by that single country. For example, an increase in fiscal pressure in the middle of a crisis to finance social safety net expenditure has large distortionary effects on the economy (e.g. increasing the excess burden from taxation) and/or the accumulation of fiscal deficits or debts might also affect its sustainability. These negative side effects would be reduced if the costs of the shock were borne by more than one country.

It is easy to argue that at both the EU or EA level it would be possible to achieve both interregional and intertemporal risk pooling, in such a way to insure at least the most significant shocks with potential advantages for all countries. The reason is that even though, on average, there is a positive correlation between the EU growth rate and MS growth rates, the match is not perfect. Economic cycles at country level are heterogeneous. This is shown in Figure 6.1 where we represent the correlation of country growth with EU growth as far as final consumption, disposable income and GDP are concerned. In the figure, darker shades represent lower correlations. As can be seen, correlation is positive, ranging from 0.4 to 0.9, but far from perfect.

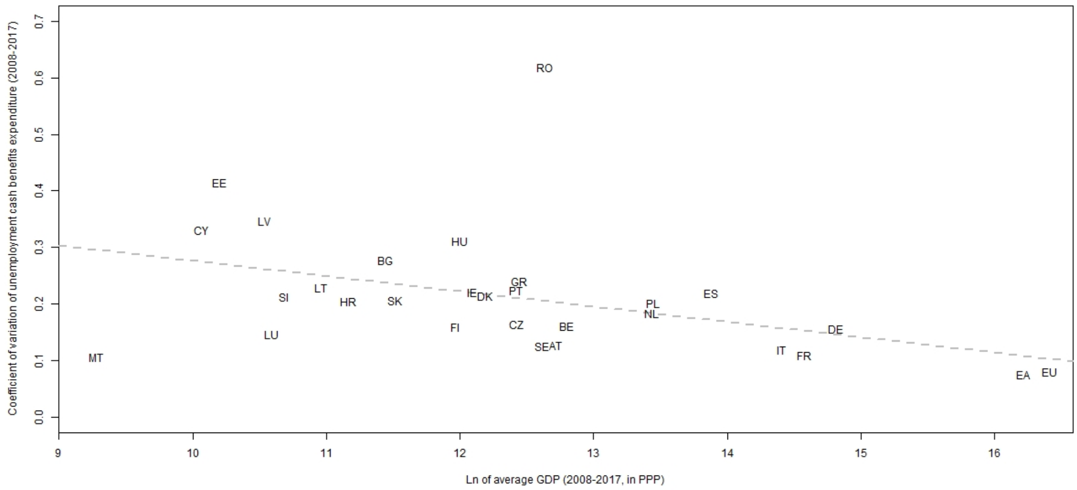
Moreover, usually the larger an economic area, the more its economic activities are diversified, implying that if a negative shock hits one of those activities the relative impact on the economic cycle is limited. This intuition is confirmed by data on unemployment benefits expenditure in the period 2008-2017, reported in Figure 6.2.

Figure 6.1: Correlation of country growth with EU growth, 2001-2018. Final consumption, disposable income and GDP are per-capita and expressed in Purchasing Power Standard (PPS)



Source: Author calculations on Eurostat data.

Figure 6.2: Scatter plot of the natural logarithm of GDP (in Purchasing Power Standard) and coefficient of variation of unemployment cash benefits expenditure. 2008-2017



Source: Author calculations on Eurostat data.

On average, bigger countries show less spending variation for unemployment benefits and, in particular, the aggregate expenditure at the EU or EA level has been less variable than that in any single country. Consequently smaller countries have, on average, more fluctuating expenditure on unemployment benefits than larger countries. All countries have to face periods of heightened expenditure either increasing public deficit, or increasing fiscal pressure, or decumulating a buffer of public finances saved during previous positive economic cycles. An insurance mechanism could help countries to address these crises, by providing resources for safety-net-related expenses during negative cycles, thus avoiding the negative side effects of having to finance expenditure entirely on their own. Hence, leaving aside potentially negative moral hazard effects that would have to be managed carefully, this simple empirical evidence supports an EU-level insurance mechanism to achieve both intertemporal and interregional expenditure smoothing.

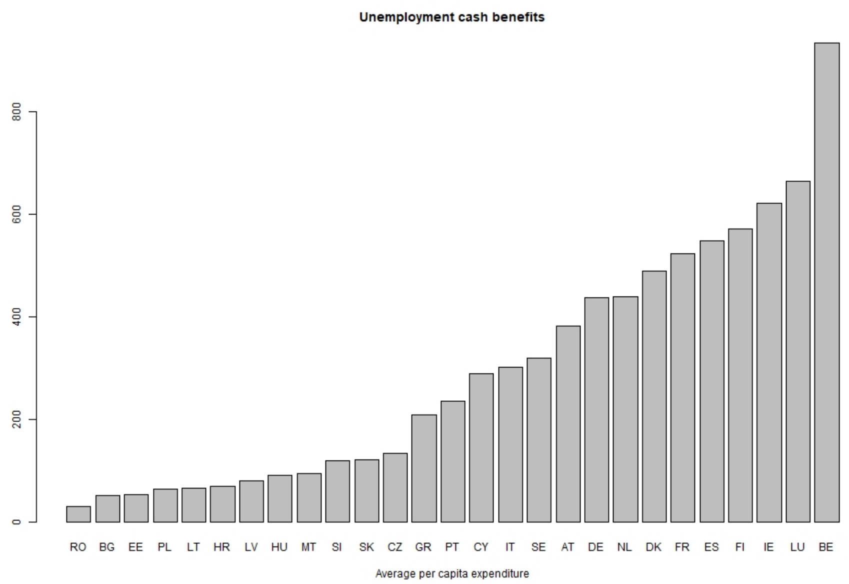
6.3. DEA analysis

6.3.1. Unemployment benefits paid in cash

As explained in Chapter 3, the DEA analysis is a methodology that allows us to understand how efficiently different decision-making units employ inputs to produce outputs. In the current setting, the decision-making units are EU MS; as inputs we consider unemployment benefits expenditure, expressed per capita and in PPS terms to control for the different price levels in the different countries, focusing in particular on those unemployment benefits paid in cash rather than in kind (source: Eurostat). We take the average for the period 2001-2017, while due to lack of data we have shorter time periods for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). The choice of the output measure is meant to quantify the ability of unemployment benefits in supporting income levels and, henceforth, consumption levels of the unemployed person and his family members while looking for a new job. Therefore, a well-designed unemployment benefits scheme should be able to enhance consumption stability with respect to disposable income, or GDP, fluctuations. For this reason, we consider as output measures either the standard deviation of consumption growth over the selected period, or the correlation of consumption growth with GDP growth over the selected period. Ideally, a perfectly working safety net would facilitate a smoothing of consumption, hence an efficient safety net should reduce the standard deviation of consumption growth and its correlation with GDP growth as much as possible given the resources deployed. The standard deviation and the correlation are calculated over the period 2001-2017 with the exceptions of Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017).

In the standard DEA analysis, we use unemployment benefits expenditure as the input and one of the two abovementioned consumption volatility measures as the output. We also adopt a more sophisticated two-stage estimator (Simar and Wilson, 2007) that allows us to control for the effects of other factors that might also influence the output level. As such factors we consider the average level

Figure 6.3: Bar plot of the average per capita expenditure for unemployment cash benefits, 2001-2017.



Source: Eurostat. Shorter time period for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017)

of social protection benefits expenditure and of GDP, both expressed in per capita terms and in Purchasing Power Standard, plus the country's average unemployment rate.[45] The first is a proxy for welfare expenditure possibly unrelated to unemployment, the second is a proxy for country general economic conditions and the third one for labour market conditions.

The country scores of the two-stage estimator are reported on the lower panel of Figure 6.4. The output is the standard deviation of consumption growth and the set of decision-making units are all

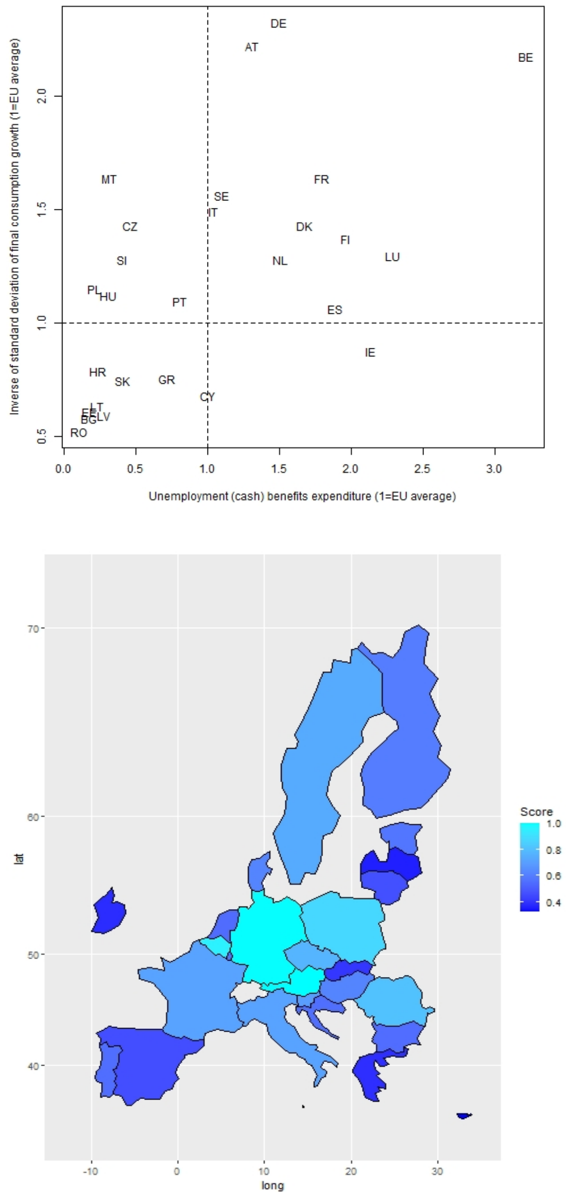
[45] Source: Eurostat. Time period 2001-2017, with the exceptions of Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). Social protection expenditure include unemployment benefits expenditure plus several other functions: sickness/health care, disability, old age, survivors, family/children, housing, and social exclusion.

of the EU MS. The most efficient countries (which have a score close to one) are represented in light blue, while the least efficient have a low score (i.e., close to zero) represented in dark blue.

We observe that the most efficient countries are Austria, Belgium and Germany. As could be noted from the scatterplot of country unemployment benefits expenditure (x-axis) and inverse of standard deviation of consumption growth (y-axis) (Figure 6.4, upper panel),[46] these countries have an above-average expenditure but are able to achieve an excellent performance in consumption stabilization. We note that Malta, Poland and Romania are slightly less efficient. They have below-average expenditure but they still achieve a good performance given the resources employed; in particular, Romania is a clear outlier, having an expenditure level below one tenth of the average among MS. Despite the huge heterogeneity in spending levels and in efficiency levels as well, the scatterplot suggests that there is a relationship between expenditure level (input) and the stability of consumption (output). In particular, countries that allocate more resources for unemployment safety nets achieve an higher stability in consumption growth.

Similarly, in the lower panel of Figure 6.5 we report the country scores obtained using as the output the correlation of consumption growth with GDP growth. For this exercise, we focus on a smaller set of countries to avoid outliers of the distribution. Namely, we consider the seventeen countries with the highest GDP within the EU.[47] The results are similar to those of the previous analysis: the rank correlation among the countries included in both sets is about 0.6. Among the most efficient countries we find

Figure 6.4: Unemployment cash benefits and standard deviation of the growth rate of consumption

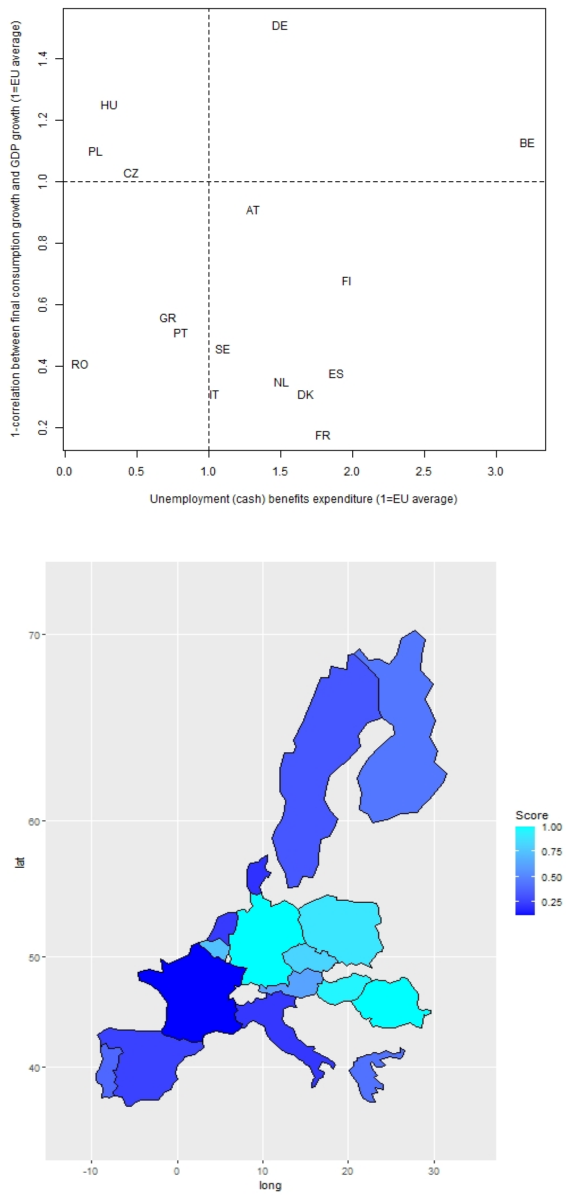


Source: Author calculation on Eurostat data. Time period: 2001-2017, shorter for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

[46] Both are normalized with respect to the average of EU MS.

[47] Ireland is within the seventeen biggest countries, but is excluded from the analysis because it has an extremely low correlation value. In particular, Irish GDP partly depends upon the profits of the multinational companies incorporated in the country, and is highly volatile. Its inclusion among the decision making units would have biased the results.

Figure 6.5: Unemployment cash benefits and correlation of consumption growth rate with GDP growth rate



Source: Author calculation on Eurostat data. Time period: 2001-2017, shorter for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). Upper panel: scatter plot. Lower panel: scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Germany, Romania and Hungary, followed by Poland, the Czech Republic and Belgium. As already mentioned, Belgium and Germany have an above-average level of expenditure, while in the Czech Republic, Hungary, Poland and Romania spending is below the EU average. Even under this setting, we observe that, on average, countries that spend more for unemployment insurance have a consumption growth pattern which depends less on the dynamics of GDP growth, hence achieving a greater degree of consumption smoothing.

Waste rate

The scores of the DEA analysis allow us to estimate the waste rate; in other words, the degree of (in)efficiency of the different countries allows us to estimate the amount of resources that they are wasting given the estimated production function. Over the time period considered (2001-2017), EU MS spent on average €157 billion PPS each year for unemployment cash benefits; in 2017, the last year for which we have data for all MS, that amount was equal to €155 billion.

The DEA analysis suggests that, if we assume that the target of the policy is the reduction of consumption growth instability, the (unweighted) average of the waste rate of EU MS is about 36%. If we take into account, for each country, their degree of inefficiency and their level of expenditure, the DEA analysis suggest a waste level of around €41 billion PPS, that is about 26% of the total expenditure at the EU level. Focusing on 2017 only, the waste is €42 billion, approximately 27% of the total expenditure. An implication is that an European insurance scheme designed following the national best practices, and complementary to the MS insurance schemes, would improve the average level of efficiency. This, coupled with the advantages of risk pooling that are discussed in Section 6.2, argues in favour of the introduction of an European unemployment insurance system.

The DEA results for the second benchmark analysis, that assumes that the target is the reduction of the dependence of consumption growth on GDP growth, further reinforce this point. Even though this analysis focuses on a subset of countries, their expenditure represents a significant share of the EU total (96%), hence the result could be considered as applicable to the EU as a whole. According to that analysis, the (unweighed) average of the waste rate is 46%, equal to €80 billion per year at the EU level (€87 billion in 2017) corresponding to a waste rate of approximately 53% (58% in 2017).

Robustness checks

We performed several robustness checks to the main analysis changing the inputs/outputs used in the analysis (Figures A.6.1 to A.6.10 of Annex A.6).

1. *Disposable income instead of consumption*. Since households may make their consumption-savings decisions in such a way to smooth consumption, the generosity of unemployment benefits might not influence consumption behaviour of the unemployed, except for those that are financially constrained (Dolls et al, 2012). Even if the rank is similar to that in the benchmark analysis, it is noteworthy that Denmark and Sweden are highly efficient in stabilizing the growth rate of disposable income with respect to the growth rate of GDP.
2. *Social protection expenditure instead of unemployment benefits*. Social protection expenditure include unemployment benefits expenditure plus several other functions: sickness/health care, disability, old age, survivors, family/children, housing, and social exclusion. Hence, social protection in general may support households income and consumption levels. The rank is almost the same as that of the benchmark analysis.
3. *Coefficient of variation instead of standard deviation*. Coefficient of variation is a measure of volatility, similar to the standard deviation. Actually, it is equal to the ratio between the standard deviation and the mean. The intuition is that countries which are growing faster (higher mean) might be intrinsically more volatile in their growth rate (higher standard deviation), and the coefficient of variation might control for this. Still, the rank correlation with the benchmark analysis is significant (about 0.6). Once we control for mean growth, Lithuania becomes more efficient.
4. *EA instead of EU*. It is not possible for countries that belong to the Euro Area to make competitive devalutions during negative cycles. Hence, their safety nets might have a different efficiency level with respect to countries who have not adopted the common currency. Hence, we repeat the analysis excluding those last countries. The rank of EA countries is barely affected.
5. *Pre-2009 vs post-2009*. The EU, and most MS, recorded a negative growth in GDP in 2009, as a consequence of the financial crisis. It is therefore interesting to consider whether our methodology suggests a different efficiency ranking in the pre-crisis (2001-2008) with respect to the post-crisis (2009-2017) period. Actually, as far as the exercise with the standard deviation is concerned, for the pre-crisis period we observe efficiency scores among the different MS that, although positively correlated with the benchmark analysis, have a correlation value lower than the one we obtained in the other robustness checks (around 0.5). In particular, in the original experiment Germany, Malta, Poland and Romania head the rankings but in data covering 2001-2008 we find Italy, Lithuania, Portugal and Slovenia are the most efficient. On the contrary, the ranking for the 2009-2017 is closer to the one of the benchmark analysis. The intuition is that our benchmark result is led by safety net efficiency during more turbulent times. Conversely, in the exercise with the correlation between

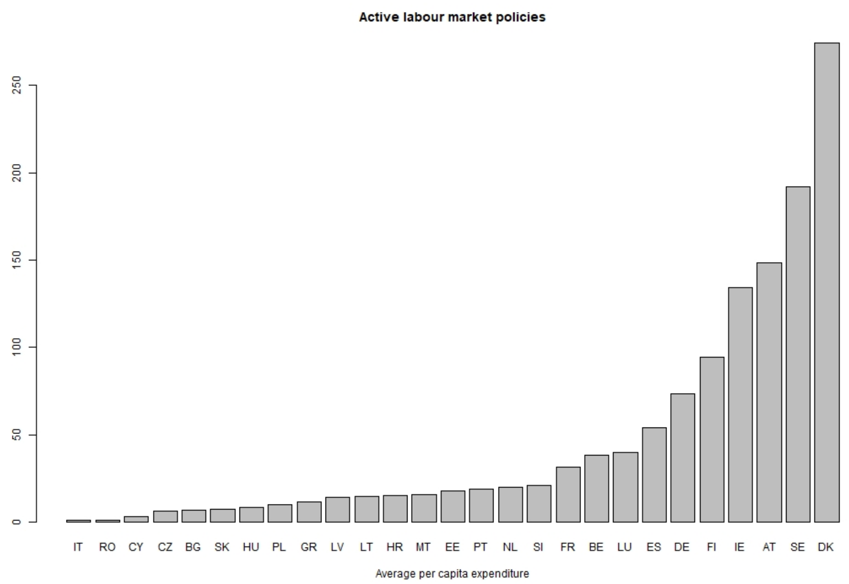
consumption and GDP growth the results appear to be similar to the ones of the corresponding benchmark analysis, both for the 2001-2008 and the 2009-2017 period.

6.3.2. Active labour market policies

In order to focus on active labor market policies, we take into account unemployment benefits expenditure related to vocational training,[48] mobility and resettlement, placement services and job search assistance. For these functions, the average expenditure in the EU has been €41 PPS per capita in the time period 2008-2017, ranging from €36 to €45 PPS. This is about one tenth of the total social protection expenditure for the unemployment function. Heterogeneity is particularly pronounced: countries' expenditure ranged from roughly €1 PPS per capita in Italy and Romania to as high as €143 PPS, €175 PPS, €214 PPS and €249 PPS in Ireland, Austria, Sweden and Denmark respectively. Hence, the heterogeneity of preferences could be especially relevant in this case.

The average of this expenditure for active labour market policies over the period 2001-2017 (Figure 6.6) constitutes the input of our DEA analysis. As the output, we consider either the average of the employment rate or the average of the share of the unemployment rate which is formed by long-term unemployed (i.e. people unemployed by more than one year). The rationale is that efficient active labor market policies should both increase the employment rate and allow people who lose their job to re-enter quickly into the labour market, without reaching the long-term unemployment stage. As for the DEA analysis for unemployment cash benefits, the time period is 2001-2017 with the exception of Bulgaria, Romania and Croatia for which we only consider shorter time periods for the reasons discussed above and, for the two-stage estimation, we include GDP per capita level, social protection benefits per capita level and the unemployment rate as control factors.

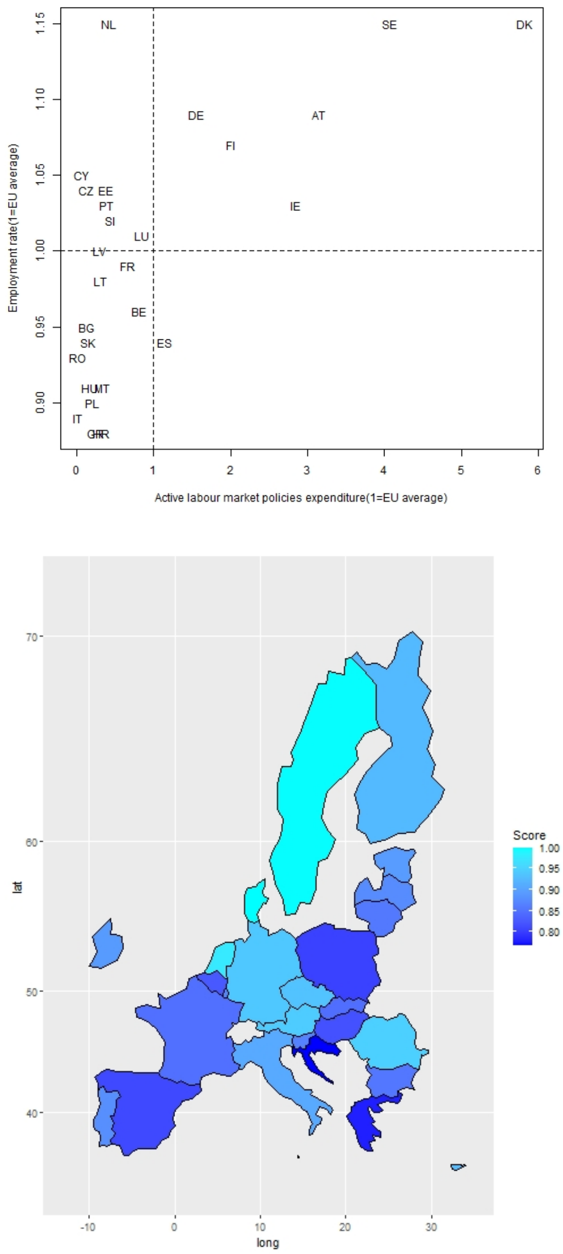
Figure 6.6: Bar plot of the average per capita expenditure for active labour market policies, 2001-2017.



Source: Eurostat. Shorter time period for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017)

[48] Both in kind and in cash, including periodic and lump-sum benefits.

Figure 6.7: Active labour market expenditure and the employment rate



Source: Author calculation on Eurostat data. Time period: 2001-2017, shorter for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). Upper panel: scatter plot. Lower panel: scores of the two-stage DEA estimator (Simar and Wilson, 2007)

In the analysis performed using the employment rate as output, we find that the most efficient countries are Denmark, Sweden – two countries with an expenditure level much higher than the average of EU MS – and the Netherlands. According to the methodology, Romania, a country with an extremely low expenditure for active labor market policies, also appears to be efficient.

The results obtained using the share of long-term unemployed as the output are slightly different: the ranking correlation between this analysis and the one with the employment rate as output is positive, but not exceptionally high (0.54). Sweden and Romania are first and fourth in the ranking, but in the second and third we find Finland, which spends more than the average, and Luxembourg, which has an expenditure level close to the average of EU MS.

Waste rate

Over the time period considered (2001-2017), EU MS spent on average €18 billion PPS each year for active labour market policies; and in 2017 the total expenditure amounted to €17 billion PPS.

The levels of inefficiency implied by the DEA analysis suggest that a part of this expenditure is not as efficient as desirable. In particular, assuming that the objective is to decrease the long-term share amongst the unemployed, the (unweighted) waste rate is equal to about 32% and the weighted one to about 33%. The waste rate for 2017 is of the same order of magnitude (29%). In absolute terms, the waste is roughly €6 billion on average during the considered period and of about €5 billion for 2017.

The analysis performed assuming that the target is to increase the employment rate suggests a lower waste rate. In particular, the unweighted inefficiency level is approximately 12% and the weighted one about 9%, with a total waste of €1.6 billion PPS. The results for 2017 are similar, with a waste rate of about 9%, corresponding to €1.5 billion PPS.

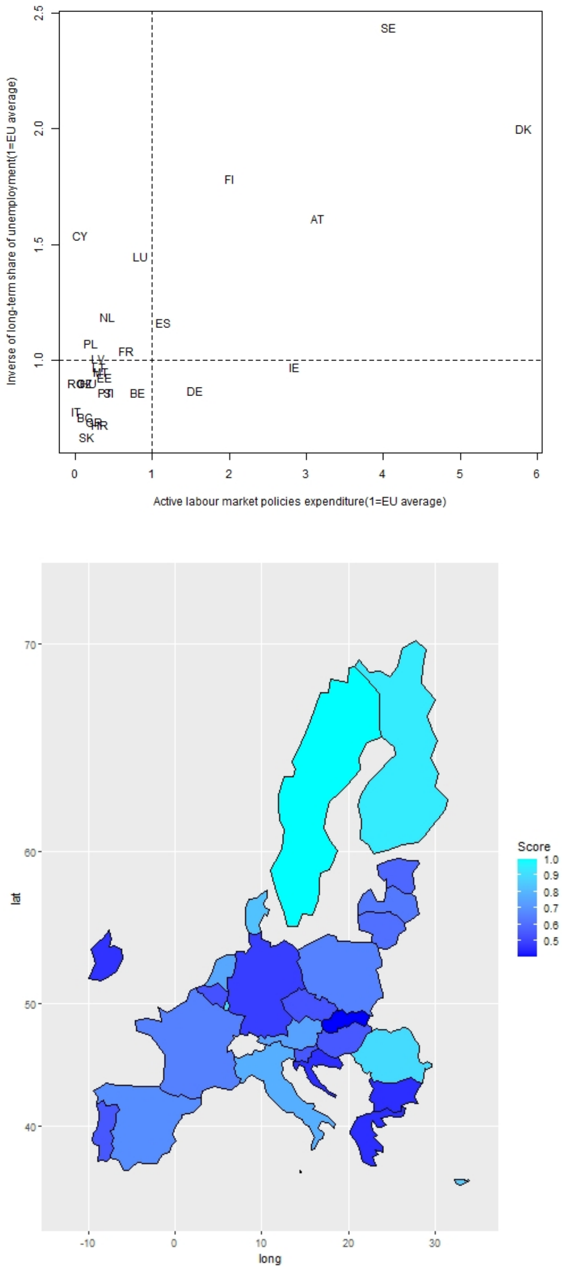
Robustness checks

We performed a few robustness checks to the main analysis (Figures A.6.11 to A.6.16)

1 *Pre-2009 vs post-2009*. In the exercise for unemployment cash benefits, we observe that the results for the period 2001-2008 are to some extent different from the ones from the 2001-2017 period. Conversely, this exercise on active labor market policies suggests that the efficiency ranking in the pre- and in the post-crisis period are consistent with the ones of the benchmark analysis (rank correlation never lower than 0.8).

2 *EA instead of EU*. The rank of the EA countries is confirmed also after the exclusion of MS with their own currencies.

Figure 6.8: Active labour market expenditure and the long-term share of the unemployment rate



Source: Author calculation on Eurostat data. Time period: 2001-2017, shorter for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017). Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

6.4. An EU unemployment insurance: a simple example

As highlighted in the introduction of the present chapter, there is an ongoing discussion among scholars and policymakers about the opportunity to introduce a common unemployment insurance scheme for the EA, as these countries have lost the ability to devalue their currency in response to asymmetric shocks, or for the EU as a whole. Proposals for common insurance funds, re-insurance funds, "rainy day" funds, or more general insurance/stabilisation schemes have been presented in research and position papers in recent years: see, amongst others, Arnold et al (2018), Benassy-Quere et al (2018), Bevably & Lenaerts (2017), Carnot et al (2017), Dullien et al (2017), Lenarčič and Korhonen (2018), Ministero dell'Economia e delle Finanze (2016a, 2016b, 2016c), Claverens and Stráský (2018), Schmid (2019). This stream of literature has also analyzed the theoretical implications of a common insurance scheme (e.g. Ábrahám et al, 2019; Dolls, 2020; Hartung, 2019, Ignasak et al, 2018; Moyen et al, 2016). Common criticisms to this approach are the heterogeneity of MS labour markets, potential problems of moral hazard and the need to avoid permanent transfers across countries (Claeys et al, 2014). Although several researchers suggest that these problems are exaggerated (Ábrahám et al, 2019; Dolls, 2020), in the present section we run a simulation based on a simple unemployment insurance scheme that takes these criticisms into account. This simulation allows us to estimate the potential benefits of the introduction of a common insurance scheme in terms of consumption growth stabilization.

In order to do so, we first check for the quantitative effect of unemployment cash benefits expenditure on the standard deviation of per-capita consumption growth and the correlation of per-capita consumption growth with per-capita GDP growth, i.e. the two output measures adopted in Section 6.3.1.[49] Since we are running the regression on a dataset including all EU MS, we are implicitly assuming an average level of efficiency of the insurance system; hence, the effectiveness of the EU insurance system could be made more effective if this is designed according to high-efficiency best practices. Therefore, our results could be interpreted as a lower bound for a well-designed insurance scheme.

As expected, regression results (shown in Annex A.6.2) confirm that an increase in unemployment benefits expenditure reduces the volatility of consumption. In particular, an increase of €100 PPS in per-capita unemployment cash benefits expenditure decreases consumption growth standard deviation by 0.20 pp and decrease the correlation with GDP growth by 1.48 pp.[50] These results are even stronger if we limit the sample to EA countries: the effect on the standard deviation is of 0.24 pp, and the one on the correlation of 1.92 pp.

The funding mechanism of the common insurance fund could be similar to the one adopted for the SURE fund. In particular, we may propose that MS contribute an additional 0.2% of their GDP to the EU budget per year. These additional contributions to the EU budget could be either transferred to countries which are suffering a negative unemployment shock, or employed as guarantees to back bonds issued on the financial markets. To avoid a permanent transfer, we include in our exercise a ceiling for the cumulative contributions of a country, net of the transfers received, equal to 1.2% of their GDP. This implies that, in other words, a country which has been a positive net contributor for several years will contribute a relatively small amount, or no amount at all, in the following years. Conversely, a country which has been a negative net contributor for several years and is now in a

[49] For five-year rolling windows, we calculate for each county the mean expenditure for unemployment cash benefits, the standard deviation of consumption growth and its correlation with GDP growth. Moreover, we use as controls in the regression GDP level (proxy for country size) and per-capita GDP growth.

[50] Qualitatively speaking, these results are robust to a check with disposable income instead of consumption.

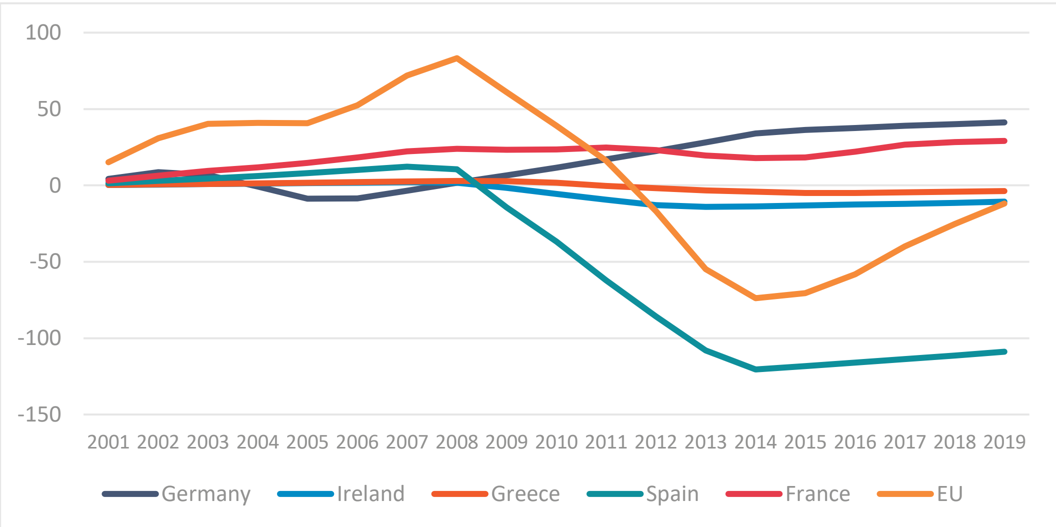
positive cycle pays a full contribution of 0.2% of GDP, implicitly repaying back a part of the transfer received from the common fund.

In our simulation, the insurance fund transfers resources to countries hit by a negative unemployment rate shock. In the spirit of Arnold et al. (2018), this transfer is activated by an increase in the unemployment rate, which has to be higher than the 7-year moving average. This transfer must be used as a top-up for the MS unemployment benefit. To preserve heterogeneity of preferences, and as an incentive not to defund the MS scheme using the EU insurance as a perfect substitute, the transfer matches the MS expenditure level and is equal to 15 cents per €1 spent by the country multiplied by the percentage points in excess of the unemployment rate with respect to the 7-year moving average. As for the contribution, we also place a ceiling on the transfers equal to 75% of the MS expenditure level.

The experiment is run for the period 2001-2019. All countries receive a transfer to be used as a top-up for at least one year and, except for Malta and Romania, all the countries are negative net contributors for at least one year.[51] The fund is in a positive balance from 2001 to 2011; hence, during this period the cumulated contributions are sufficient to provide support to the countries that face a negative unemployment shock, including the significant shock as a consequence of the financial crisis of 2008-2009. Conversely, since 2012 the simulation reports a negative balance for the fund, with a (negative) peak of -€74 billion in 2014, followed by a progressive reduction of the negative balance to reach -€11 billion in 2019. In other words, during that period the resources of the fund would not have been enough: it would have been necessary either to redirect resources from other articles of the EU budget, or to issue bonds backed by the EU budget or by cumulated contributions of the insurance fund.

In Figure 6.9 we plot the dynamics of the country balances for some representative MS and the EU (the one with all MS is reported in Annex A.6.2, Figure A.6.17). On one hand, thanks to the cumulative

Figure 6.9: Cumulative net contributions (€ billion) to the EU insurance fund for selected countries, 2001-2019.



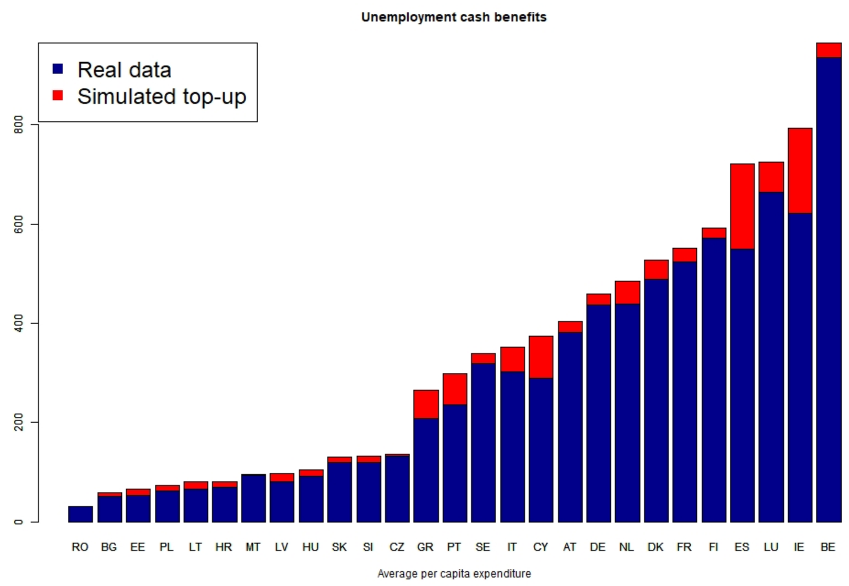
Source: Author elaborations on Eurostat data.

[51] To be a negative net contributor in a given year, the transfer received has to be higher than 0.2% of GDP of that country.

contributions ceiling, even though Germany and France are positive net contributors, their contributions are capped at 1.2% of the GDP. Moreover, note that Germany receives a positive net transfer for the period 2003-2005, while France receives a positive net transfer in 2009 and for the period 2012-2014. On the other hand, Spain receives positive transfers since the beginning of the financial crisis, in 2008, until 2014. Since 2015 Spain is a positive net contributor, and over the period 2015-2019 its contributions are higher than the ones of France or Germany, despite a lower GDP. This result is led by the fact that France and Germany are close to the ceiling, while Spain is not.

In per-capita and PPS terms, the highest transfer of the simulation exercise is the one received by Ireland in 2010, equal to €777 PPS per capita. According to our preliminary estimates, this additional expenditure for unemployment benefits, on top of the MS benefits, induces a 1.6 pp reduction in the standard deviation of consumption growth and an 11.4 pp reduction in the correlation of consumption growth with GDP growth. Other countries that receive high per-capita transfers are Spain, with a peak of €599 PPS in 2009, Cyprus (€425 PPS in 2013), Portugal (€256 PPS in 2013), Italy (€246 PPS in 2013) and Greece (€240 PPS in 2011). On average, per-capita unemployment benefits expenditure in the EU would have increased by about €45 PPS (i.e. an 11% increase), leading to a decrease in the standard deviation of consumption growth of 0.09 pp and a decrease of the correlation with GDP growth of 0.67 pp. The average top-up received by MS and, for comparison purposes, average expenditure from

Figure 6.10: Bar plot of the average per capita expenditure for unemployment cash benefits and simulated top-up, 2001-2017.



Source: Eurostat and author calculations. Shorter time period for Romania (2003-2017), Bulgaria (2005-2017) and Croatia (2008-2017)

real data are reported in Figure 6.10. Relevant increases in absolute terms are observed in Spain (+€173 PPS per capita) and in Ireland (+€171 PPS). In relative terms, the top-up leads to an increase in unemployment benefits expenditure higher than 25% in five countries: Spain (+32%), Cyprus (+29%), Ireland (+28%), Greece (+27%) and Portugal (+27%).

Del Monte and Zandstra (2014) in their Cost of Non Europe exercise, recalled also by CONE Report (2019), have run a similar simulation for an European Unemployment Insurance scheme. Considering a multiplier of 1.5 for unemployment benefits expenditure, they find that such a scheme would have reduced GDP loss by €71 billion in Estonia, Greece, Ireland, Latvia, Lithuania and Spain over the period 2009-2012. Our simulation, in turn, suggests an even higher GDP effect (€175 billion, over the same period and considering the same six countries). The difference is related to the different design of the insurance scheme; nevertheless, the common intuition is that an insurance scheme would be highly beneficial for the countries involved.

Moreover, it has to be stressed that this simulation exercise is static, hence we do not take into account the effects on year *t* of possible transfers received in previous periods. For example, according to real data, Ireland had an unemployment rate higher than the 7-year moving average between 2006 and 2013, hence in our simulation this MS receives transfers between 2006 and 2013. However, given that transfers in one period will help to support consumption smoothing despite the negative economic shocks, this has positive effects on employment, GDP and consumption also in subsequent periods, indeed reducing the amount of transfers needed in the following periods. This further argues in favour of the sustainability of the system.

Positive spill-overs

The advantages of risk pooling, discussed in Section 6.2, and the results of the simulation of Section 6.4 argue in favour of the introduction of an EU unemployment insurance scheme. However, the simulation alone does not make clear whether this insurance scheme would provide benefits only to those countries that are net receivers of transfers or would provide appreciable benefits to the EU as a whole, including the countries that are net contributors to the system.

As shown in the introduction of this chapter (see Figure 6.1), the growth rates of the MS are positively correlated, although not perfectly correlated, with the growth rate of the EU. This is true as far as disposable income, final household consumption and GDP are concerned. This suggests that, on average, all MS would benefit from an higher growth in the EU.

Empirical research has studied whether also the reverse effect is true, i.e. if an increase in the growth rate in one country provides appreciable effects on the other MS. The evidence is mixed. In't Veld (2016) focuses on the effects of an increase in public investments in one country on the rest of the Euro Area, and finds that during normal times the spill-over effects are rather small and could even be slightly negative. However, these spill-over effects become positive and sizable in a situation in which the interest rates are constrained at the zero floor level, that is when monetary policy has lost its ability to further support the economy. From a quantitative point of view, he finds that an increase of public investments of 1% of GDP for ten years in Germany and the Netherlands would have produced a 2% increase in GDP in these two countries in ten years, but also that the GDP of the rest of the Euro Area would have been 0.5% higher, thanks to higher demand from expanding countries and depreciation of the Euro. The increased demand in the rest of the EU would also have supported growth in the expanding countries. A very recent example, on which to the best of our knowledge there have been no empirical analyses yet, is the decision of Germany to cut VAT rates for six-months. This decision boosts demand in Germany and, given that Germany imports from other EU MS constitute around 23% of all intra-EU trade and that we are in a zero lower-bound condition, expanding demand in Germany is likely to lead to higher exports for partner EU countries. On the whole these results suggest that, at least in periods where monetary policy is constrained, even countries that are net contributors would benefit from more stable consumption growth in the other countries of the EU.

7. Defence

Main findings

- We run two exercises to estimate inefficiency in current spending in the defence sector using the DEA methodology. First, we consider the defence expenditure per capita as an input and the number of deployed troops as an output. Secondly, we use as an input military equipment procurement and as output R&D expenditure as a proxy of future quality of equipment.
- In the first exercise, we find that MS on average waste about 46% of their current expenditure on troop deployment, with an overall estimated current waste of about €32 billion. This figure is confirmed by several robustness exercises.
- Our results suggest the existence of large potential benefits from further European integration in troop deployment, supporting expanding initiatives such as the EU Battlegroups.
- In the second exercise, we find that MS on average waste about 50% of their current expenditure in military procurement, with an overall estimated waste of €12.7 billion.
- We also find in both exercises that larger countries are systematically more efficient than smaller countries, as they can exploit their larger scales. The DEA methodology also suggests the existence of strong returns to scale in both cases, particularly for military procurement.
- This suggests that coordination of policies and common spending in the defence sector would allow MS to exploit economies of scale, saving resources and improving the quality of spending.
- For instance, if 7 billion or 25% of current MS expenditure in procurement was integrated at European level (a reasonable hypothesis), MS countries would collectively save about 2.7 billion.

7.1. Defence in Europe

Security and defence are an exclusive MS prerogative, performed in the context of international treaties. Thus, under the umbrella of NATO, security in Europe has been for years just the 'summation' of MS defence systems. Cooperation among European countries is common, but MS military budgets have remained separate in order to preserve MS sovereignty in defence policy. Moreover, while major countries have had the tendency to protect and subsidize their own national producers of military weapons, smaller countries have relied mainly on imports from political patrons and allies. Given the 'public good' nature of defence and the large cross-border spill-over effects across countries, this situation potentially generates – according to our conceptual framework in Chapter 2 – waste in MS spending and lack of overall military capabilities.

In recent years, the political debate about a common European defence system has regained momentum. The discussion about a common EU security policy is largely intertwined with industrial policy, and with the issue of the economic consequences of military spending not only in terms of sustaining aggregate demand but also of supporting innovation and development (Mogherini and Katainen, 2017). The resurgence of this debate has been partly the (indirect) outcome of the Wales summit of NATO (held in 2014), when the Readiness Action Plan was approved together with the so-called 'NATO rule' (2% of GDP allocated to defence). One pillar of the Readiness Plan was the necessity to create deployable forces for different types of missions. Moreover, MS agreed that as part of the drive to increase military budgets, novel capabilities should be developed, by allocating a constant proportion (20% of their defence budgets) to spending on major equipment, including related Research & Development.

The NATO summit clearly marked the beginning of a new period for military spending, but the agreement did not occur in a vacuum for European countries. In July 2013 the Commission released the Communication "*Towards a more competitive and efficient defence and security sector*" expounding three targets of a future roadmap: (i) An internal market for defence where European companies can operate without discrimination in all MS; (ii) a secure EU supply regime for armed forces of all MS; (iii) a European research program covering both security and defence. Since then, initiatives to pursue further integration and superior cooperation in military affairs have gained momentum. In March 2015, the Council established the review of an Athena mechanism devoted to financing the common costs for EU military operations. More importantly, in December 2017, the EU Council established the Permanent Structured Cooperation (PESCO). Unlike previous initiatives, PESCO is expected to pave the way for a future European defence force policy because obligations and commitments for countries are binding. Within the PESCO framework, MS are also to develop joint capabilities. Under the umbrella of PESCO two instruments are managed: (i) the Coordinated Annual Review on Defence (CARD) managed by the European Defence Agency (EDA) to monitor military expenditures at both MS and EU level; (ii) the European Defence Fund. There has also been work to develop the military industrial base, such as the establishment by Regulation (EU) 2018/1092 of the European Defence Industrial Development Programme (EDIP) an industrial programme that aims to support the capacity of the EU defence industry.

However, in spite of these recent advancements, the majority of military spending is still undertaken on a national basis. The continuous relevance of these issues is confirmed by the unilateral initiatives undertaken by MS or subsets of MS. We mention the development of fighter aircraft as one important example. France and Germany signed an agreement to develop a prototype of the next generation fighter jet, whereas Italy, Netherlands and the UK are involved in the project to build the F35 Joint Strike Fighter of US Lockheed Martin. Sweden still develops the Gripen fighterjet also chosen by Czech Republic, Hungary and Croatia. In the meantime, in 2019, Italy and UK signed an agreement to develop a sixth-generation jet fighter (the BAE Systems' Tempest). One could easily identify similar examples for other types of military equipment.

Moreover, in spite of well-known EU initiatives such as Airbus and MBDA, the industrial military landscape is still largely characterized by the existence of 'large national businesses' (e.g. Leonardo and Fincantieri in Italy, Thales in France, Navantia in Spain) surrounded by a plethora of national sub-contractors. MS still rely heavily on national industrial champions, which are often state-owned or have strong ties with some allies only. A clear indicator of the existence of still separate MS defence markets is the intra-industry index, which remains very low in spite of the technology available in this industry. A recent development is that some European 'large national businesses' have also become top exporters in a world market that is characterized largely by monopolistic competition. This has increased requests for political support and public subsidization by these companies.

Summing up, in spite of recent progresses, the EU defence industry is still characterised by the duplication of costly R&D programmes (e.g., to develop aircrafts, helicopters, missiles) and by small-scale production levels for MS markets that do not allow producers to develop significant economies of scale. Tellingly, Hartley (2020) shows that in Europe there are 180 different types of military equipment (rifles, ammunitions tanks, airplanes, ships etc) compared to only 30 in the US. Mogherini and Katainen (2017) also highlight the potential losses induced by duplication of projects. For instance, they note that in the EU there are 17 main battle tanks, 29 types of frigates and 20 fighter planes. The corresponding figures for the US are respectively, 1, 4 and 6. Duplication generates higher costs, induced by lack of interoperability, loss of technological advancement due to fragmentation in R&D and investment, and additional burden on defence budgets due to maintenance and operational costs etc. (see Briani, 2013, for a discussion). The fragmentation of defence markets in the EU, in addition to the lower level of spending, is the main cause of the technology and efficiency gap with the US. The duplication of R&D programmes across countries reduces the potential results from investments in terms of innovation, including potential positive technological spill-over effects on the private sector.

There is a shared awareness, supported by scientific studies (e.g., Fontanel and Smith 1991, Hartley 2003 and Kollias 2008), of the inefficiencies within the current European defence systems and of the potential efficiency and technological gains that could be obtained from exploiting a larger scale, by re-allocating at a European level some elements of defence procurement. The EU Parliament CONE Report (2019) estimates savings of €22 billion that could be obtained by integrating some defence functions at EU level. A previous study by Bertelsmann Stiftung (2017), focused on land forces only, finds (under a very strict and conservative assumption on wages) that there could be an opportunity for savings of between €3 billion and €9 billion per year.

7.2. Our approach

Our work goes beyond these previous studies by employing the methodology presented in chapter 3, which allows us to estimate the potential efficiency gains from the introduction of common EU spending on specific policy areas using benchmarking techniques. The common spending we discuss here goes beyond the simple idea of 'burden-sharing', which refers to military operations and general military spending. We consider some aspects of the defence system that could be further enhanced at the EU level under the PESCO framework.

As discussed in chapter 3, the DEA methodology requires the definition of inputs and outputs. However, unlike other public services, there are no established indicators of output/outcome for defence (a textbook example of a 'pure public good') and very few studies have discussed the topic along these lines (see however Hartley and Solomon, 2015). For instance, for defence, 'peace' is an obvious desired outcome. However, as common actions at the EU level have guaranteed peace for all

MS countries, the lack of variability means that this indicator cannot be used as an outcome measure in our benchmarking exercise. Beeres and Bogers (2012) also highlight that the best way to evaluate performance of the defence sector is by combining various indicators and measures. Faced with these difficulties, in what follows we employ two different indicators as 'output' for defence: (i) deployability of troops; (ii) R&D investment in defence as a proxy of future military equipment quality.

Deployability of troops is a potential measure for defence efficiency because it captures the capability of a country to respond quickly to conflicts and crises. As the input for this exercise, we focus on total defence expenditure. To guarantee robustness with our estimates, we employ alternative definitions for both deployability and defence expenditure. Our results highlight that there is ample room for efficiency gains by exploiting increasing returns to scale in the production of 'deployable troops'. In this respect, it seems clear that increasing common action at the EU level would generate benefits for the military capabilities of MS.

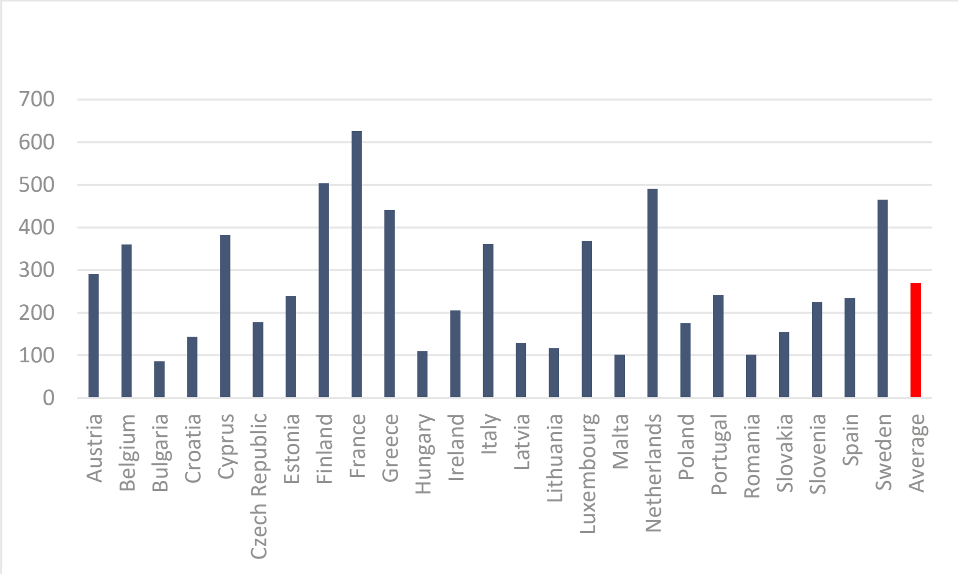
Secondly, as a more refined exercise, we focus on R&D expenditure in the military sector as a desirable 'output' of defence system. Indeed, there is extensive empirical literature which suggests that defence R&D expenditure is a proxy of future military capabilities. As the 'input', we focus on procurement of defence equipment. Our results show that most EU MS are some way from the efficiency frontier. The results also confirm that there is ample room for efficiency gains by exploiting increasing returns to scale. Larger countries on average already exhibit greater efficiency scores than smaller countries and the estimated production function across countries clearly exhibit increasing returns to scale. Re-allocation of competences to the EU would then generate benefits for all MS in terms of enhanced military capabilities.

7.3. Total defence expenditure and deployability of troops

The main input measure in this first exercise is total defence expenditure (per capita). We exploit data provided by the EDA as discussed below. We take the average for the period 2005-2017. The average defence expenditure per capita is €269 and the standard deviation is 151.63. Figure 7.1 presents ratios across the period 2005-2017 for the countries considered.

While identifying resources consumed as inputs is an easy task, attempting to define output/outcome measures in this policy area is much more complicated for the reasons discussed above. In this section, we use as an output indicator the number of 'deployable' troops that is the numbers of military personnel (e.g. soldiers) that could be readily employed in a conflict (land forces) on the total. This is both a measure of the effective military capability of a country and also a measure of its commitment to have a well-functioning army. Indeed, at the Istanbul Summit in June 2004, NATO defence ministers agreed that 40% of each nation's overall land force should be structured, prepared and equipped for deployed operations under NATO control. However, in 2017, according to EDA, the simple average quota of deployable forces in the EU27 was only 25.8% of total land forces. Figure 7.2 presents mean values across the period 2005-2017 of deployable troops (land forces) per millions of inhabitants. Greece is the MS with the highest ratio. Notice that *EDA does not provide data for Germany* and thus we are forced to exclude Germany from our analysis. This lack of data is not accidental. Because of the Second World War peace agreements, German military has been severely constrained in its development between 1945 and 1990. Even after 1990, the Treaty for the Final Settlement severely limited military developments in Germany. Glatz et al. (2018) notes that the current approach of German military engagement is centred on international military peace missions, but even the latter have gained a legal basis in Germany only in 1994. Notice also that because of Brexit, we decided not to include the UK in our main analysis. However, as matter of comparison, later on we will also briefly discuss an estimation including the UK in our computations.

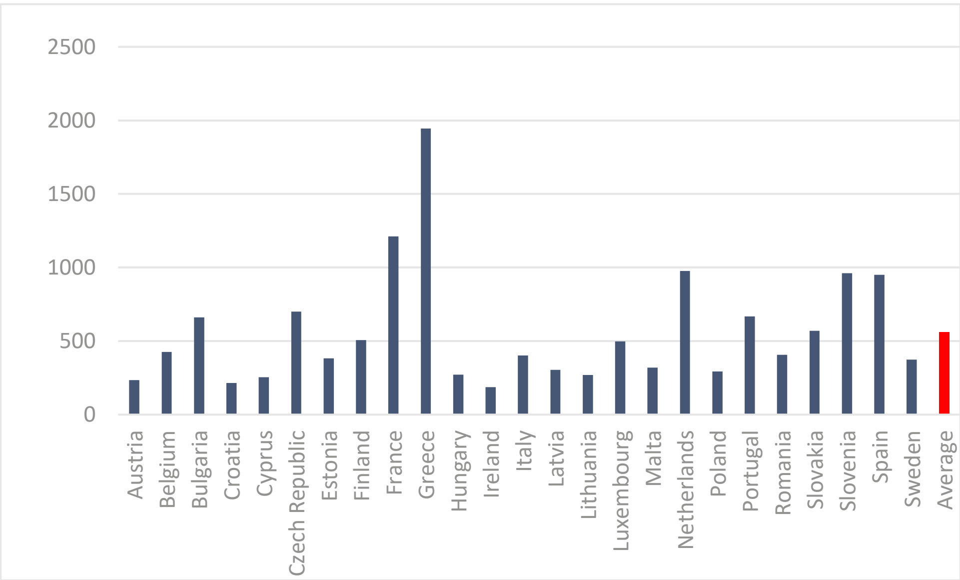
Figure 7.1: Defence expenditure per capita, mean values 2005-2017, € Constant terms (base year, 2015) Source:



Source: elaborations on EDA data, data on population from Penn World Tables.

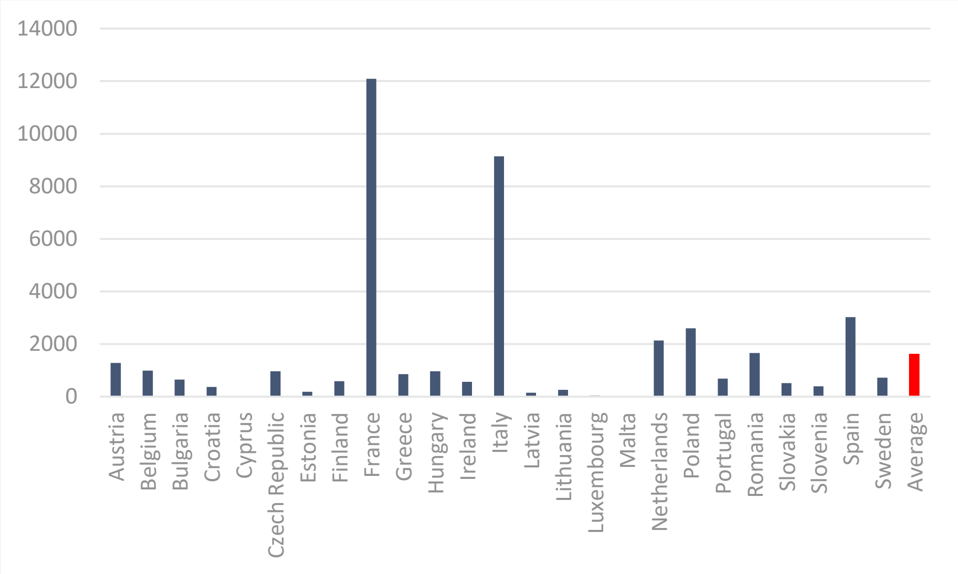
The EDA also reports the average number of deployed troops per country/year. Figure 7.3 reports the average number of deployed troops per year for MS countries across the period. The MS average is 1,6 thousand troop for millions of inhabitants and the standard deviation is 2,8, thus denoting a very high dispersion across MS. France and Italy are the major senders of troops. France has contributed to military missions by sending on average more than 12,000 troops per year between 2005 and 2017, while the average for Italy is just above 9,000.

Figure 7.2: Deployable troops per million inhabitants (mean values, 2005-2017) Source:



Source: elaborations on EDA data, data on population from Penn World Tables.

Figure 7.3: Average deployed troops per year across the period 2005-2017 Source:



Source: EDA

Using the definitions of input and output discussed above, we employ an input-oriented DEA VRS model (see Chapter 3 for details) to estimate waste in total spending across MS. Table 7.1 presents our results. Bulgaria, France, Italy and Romania appear to be the most efficient. The DEA estimation returns an average efficiency score *Θ* of 0.54 for all MS whereas the average efficiency score for larger countries is 0.85. That is, larger countries appear to be more efficient than other MS, an implicit indicator of the existence of returns of scale (see below). France and Italy in particular exhibit an efficiency score equal to 1, whereas the corresponding figures for Poland and Spain are respectively 0.765 and 0.635.

Using our estimated *Θ*, we can compute the waste for each MS. For each country, the current waste is computed as: *waste* = (1-*Θ*) x *Actual Input* where *Actual Input* is the average level of defence expenditure per capita across the period 2005-2017. The third column of Table 7.1 reports the current average waste for countries; this is slightly larger than €1.2 billion with a standard deviation of 1,7. Summing over all countries, the average current waste per year is about €31.5 billion. Notice that for larger countries (Italy, France, Poland and Spain) the total waste is only €5.5 billion, again pointing to relevant scale effects. We can use the VRS-DEA model to directly check for the existence of returns to scale in the production function (see again Chapter 3 for a discussion on the methodology). We report the results of this check in the fifth column of Table 7.1, where IRS stands for 'increasing returns to scale'. As can be seen, production functions for all countries, except France and Italy, show increasing returns to scale. This evidence confirms that common action in troop deployment at the EU level would allow the EU to exploit the benefits that can be generated from increasing returns to scale and improve military capabilities.

Including the UK[52] in the analysis would not change much our results. Not surprisingly, given its size and large spending, the UK appears to be on the efficiency frontier, exhibiting an estimation of *Θ* =1 and therefore no waste. The relative position of the other countries also does not change much.

[52] We can do it only for the period 2005-14 because of data availability.

Consequently, summing over all countries, the average current waste per year also does not change much, raising to about €31.6 billion, only slightly larger than the previous estimation.

Table 7.1: DEA estimation: defence expenditure per capita and employed troops

Country	Efficiency score (VRS model)	Defence expenditures per capita (€) (average 2005-2017)	Average aggregate waste(€m) = average waste per capita x population 2017	Scale efficiency	Returns to scale
Bulgaria	1	86.03	0	0.30	irs
France	1	625.61	0	0.76	drs
Italy	1	360.62	0	1	crs
Romania	1	101.45	0	0.64	Irs
Malta	0.85	101.24	6.54	.01	irs
Hungary	0.83	109.90	184.61	0.42	irs
Poland	0.77	175.22	1569.03	0.76	irs
Lithuania	0.74	116.74	88.67	0.12	irs
Latvia	0.67	129.11	83.92	0.067	irs
Spain	0.63	234.22	3963.96	0.80	irs
Croatia	0.60	143.98	242.67	0.17	irs
Slovakia	0.56	154.66	373.67	0.24	irs
Czech Republic	0.51	177.22	917.19	0.42	irs
Ireland	0.42	205.14	567.03	0.26	irs
Slovenia	0.38	224.80	288.59	0.18	irs
Estonia	0.36	238.67	199.86	0.08	irs
Portugal	0.36	241.15	1594.96	0.31	irs
Austria	0.33	289.99	1696.49	0.53	irs
Belgium	0.25	360.32	3075.44	0.43	irs
Netherlands	0.24	490.38	6351.23	0.71	irs
Luxembourg	0.23	368.37	164.72	0.02	irs
Cyprus	0.23	381.77	252.88	0.00	irs
Greece	0.20	440.73	3922.99	0.38	irs
Sweden	0.19	465.38	3747.92	0.33	irs
Finland	0.17	503.57	2305.99	0.17	irs

Robustness analysis

To check the robustness of our findings, we consider two alternative models employing different definitions of both input and output variables. In particular, we consider (i) total defence expenditure (input) and employable troops (output); (ii) total defence expenditure (input) and average employed troops (output).

(i) Total Defence expenditure and deployable troops

The first robustness exercise employs defence expenditures and deployable troops in levels. In other words, in what follows we consider defence expenditures expressed in € millions at constant prices (base year 2015) and the count of employable troops. An input-oriented DEA VRS model is used to estimate waste due to lack of efficiency. Bulgaria, France, Greece, Malta and Spain appear to be the most efficient countries. The average efficiency score is 0.504. With the exception of Poland, larger countries exhibit efficiency scores larger than 0.80, recording an average figure of 0.79. We compute the national and average waste by means of our estimated *Θ*. For each country, the current waste is computed as: *waste*= (1-*Θ*) x *Average level of defence expenditure across the period 2005-2017*. The average waste per country/year is almost €1.32 billion. The average current waste per year summing for all the countries is slightly larger than €32.9 billion. In this case only 14 countries, the smaller ones, exhibit IRS.

(ii) Defence expenditure and deployed troops

As a further robustness test, we consider as output the actual number of deployed troops with level of defence expenditure as the input. In this case, the average efficiency score is 0.607, implying that EU countries are characterised by an average level of inefficiency of about 39% of current spending. The average efficiency score for large countries is about 0.8 so that again these countries appear to be more efficient in deployment of troops. In the light of such efficiency scores, the average waste per country/year is almost €1.3 billion. The average current waste per year summing all the countries is slightly larger than €32.1 billion. Only 11 countries out of 26 exhibit increasing returns to scale.

7.3.1. Summary

Our exercise using DEA estimations suggests the existence of potential benefits from further European integration of troop deployment. Whatever the definition of input/output used, larger countries turn out to be more efficient, and in most cases, except for the very large countries that already exploit returns to scale, the production functions of MS exhibit IRS. Table 7.2 below summarizes the variables used, the estimated waste and the number of countries that demonstrate increasing returns to scale. There is clear-cut and substantial waste, which could be reduced by further integration in defence expenditure across MS. Table 7.3 reports the Spearman's Rank correlation coefficients between the different estimates of waste. All coefficients are positive and statistically significant. That is, our estimates are solid and statistically interdependent.

Table 7.2: Synoptic table of results

Input	Output	Average efficiency score	Waste (€ billion)	countries with IRS
Defence expenditure per capita	Average deployed troops	0.54	**31,6**	25
Defence expenditure	Deployable troops	0.50	**32,9**	14
Defence expenditure	Average deployed troops	0.61	**32,1**	11

Table 7.3: Spearman Rank Correlation Coefficients for estimates of waste

Input / output	Def.exp. pc / av. Deployed troops	Def.exp. /deployable troops	Def.exp. / deployed troops
Def.exp. pc / av. Deployed troops	1		
Def.exp. /deployable troops	0.42**	1	
Def.exp. / av. deployed troops	0.43**	0.43**	1

Summing up, our results then provide strong support for strengthening initiatives such as the EU Battlegroups. These are are military units managed under the Common Security and Defence Policy (CSDP) framework. They have been created in 2005 to serve hypothetically as a EU rapid response capability to face international crises. But they are currently underfunded and underdeveloped, with also a complex governance mechanism that would need to be streamlined to make them effective (see Reykers 2017).

An important limitation of our results is that Germany, the largest MS, is not included in our computations for the reasons explained above. A further complication is that a complete analysis of efficiency in the deployability of troops should also consider NATO allies that are not members of the EU, in particular the US and the UK. As we discussed above, including the UK does not seem to change much our global results of inefficiency. On the other hand, just adding the UK is not enough, because the US still has a substantial number of troops across Europe and US troops are decisive for many reasons. A further point is that as we said above, NATO has a target percentage quota of deployable troops with respect to the total military personnel. However, currently the average percentage quota of MS is well below the NATO target.

7.4. Equipment procurement and R&D in defence

The previous exercise based on total defence spending provides a rough approximation of the benefits that could stem from increased common action in defence policy at the European level. To improve our understanding of the potential gains, in this section we refine the analysis and concentrate on specific spending items, for which one can define more easily output/outcome measures. In particular, one can think of a 'production function' in which spending for equipment procurement today will lead to better and more technologically advanced equipment in the future. In this respect, a sensible outcome measure for defence is the 'quality of future military equipment', as the level of supply of 'defence' clearly depends on the technological level of military equipment. We then proxy the 'quality of future military equipment' with the present level of defence R&D expenditure. In light of the evidence produced by Middleton et al. (2006), we rely upon the idea that *current* defence R&D determines *future* military equipment quality and impacts on final defence outcome. As an input, we use expenditure on equipment procurement, as typically military procurement stimulates R&D towards improving reliability and performance of existing systems (Movery, 2010). In other words, the basic hypothesis in this section is that spending in equipment procurement (input) stimulates R&D in defence (intermediate output), which will determine the quality of military equipment in the future (outcome).

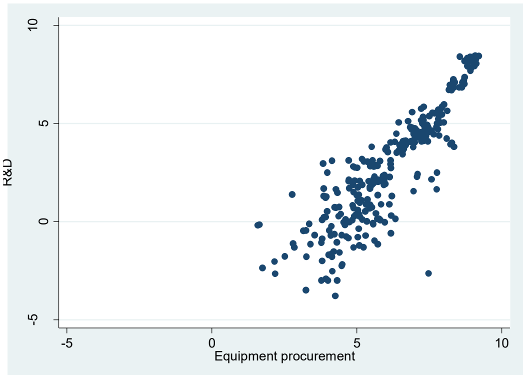
In this respect, it is worth recalling that all Nato members, including therefore all Nato countries also members of the EU, at the 2014 Wales summit agreed to increase their military spending to 2% of GDP and – more importantly in this context – to devote a 20% quota of the defence budget to equipment procurement. As in the previous exercise, data for the analysis are drawn from EDA and the time period considered is 2005-2017. Since data are at current nominal prices, we convert them to constant prices taking 2015 as the base year. Figure 7.4 shows a positive correlation between defence R&D spending and equipment procurement.

Before applying our DEA methodology, we employ panel regressions to study potential different lags for equipment procurement as explanatory variables of R&D. The regression model is discussed in Annex A.7. Results of the regressions suggest that the *stimulus* of equipment procurement on R&D decreases over time but still remains positive. For example, taking a 4-year lag of equipment procurement, the expected change in R&D with respect to a 1% change in equipment procurement is 0.35%. Taking a 2-year lag of equipment procurement the expected change in R&D with respect to a 1% change in equipment procurement would be 0.54%. These results confirm that defence equipment procurement is a significant predictor of defence R&D expenditure so supporting our choice of variables.

7.4.1. DEA estimations

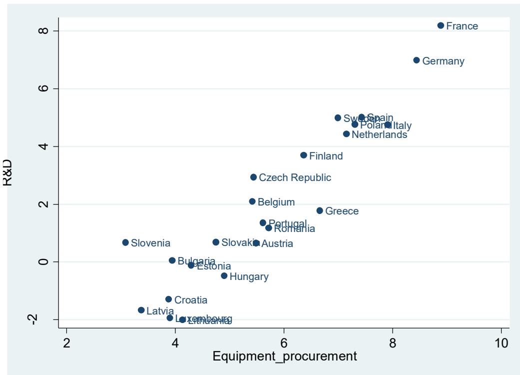
In this section, we present the results of our DEA estimations. Equipment procurement is in € million and the output variable is R&D expenditure in defence in € million. The time period covered is 2005-2018. Cyprus, Ireland, Latvia, Lithuania, Luxembourg and Malta have been omitted from the analysis due to a lack of data. We consider a single record per country using the average values across time of the variables considered. The average equipment procurement per country is €1.2 billion and the standard deviation is 1857. The average expenditure is defence R&D is €278.2 million and the standard deviation is 828.4. Figure 7.5 confirms the clear-cut positive correlation between the mean value of defence R&D and mean equipment procurement expenditure. As in our previous exercise, we use our definition of input and output in an input-oriented DEA VRS model to estimate waste due to a lack of efficiency. Table 7.4 reports the estimated efficiency scores (Θ). France and Slovenia appear to be the most efficient countries. The average efficiency score is 0.339, implying that the EU countries are characterised by an average level of inefficiency slightly above 65% of current spending. Taking into account the size of countries in terms of population, larger MS (France, Germany, Spain, Poland and

Figure 7.4: Defence R&D spending and equipment procurement



Source: elaborations on EDA data

Figure 7.5: Defence R&D and equipment procurement (log of mean values, 2005-2018)



Source: elaborations on EDA data.

Italy) on average appear to be slightly more efficient than smaller countries. The former exhibit an average Θ equal to 0.354.

Using our estimated Θ, we can compute the waste for each MS. For each country, the current waste is computed as: *waste*= (1-Θ) x *Actual Input* where *Actual Input* is the average annual level of equipment procurement across the period 2005-2018. The second column of Table 7.4 reports the current waste for countries. In other words, the average waste per country/year is slightly larger than €635 million whereas summing over all countries the average current waste per year is slightly larger than €12.7 billion. Larger countries on average exhibit a waste equal to €1.57 billion.

We also use our methodology to characterise returns to scale of the production function (see Chapter 3). All countries except France exhibit increasing returns to scale. This result confirms that a larger scale would generate benefits in terms of future capabilities for EU MS. To summarise, the presence of increasing returns to scale in several countries supports the idea that encouraging further integration in defence equipment procurement would enhance the development of future capabilities for EU.

Table 7.4: Efficiency score and average waste in defence R&D

Country	Efficiency score (VRS model)	Average equipment procurement expenditure (€m) (2005-2018)	Average waste(€m)	Scale efficiency	Returns to scale
France	1	7332.63	0	1	crs
Slovenia	1	38.41	0	0.35	irs
Croatia	0.76	50.74	12.33	0.02	irs
Bulgaria	0.51	75.19	36.77	0.07	irs
Germany	0.47	4749.49	2508.68	0.99	irs
Estonia	0.47	81.80	43.38	0.06	irs
Sweden	0.32	1109.84	758.35	0.93	irs
Slovakia	0.31	125.96	87.54	0.16	irs
Hungary	0.26	149.02	110.60	0.64	irs
Czech Republic	0.26	245.43	182.36	0.61	irs
Spain	0.20	1890.85	1521.95	0.94	irs
Poland	0.19	1587.25	1292.97	0.92	irs
Finland	0.18	595.94	487.84	0.77	irs
Belgium	0.17	243.14	201.85	0.40	irs
Netherlands	0.16	1315.8	1107.25	0.88	irs
Austria	0.15	264.83	226.40	0.13	irs
Portugal	0.14	281.26	241.15	0.38	irs
Italy	0.11	2831.73	2514.29	0.92	irs
Romania	0.09	413.42	375.01	0.24	irs
Greece	0.05	1053.37	997.44	0.56	irs

Again, a similar exercise also including data for the UK (for the years 2005-2017 only) would not change the results significantly. The UK appears to be very close to the efficiency frontier exhibiting a $\Theta = 0.87$ and increasing returns to scale in the technology. Considering the UK too and summing over all countries, the average current waste per year would increase to about €13.8 billion.

7.4.2. Results from an output-oriented DEA model

In what follows, for completeness, we estimate an output-oriented DEA VRS model. An output-oriented DEA model determines the potential output expansion given current consumption of inputs if the decision-taking unit had operated on the efficiency frontier. The output-oriented DEA analysis will determine potential defence R&D expenditure given current levels of equipment procurement if the MS operate efficiently along the frontier. Using our estimated MS Θ, it is possible to compute the potential gain for EU countries. For each country, the potential gain is computed as: PG = (1-Θ) x *Actual Output* where *Actual Output* is the average level of defence R&D across the period 2005-2018. The average potential gain per country/year in output would have been equal to €62.95 million keeping the level of inputs constant, whereas the average potential gain per year summing all the countries is just above €1,2 billion. In particular, large countries on average would have a potential gain equal to €193.55 million each. The Spearman rank correlation between the current waste presented in Table 7.4 and the potential gain computed here is 0.894 and statistically significant.

The figures drawn from this exercise are substantial when contrasted with the present efforts by EU institutions to run common military projects, including procurement. For instance, the EU Commission in 2020 announced a €205 million financing of sixteen pan-European defence industrial projects and three 'disruptive technology' projects. In general, between 2019-2020, pilot programmes of the European Defence Fund, namely the European Defence Industrial Development Programme (EDIDP) and the Preparatory Action on Defence Research (PADR) were worth respectively €500 million (2019-2020) and €90 million (2017-2019).[53]

In sum, keeping the same level of equipment procurement, there is room for a gain in the level of defence R&D and therefore in the expected quality of future equipment. In addition, even with the output-oriented model we estimated the presence of returns to scale. When using an output-oriented DEA model, all large countries except France, exhibit increasing returns to scale so confirming that a larger scale would generate benefits in terms of future capabilities for EU MS.

7.5. Concluding remarks

In this chapter, we estimate the current waste in the European defence sector by means of the DEA methodology discussed in Chapter 3. We run two exercises. First, we consider a model with the defence expenditure per capita as the input and the number of deployed troops as output for the period 2005-2017. Secondly, we used as input military equipment procurement and as output R&D expenditure to proxy for the future quality of equipment for the period 2005-2018.

In the first exercise, in the baseline model, we obtain a **total waste of approximately €32 billion**. Similar figures also emerge in the robustness exercises we perform, in which we modify the definition of inputs/outputs. Larger countries appear to be on average more efficient than smaller countries in our defence modelling, and our methodology suggests the existence of increasing returns to scale in the production functions of most countries. There is therefore strong evidence of potential efficiency gains if common EU spending in troop deployability is facilitated.

[53] For more detail, see the press release https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1053 .

For the second exercise using military procurement and R&D, the main results are: (i) on average EU MS are far from the efficient frontier; (ii) larger countries on average exhibit greater efficiency scores than smaller countries; (iii) **the total waste is slightly larger than €12.7 billion**; (iv) all countries (except France) exhibit increasing returns to scale. The latter result suggests that common spending in military procurement would indeed generate large benefits in terms of future capabilities for EU MS.

It is worth stressing some caveats of our research. First, because of the period considered, PESCO could not influence our results, as this agreement was only signed in December 2017. It might be that growing cooperation under PESCO will improve in the future the efficiency of the less efficient MS. Second, as our focus here is the EU, the main analysis has not considered the UK, although we also showed that extending the computations to this country would not affect much our global results of inefficiency. However, the real point is that the UK has a pivotal role in the European security landscape and many EU defence businesses are deeply integrated with British producers. In this respect, the relationship between the UK and the EU after Brexit, or more generally between NATO and EU MS, will continue to be decisive in determining the efficiency of the European defence system in the future. Third, there is a problem of data availability. This is hugely significant in the first exercise studying troop deployment, because EDA does not release German data, but it is serious also in the second, as a lack of data forced us to omit several countries from the analysis. Further research ought to be based on a full dataset to define more precisely the amount of financial resources in defence that could be better used at the EU level.

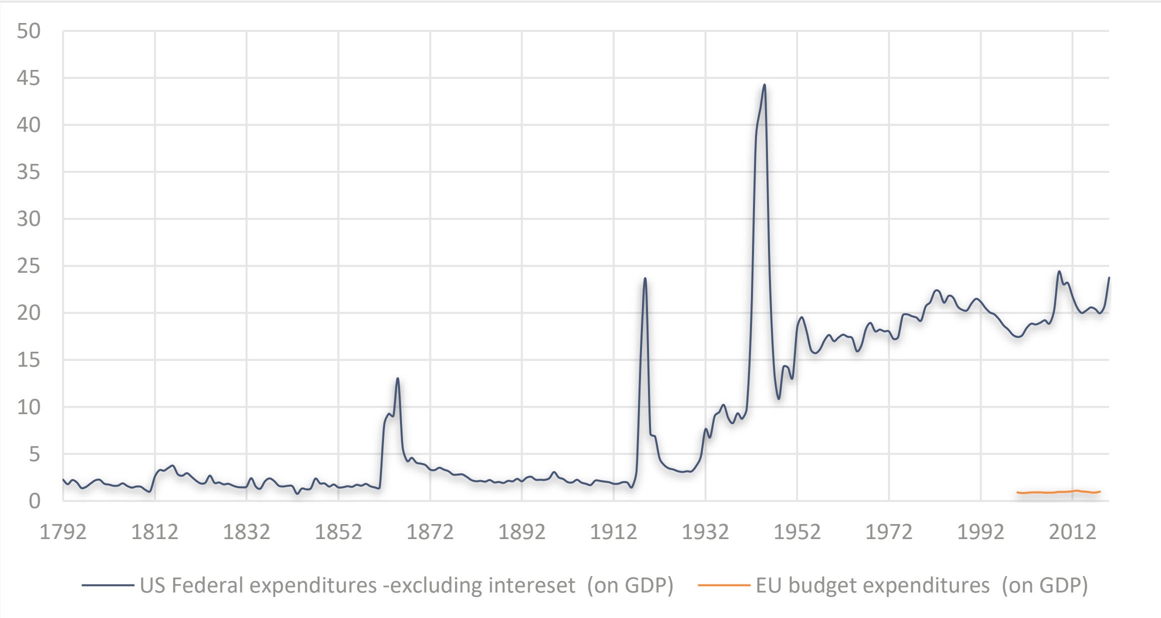
8. Lessons from the US

8.1. Introduction

Our empirical analysis shows the existence of large amounts of waste in the production of services in the EU countries and the potential advantages that could come from common policy at the EU level in a number of selected areas, particularly for policies that could exploit large returns to scale and important spill-overs across countries. However, the existence of potential benefits does not necessarily mean that these efficiency gains would be realized if that particular function were moved to the EU level, as this depends on how that function would be managed once delegated to European institutions. Moreover, several aspects of the relationship between the Union and the MS, whose choices in particular areas have developed in the context of MS political preferences and MS institutions, should be considered. All functions discussed in the previous chapters involve MS sovereignty; the efficiency advantages of devolving them to EU institutions need to be compared with the potential costs and benefits of having to co-decide future policies with other countries rather than autonomously.

It might then be useful to compare our results and policy prescriptions with the experience of other federations that faced similar questions. In particular, a comparison with the US experience is appropriate, both due to the importance and size of the US economy, comparable to that of the EU, and because the US federation also evolved starting from autonomous states that still retain important margins of self-rule. Moreover, the US is a solid democracy, with political institutions similar to those of European countries and of the EU in many respects. In what follows, we first discuss the evolution of federal fiscal relationships in the United States looking for ideas that can inform the EU case. We then discuss the organization and the spending in the four functions that we have analyzed empirically, namely Health Policy, Energy Policy, Unemployment Benefits and Defence, looking in particular at the relationship between the federal and the state level in the provision of these services.

Figure 8.1: US federal expenditures and EU expenditures on GDP, 1792-2018



Source: Williamson (2012), OMB, US Census, IMF, European Commission and Eurostat

8.2. The Evolution of the US federation

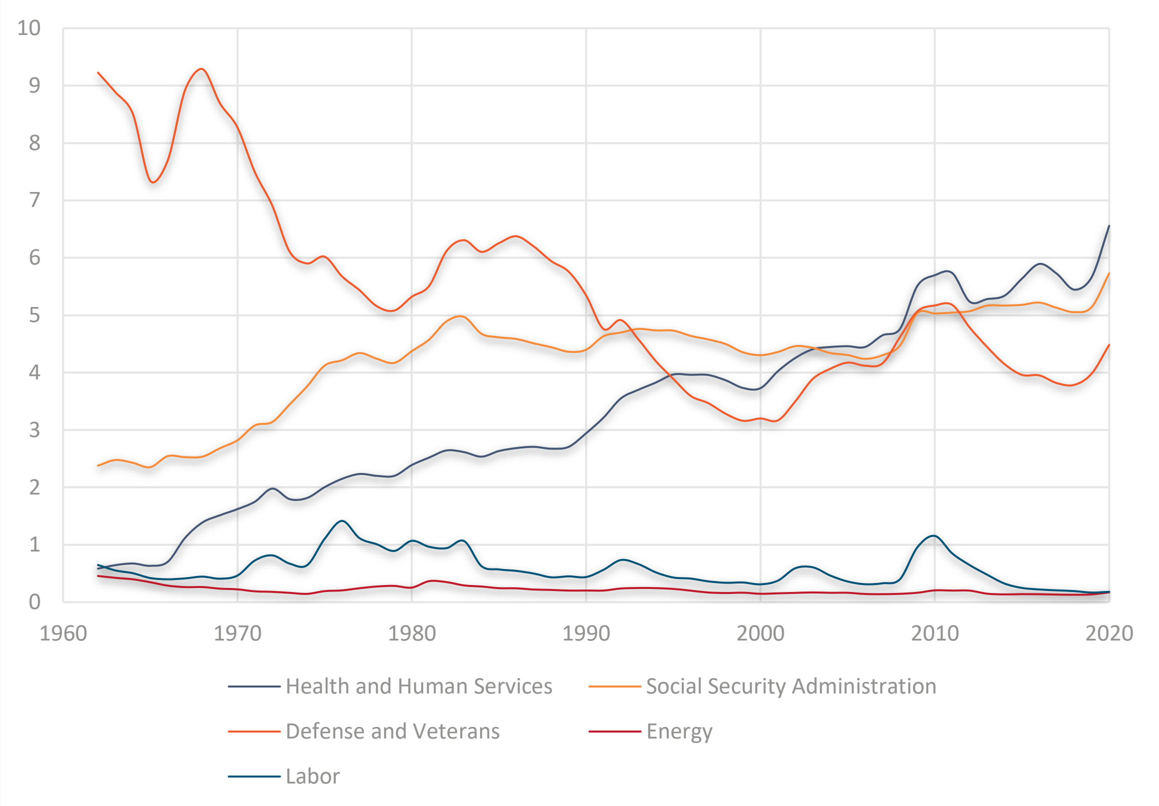
As we can see from Figure 8.1, which plots the temporal evolution of both the federal expenditure in the United States and the budget of the European Union (EU), federal expenditure in the US, excluding peaks due to wars, began to grow significantly only after the New Deal in the 1930s, about 150 years after the foundation of the country. Although the EU budget now stands at a much lower level (1% of GDP) than that of the US federal government (20% of GDP), it is worth observing that the United States took almost a century to reach the current levels of European expenditure. The history of the US fiscal union, therefore, is a reminder of the need to take a long view when discussing the movement of functions and resources to the European level (Kirkegaard and Posen, 2018), even if this comparison needs some caution given the very different situations faced as the US grew in the 19th and 20th centuries and the EU as we move into the 21st.

It is also important to highlight that the centralization of expenditures in the US took place during times of particular crisis, when the need for national survival overcame resistances to centralization that were often led by a fear of increasing central government power.

The first peak of US federal expenditures coincided with the federal state's necessity to finance the US Civil War (1861). In this period, exceptional fiscal measures were adopted, such as an increase in import tariffs and the introduction of an unprecedented federal personal income tax. This centralization was accepted only because of the war-time emergency, and indeed as can be observed by Figure 8.1 after the end of the US Civil War (1865) the level of US federal expenditure returned to near the previous levels.

A second shock occurred with the First World War (1917-1918). The cost of this was approximately ten times higher than the Civil War, so unsurprisingly centralized expenditure was also much greater. Federal income tax and other taxes rose to unprecedented levels, and at the same time, part of the increased expenditures was financed through an increase in public debt. The federal government successfully sold bonds to tens of millions of Americans (The Liberty Bond campaign) creating over $19 billion of the total US Treasury net debt. The war effort gave the federal government large economic powers but more importantly demonstrated what federal government powers could achieve. The First World War showed American citizens the enormous economic potential of a powerful central government and marked the point of no return to a minimalist federal government (Kirkegaard and Posen, 2018).

Figure 8.2: US federal expenditures on GDP, by Agency (1962-2020).

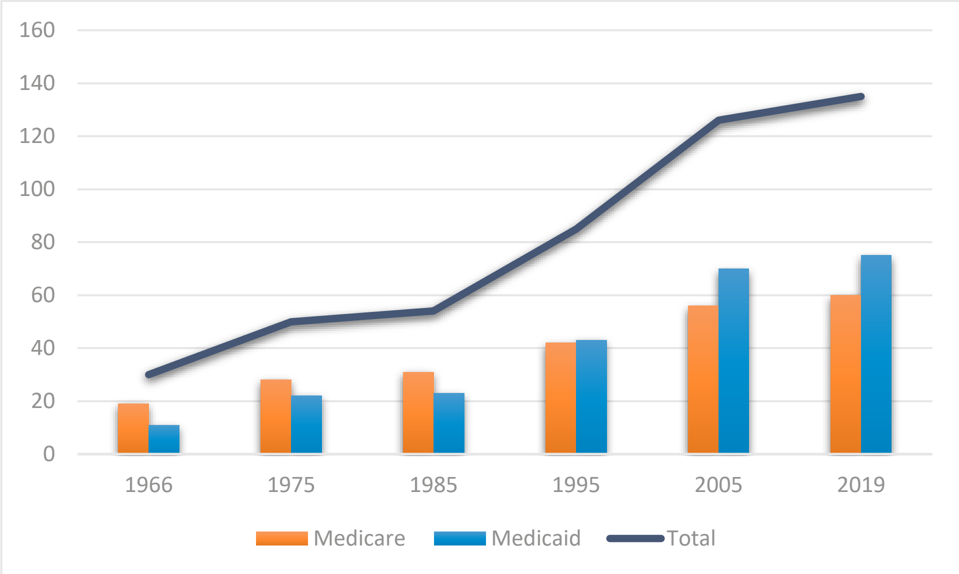


Source: OMB, 2020 estimate

In the 1920's, federal government expenditures continued to grow, especially due to federal subsidies to selected industries and the direct involvement of the central government in infrastructure construction. Moreover, the New Deal in response to the Great Depression (1929-1933) definitively strengthened the role of the federal government, authorizing greater spending and public deficit. In the 1930's new federal government institutions, which have remained active, were established with the aim of providing direct support to the unemployed and supporting state and local governments. As a reaction to the economic crisis, in 1935 the Social Security Act was approved, establishing generally available old age pensions in the United States; it facilitated states' unemployment insurance schemes; and provided states with grant funding for old age assistance, public health, aid to the handicapped, and other social causes. The Second World War (1941-1945) marked a further emergency that allowed the centralization of public spending for war purposes, in a similar way to the situation during the First World War.

A general message that then emerges from the US historical experience is that centralization and federal expansion typically occurs because of large crises, when it becomes obvious that the emergency can only be managed efficiently by pooling resources at a central level. Wars are the most telling examples, but large economic crises also played an important role. Once centralization occurs, federal spending only partially returns to pre-crisis levels, as institutions developed to fight the emergency tend to persist and become engrained in the system and acceptable by citizens because of their higher value and efficiency. The potential similarity with the present COVID-19 crisis and the tools created by the EU to fight the crisis, such as SURE and the New Generation Fund, is obvious.

Figure 8.3: Medicare and Medicaid budgets, in millions of dollars.



Source: Centers for Medicare & Medicaid Services (CMS)

Figure 8.2 shows the evolution of US federal expenditure by function: the most relevant functions are Health Care, Social Security and Defence. The first two show an increasing trend from 1960 to 2020, while Defence spending was on a decreasing path until 2000 and then started increasing again. In 2020, federal spending in Defence was more than 4% of GDP, Social Security 6% of GDP and 6.5% on Health Care. On the contrary, Energy spending and Labor benefits make up only small fractions of federal expenditure.

8.3. Health policy

8.3.1. Relationship between the Federal government and the states

The United States does not have a unique national system of health insurance and, unlike most countries in the European Union (see Chapter 4), private health insurance is the prevailing system of finance. The two major public health insurance mechanisms are Medicare and Medicaid, both established in 1965 with the Social Security Act. In 2019, Medicare processed over one billion fee-for-service claims from 60 million individuals (mostly over 65) while Medicaid was the primary source of health care for more than 75 million low-income adults and children.[54] Medicare is administered by a federal agency (the Centers for Medicare and Medicaid Services, CMS), while the states and the federal government are jointly responsible for the Medicaid program. Both programs have been increasing in value in the last 50 years (Figure 8.4).

Medicare is a uniform national public health insurance program for people older than 65 and for persons of any age with disabilities and End-Stage Renal Disease (ESRD). The Health Insurance contribution rate is set at federal level: 1.45 percent of earnings, to be paid by each employee and a matching amount by the employer, and 2.90 percent for self-employed persons. People younger than 65 need to buy health insurance privately. Turning to Medicaid, the Federal Government pays a share of the medical expenditures under each State’s program. That share, known as the Federal Medical

[54] Over 10 million people are dually eligible, that is, covered by both Medicare and Medicaid.

Assistance Percentage (FMAP), is determined annually by a formula that compares the State's average per capita income level with the national income average. By law, FMAP cannot be lower than 50 percent or higher than 83 percent. The lower a state's per capita income with respect to the average, the higher the FMAP for that state, so states with higher per capita income level are reimbursed a smaller share of their costs.

8.3.2. Public Procurement and R&D

Although the US's public procurement system is particularly fragmented, many goods and services are purchased at the federal level. Indeed, in fiscal year 2019, the US Federal Government spent $597 billion on contracts, with an increase of 6% compared to the previous year (Bloomberg Government, 2020). As for health care, federal procurement is administered at the Department of Health and Human Services. For the medical and healthcare contracts, this department paid contracts for $26.5 billion in 2019, with a significant increase of $2.4 billion compared to the previous year. The largest of these contracts typically pay for medications and vaccines from drug companies, and for services from IT companies. Healthcare federal contracts are characterized by a very concentrated audience of suppliers. In the fiscal year 2019, 66% of Health and Human Services contracts worth $17.5 billion were awarded to the top one hundred companies.

All levels of government support research in the medical sector in the United States. The most important source of support at the federal level is the National Institute of Health (NIH), which oversees advancements in all aspects of biomedical research. The NIH preferentially funds basic and purely academic research, although there are special calls and funding opportunities for studies closer to clinical issues and biomedical innovation. In 2017, total U.S. medical and health R&D spending was $182.3 billion. Federal agencies invested a total of $39.5 billion, with the NIH accounting for nearly

Figure 8.4: Health expenditure by government schemes for medical goods as a percentage of GDP

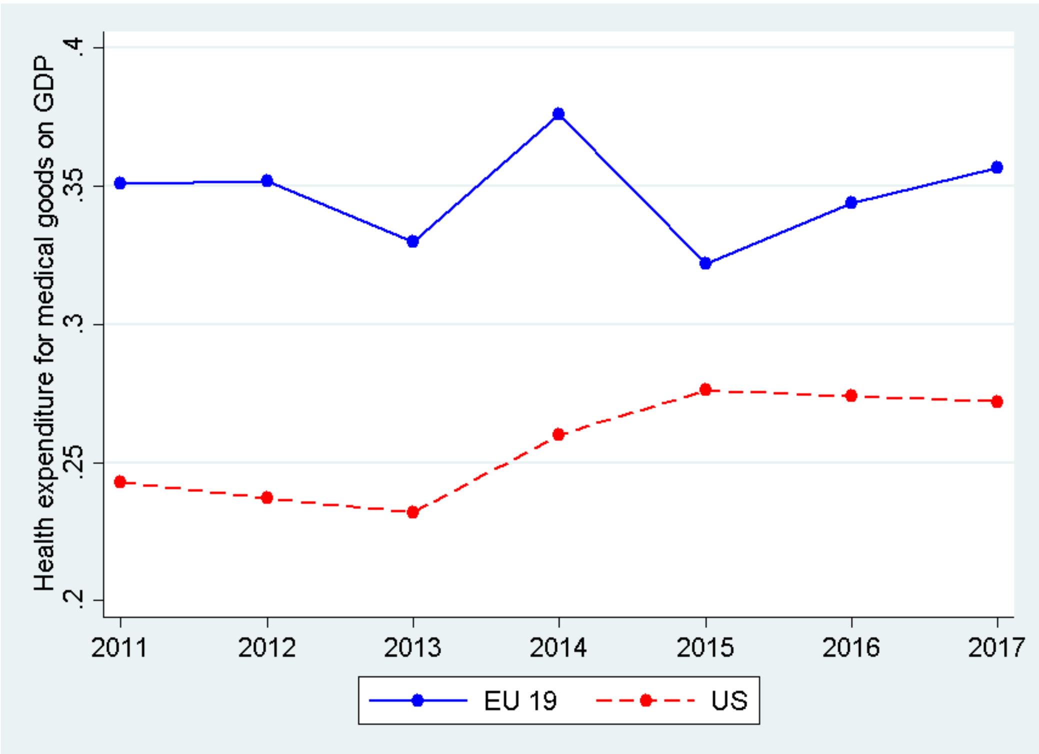
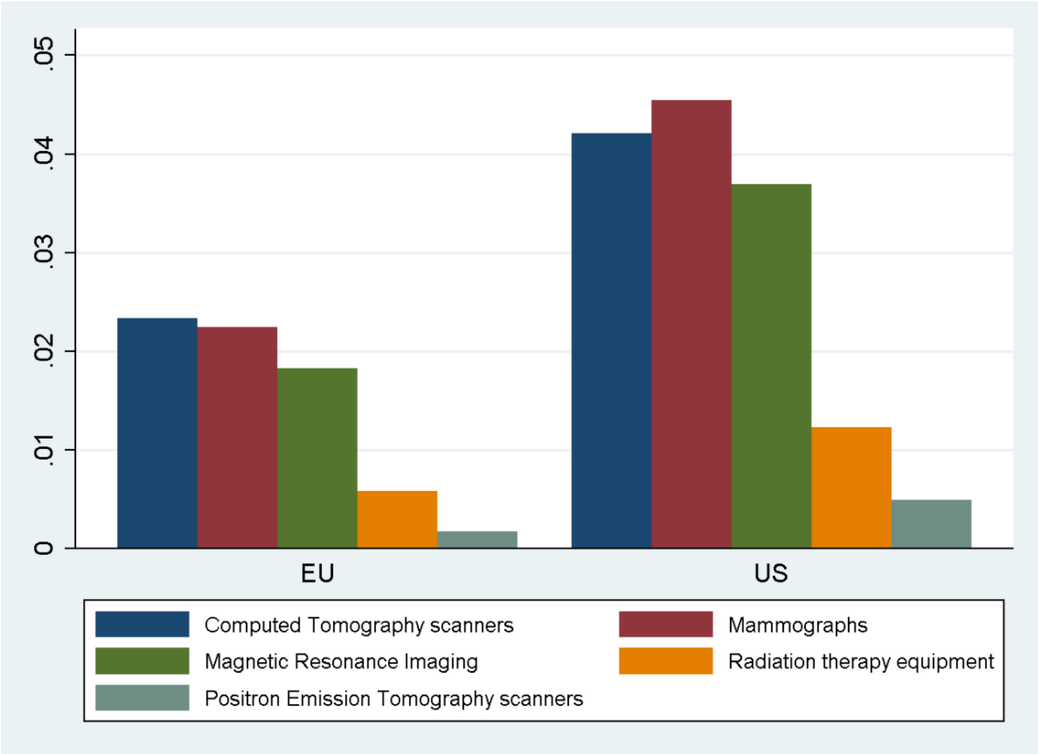


Figure 8.5: Medical technologies for 1,000 inhabitants, average value 2011-2017.



Note: 19 EU countries data available for Computed Tomography scanners, 15 for Mammographs, 17 for Positron Emission Tomography and Magnetic Resonance Imaging units, 14 for Radiation therapy equipment.

82.1% of federal spending; state and local government support accounted for just 1.3% of total U.S. investment in medical and health R&D (Research America, 2018).

8.3.3. Comparison with our results

The difference between the market based US health care system and the European ones, largely founded on universal coverage financed through general taxation or with a system of compulsory collective social security is too large for the first to be considered as a potential model for the second. Moreover, the US private health system has well known problems in term of excessive costliness and insufficient coverage of the population. Still, there are elements to consider and lessons that the EU can learn from the US experience. In line with our suggestions in Chapter 4, in the US public procurement of medical and health care services, especially for drugs and vaccines, is almost a federal competence, with potentially large cost savings. On the contrary, very few common health programs are funded directly by the EU budget and in general even across-the-border procurements are rare, as only 1.6% of national EU public contracts are won by a company operating in another EU country (EU Commission, 2011). Interestingly when we compare the medical technologies (purchased by government schemes) per 1,000 of inhabitants averaged in the period 2011-2017 we find that EU has a lower number than the US (Figure 8.5) even if the proportion of GDP spent on procurement is greater in the EU than in the US (Figure 8.4). Notice that in the US medical technologies are purchased also by the private sector, so we should divide the number of medical technologies by the population served by the public sector, however in this case we would obtain an even greater ratio than that obtained by dividing by the total population.

Moreover, federal authorities manage and finance the majority of research and development spending in the medical and biological fields in the US. The most important federal source of support is the NIH which oversees the advancement of all aspects of biomedical research. The NIH mainly funds basic and purely academic research, however there are special calls and funding opportunities targeted at different types of research closer to clinical issues and biomedical innovation. Funding is still largely national in Europe, which presents a risk of duplication of projects and waste of resources. Interestingly, when looking at average health expenditure by government schemes data 2011-2017 in medical goods, as defined by OECD (Table 8.1),[55] we see that US spends €45 billion and EU spends €42 billion, very similar sums. However, when we look at selected medical equipments (like Computed Tomography scanners, Mammographs, Positron Emission Tomography, Magnetic Resonance Imaging units, and Radiation therapy equipment) for which data on quantities are available (source OECD), it is immediate to notice that purchased quantities are quite different between US and EU. The EU MS are able to buy almost 23,000 units of these medical equipments while the US buys 45,000 units. Clearly, total expenditure for medical goods includes other items for which we do not have data on quantities. However, assuming a bias of the same magnitude (in percentage of the number of the selected medical technologies) in EU and US, a very simple back-of-the-envelope calculation suggests that the unit cost of purchasing medical technologies is 1.84 million per unit for EU and almost 1 milion for US. This suggests that if the EU adopted the procurement system of US there could be important savings. In particular, assuming the same unit cost of US to buy the same quantity of medical equipments (23,000) in the EU, the total expenditure would have been €22.5 billion instead of €41.59 billion, with a net saving of 19.1 billions.

Table 8.1: Health expenditure and medical goods, US and EU 27, average values 2011-2017.

	Health expenditure for medical goods (€ bn)	Total medical technologies	Health expenditure on total technologies (€ m per unit)
EU 27	41.59	22,568	1.8429
US	45.03	45,170	0.9968

Finally, the combination of federal and state funding for specific targeted health programs, could also be considered if some functions relating to health care were moved to the EU, as recently proposed by some MS to have a joint EU laboratories for COVID-19 vaccine development (European Parliamentary Research Service, 2020a). In an open Union, where people can freely move from one MS to another, having a healthy population in one country obviously produce positive externalities to other countries. These externalities should be internalized at the European level.

8.4. Climate and energy Policy

8.4.1. Emission trading programs in the US

Countries can implement different policy measures to reduce polluting emissions, but one of the most flexible and effective tools would seem to be the cap and trade program (Abrell et al., 2011). With a cap and trade program a government issues a limited number of annual permits that allow companies to emit a certain amount of emissions, the 'cap'. Companies are taxed if they produce a higher level of emissions than their permits allow. Companies that reduce their emissions can sell, or 'trade,'

[55] Source: OECD, EUROSTAT and WHO Health Accounts SHA Questionnaires (JHAQ).

unused permits to other companies. An example of cap and trade system is the Emissions Trading System (ETS) introduced in Europe in 2005.

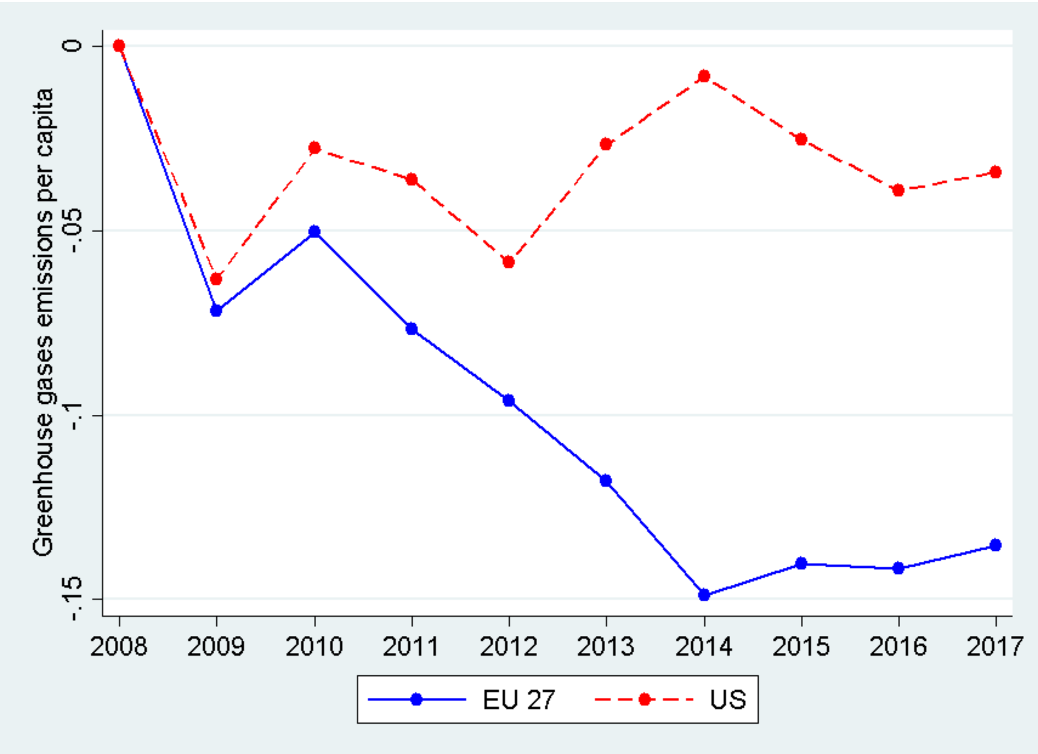
In the US, at central level, landmark emissions trading programs regulate mainly two air pollutants: SO_2 and N_2O. However, despite the American Clean Energy and Security Act (approved in 2009) and the attempts promoted by President Obama, there is presently no national emissions trading scheme for the rest of the most significant pollutants, for instance CO_2.

Concerned at the lack of federal action, several US states have created sub-national cap-and-trade programs. This means that states have become an important testing ground for climate policies. For instance, ten States are participating in the Northeast Regional Greenhouse Gas Initiative to reduce carbon dioxide emissions from the electric power sector. Carbon dioxide emissions from power plants throughout the region are capped, and the regulated power plants trade emission allowances. Since the program started, covered emissions have fallen by about half from their 2005 level, and investments from allowance auctions have generated almost $3 billion in economic value for the states (Hester and Harrison, 2017).

Another example is the California cap-and-trade program. Started in 2013, this program was the first multi-sector cap-and-trade program in North America. The greenhouse gas emissions cap set under the program will decrease by approximately 3 percent annually to help the state achieve its legislated goal to reduce emissions to 1990 levels by 2020. After that, under a state law enacted in 2017, the cap will be further reduced to help achieve an additional 40 percent reduction in state emissions by 2030.

There are also other greenhouse gas cap-and-trade programs emerging at the state and regional levels, including seven states (and three Canadian provinces) participating in the Western Climate

Figure 8.6: Decrease of Greenhouse gases emissions per capita with respect to 2008 for the years 2008-2017.



Initiative, and six states (and one Canadian province) participating in the Midwest Regional Greenhouse Gas Reduction Accord.

Table 8.2: GHG emissions in EU and US and difference in internalized externality values.

Year	GHG emissions US (millions of tons)	GHG emissions EU 27 (millions of tons)	GHG emissions EU counterfactual (millions of tons)	Difference GHG emission EU and EU counterfactual (millions of tons)	Internalized externality values (€ billion)
2008	7,018	4,396			
2009	6,632	4,086	4,154	68	1.033
2010	6,941	4,174	4,348	174	2.707
2011	6,932	4,064	4,342	278	3.672
2012	6,819	3,984	4,271	287	2.161
2013	7,100	3,903	4,448	544	2.441
2014	7,289	3,773	4,566	793	4.767
2015	7,215	3,820	4,519	700	5.383
2016	7,165	3,821	4,488	668	3.565
2017	7,249	3,853	4,541	688	3.938
Total	**70,360**	**39,874**			**29.667**

8.4.2. Comparison with our results

The emission trade programs in the US do not have federal markets, and programs run by states or regions are not coordinated to the same level as similar programs in Europe. In this field, EU coordination is markedly better and as such the EU can achieve more efficient results in terms of emission reduction. A federal market can better internalize the externalities which would not necessarily be resolved in local markets of emission permits, and can also save important administrative and regulatory costs. In fact, as we can see in Figure 8.6, the EU has been more able to reduce the emissions of greenhouse gases (GHG) per capita than the US for the years 2008-2017 during which the use of the ETS mechanism has been more and more varied. As an exercise, we can try to quantify the added value of the EU approach compared to the fragmented US response by evaluating the difference in greenhouse gases emission between the EU and the US by using the ETS allowances price, implicitly assuming that these prices correctly capture in each year the social value of emissions. This is obviously a strong assumption but we nevertheless feel that performing this experiment can provide a worthwhile estimate of the difference between the two approaches. These prices decreased through the period of our analysis for the reasons discussed in Chapter 5, while the difference in emissions between EU and US increased. The combination of these two effects determines the monetary benefit for EU in decreasing emissions with respect to US.

We compare EU and US by building up a series of EU emission using the GHG emission trend of the US: this might give an idea of how EU emissions could have developed if the ETS system would have been that of the US. We than compare the previous counterfactual EU emissions with the actual EU emissions. The value of the difference between the EU internalized externality and the US internalized externality goes from €1 billion in 2009 to €3.9 billion in 2017 (Table 8.2). If we sum all the differences for the years 2009-2017, we find that the additional benefit to the EU of its common ETS system with respect to the fragmented US system is equal to €29.6 billion, 0.25% of the current EU GDP.

8.5. Social insurance policy - Unemployment Benefits

8.5.1. Relationship between the Federal Government and the states

The Social Security Act of 1935, introduced after the 1930's crisis, established the Unemployment Insurance (UI) program, to provide temporary assistance to unemployed workers by replacing a portion of their lost wages. Both the federal government and the US states bear some responsibility for the program. Although federal law sets certain requirements for participating in the program, such as the categories of workers that must be covered or minimum eligibility criteria, each state designs its own program. Specifically, states can decide key elements of the program: eligibility criteria,[56] the benefit levels, the duration of the program and the funding system, as states are also able to decide the level of tax contributions requested from workers to finance the scheme. As a result, over the years, the program has evolved to produce large differences across states.

For example, in Montana, in order to receive UI Benefit, a worker must have earned at least $1,000 in the preceding or current year. In Arkansas, it is enough to have been employed for 10 or more days in a given calendar year. The benefit varies from $235/week in Mississippi to $750/week in Massachusetts. The duration varies from 5 weeks in North Carolina to 30 weeks in Massachusetts. Finally, the amount of labor tax contributions for the Unemployment Insurance varies from a rate of 5.4% in 10 states to 12% in Wisconsin.[57]

In addition to the UI tax rates, employers pay a Federal Unemployment Tax (FUTA). FUTA levies a 6 percent employer payroll tax on the first $7,000 in wages paid to eligible employees. The FUTA tax is used by the federal government to fund the federal share of extended benefits, the benefits under federal supplemental and emergency programs, the loans to state trust funds when they cannot pay benefits and other costs.[58] The federal funded share of extended benefits is a quasi-automatic stabilizer, which is activated when a state unemployment rate exceeds certain threshold levels; it allows the state to provide unemployment benefits beyond the 26 weeks/6 months maximum ceiling defined by the federal law. The Federal Government Disaster Unemployment Assistance is another part of the federal supplemental and emergency programs and this particular program is available to workers who lose their jobs because of a federally recognized major disaster. It is generally available only for the duration of the emergency.

With FUTA revenues, the federal government supported supplemental and emergency programs to extend further unemployment compensation during national recessions. An example was the Emergency Unemployment Compensation 2008 (EUC08) program. On July 2008, the first EUC08 extended UI for 13 weeks for all states. The extension did not always involve all states: after the first extension, the Extended Benefits was provided only for states in particular occupational crisis and 13 additional weeks were authorized only if state total unemployment rate was above 6%. The strengthening of unemployment benefits from the central level has been recently used in response to the COVID-19 pandemic. The Coronavirus Aid, Relief, and Economic Security Act (CARES) was

[56] States charge employers varying levels of payroll taxes, in accordance with the financing requirements of their different benefit levels. Only Alaska, New Jersey, and Pennsylvania levy any UI charges on workers, too.

[57] Alaska, Florida, Georgia, Idaho, Maine, Nebraska, Nevada, New Mexico, Oregon and Mississippi.

[58] Federal and state UI administration costs; labor exchange services employment and training for veterans; and some labor market information programs.

approved by the Congress in April 2020 and adds $600 to the weekly benefit amount of all UI recipients through to the end of July 2020.

The UI program is forward funded: states collect trust fund reserves in advance to pay benefits. However, during exceptional periods when states exhaust their UI reserves, they may borrow from the federal government. These loans are financed by FUTA and the federal government determines repayment terms for loans.

The UI program is financed by the Unemployment Insurance Trust Fund, from UI taxes defined, as we have already seen, from the states general revenues, plus the FUTA tax defined by the federal government. The Unemployment Insurance Trust Fund in the U.S. Treasury consists of 53 state accounts, with each trust fund building up reserves from employer taxes during periods of economic expansion. When the federal accounts reach prescribed statutory ceilings, the excess funds are transferred to individual state accounts (Reed Act). However, this happened only eight times since 1956, most recently in 2002.

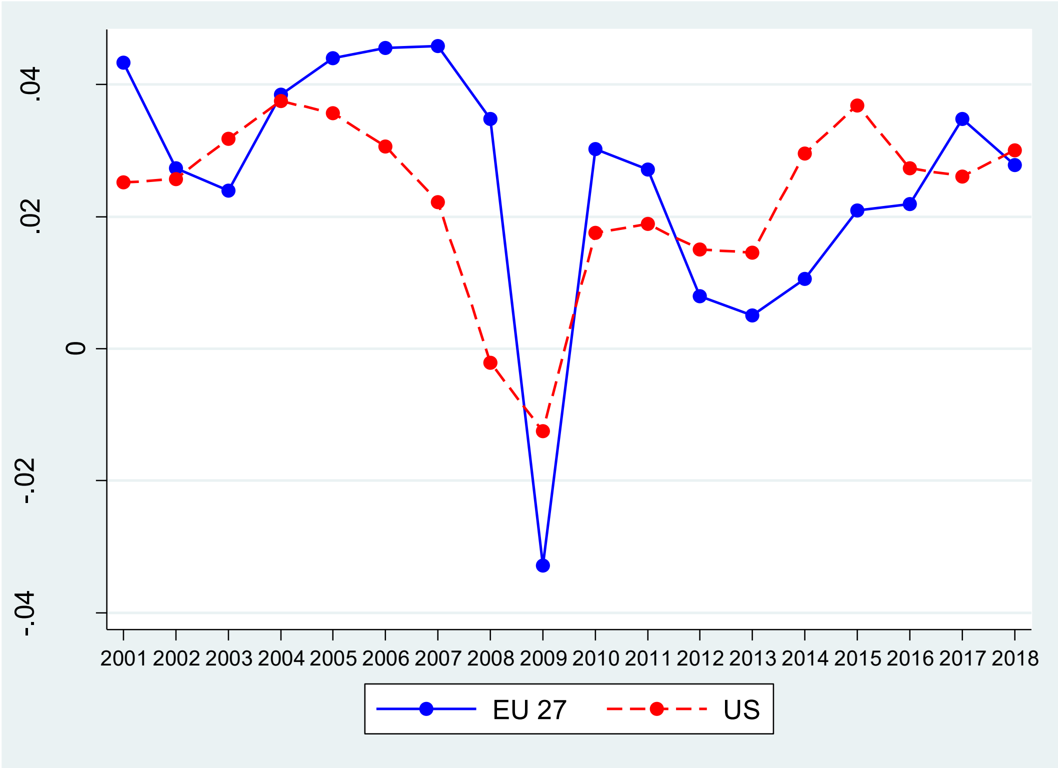
8.5.2. Comparison with our results

The systems of social unemployment protection are very different between the US and Europe. Unemployment benefits in European countries are typically larger (the US federal budget for unemployment benefits is only approximately 1 percent of GDP, while the corresponding figure for the average EU-28 is about 2 percent of GDP) and last longer than in the US. Despite these differences, in line with our results in Chapter 6, the US experience offers some interesting lessons for the EU. As we discussed in Chapter 6, unemployment protection in Europe has so far been a MS function and EU MS systems differ widely (Del Monte and Zandstra 2014). The EU legislation provides coordination across MS systems for people who move within the Union (EC 883/2004).

Given the large heterogeneity of MS systems, which reflect differences in preferences, structural differences in labor markets and levels of economic development, a unified European unemployment system would be hard to justify. However, the US system is also largely differentiated across states in order to take into account structural differences, including political preferences and economic characteristics. The most appealing features from an EU perspective is that the federal US government offers some basic common funding to the state unemployment systems and supports them with temporary benefits when local economies are hit by a particular large crisis or MS have exhausted their resources. The US system also has an interesting discretionary practice of providing by federal authorities, a fully funded additional extension for workers adversely affected by particular circumstances, such as deep economic crises with high levels of unemployment, or natural disasters. A European funded co-insurance system of national systems could adopt these features. Additionally, it is worth highlighting that Kirkegaard and Posen (2018) strongly suggested that the introduction of the UI program in the US in the 1930's was instrumental in fostering convergence of regional economies in the country.

Comparing the EU with the US, it is interesting to note that household final consumption expenditure is smoother in the US than in the EU (Figure 8.7), although of course this is not only a result of the federal insurance offered by the US. The same is true for the standard deviation of households final

Figure 8.7: Households final consumption expenditure (annual growth) 2001-2018.



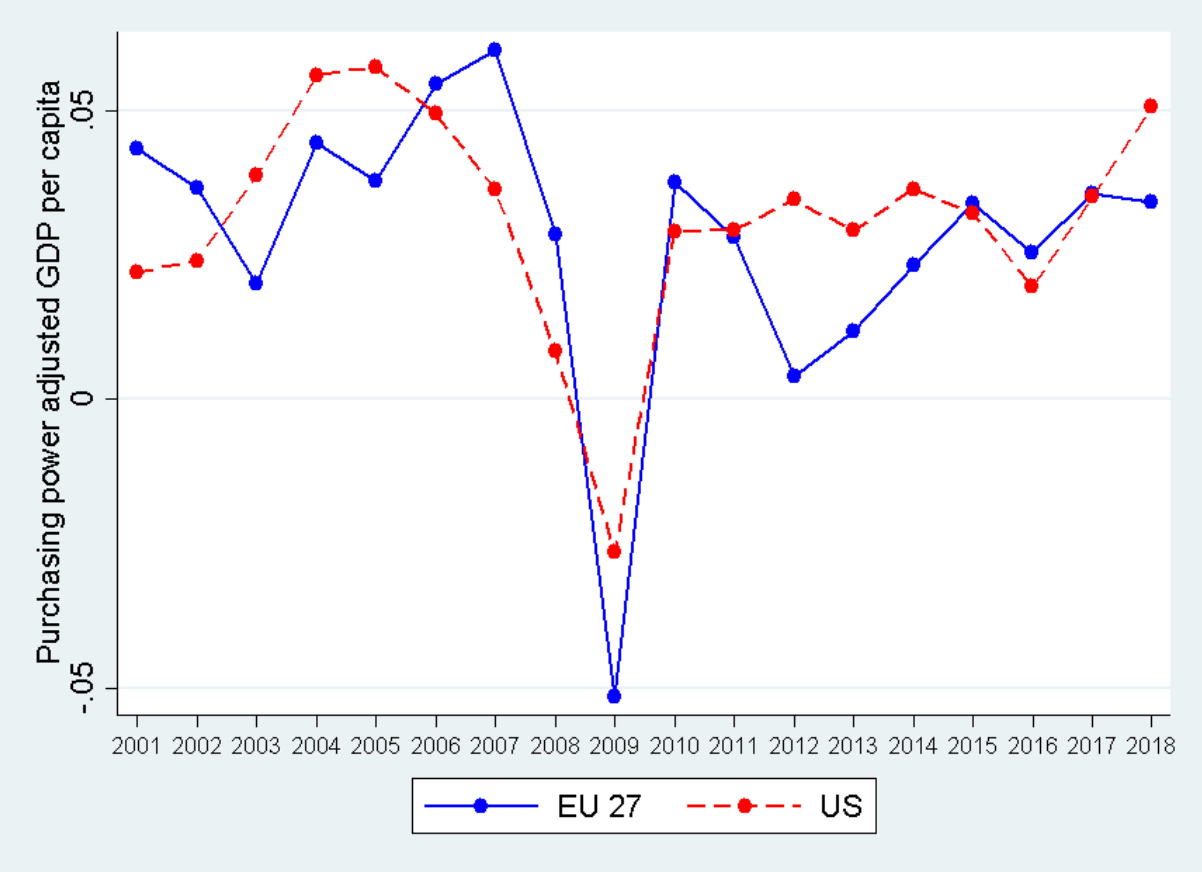
consumption, which is 32% lower in US than in EU. The correlation between GDP per capita and household consumption is also lower in the US than in the EU after the 2009 crisis (Table 8.3).

Notice that the increase in households' final consumption in the decade after the 2008 crisis was 20% in the US and 15% in the EU. If we attribute to EU the same consumption growth seen in the US, where federal unemployment benefits were implemented, after the 2008 crisis, we estimate a potential higher consumption in the EU than the EU actual consumption of 215 billion. The increase of the GDP per capita in the decade after the 2008 crisis was 28% in the US and 21% in the EU. The US GDP growth rates followed a more stable path than the EU after the 2008 crisis (Figure 8.8). If we replace the same growth of GDP of the US in the EU, we calculate a potential higher GDP in the EU than the EU actual GDP of 943 billion. Of course, these results can not be due only to the action of the unemployment benefits and other factors influenced consumption and GDP.

Table 8.3: Correlation between Households final consumption expenditure (annual growth) and GDP per capita, PPP (annual growth)

	2001-2007	2008-2018	DIFF. post/pre crisis
EU 27	*0.8239*	*0.9532*	0.1293
US	*0.8314*	*0.8386*	0.0072

Figure 8.8: Purchasing power adjusted GDP per capita (annual growth) 2001-2018.



8.6. Defence

8.6.1. Relationship between the Federal government and the states

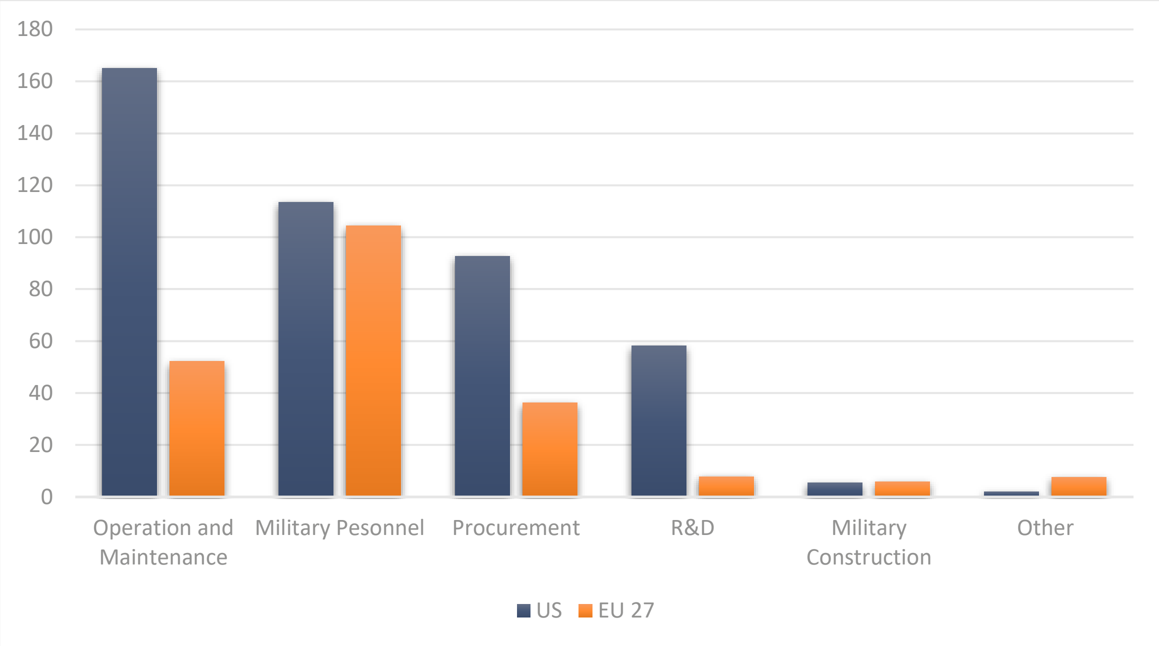
Today, all the US's defence forces are organized and structured into two general categories: the Active Component and the Reserve Component: the first is the national force while the second are the states' defence forces. The Active Component consists of active duty military personnel in the Army, Navy, Air Force, and Marine Corps (the four Service branches). The Reserve Component consists of the Reserves of the Active Component branches and the National Guard, which is made up of the Army National Guard and the Air Force National Guard. These are the states' defence forces, although some are fully funded by, and report directly to, the federal government. Each state can also have defence forces in parallel to their National Guard forces. The state defence forces generally perform emergency management and homeland security functions.

8.6.2. Public Procurement and R&D

Although some troops refer directly to the Governors of each state, according to Title 10 and Title 41 of the United States Code, defence and security procurement is wholly managed by the Department of Defence, with the Office of the Under Secretary of Defence for Acquisition, Technology and Logistics responsible for the oversight of the procurement activities of the various segments of the Department of Defence.

By the 2019 fiscal year, the Department of Defence was the biggest spending department in terms of dollars allocated. Defence contract spending was $404 billion in 2019, a $30 billion increase from the prior year. In total, spending at the Pentagon surged by $122 billion between 2015 and 2019 (Bloomberg Government, 2020). The Defence contracts are concentrated on a limited numbers of suppliers. Defence contracts worth $248 billion (67%) were awarded to the top one hundred companies and $154 billion (38%) to the top ten. These big contracts induce savings due to scale economies which are possible because of the centralization of the purchases (see Chapter 7).

Figure 8.9: Defence budget, 2017, in billion of euro.



All investment for research and development in Defence is financed and managed by the Federal Government. The amount of resources made available to the Department of Defence is substantial. It represents about 44% of the total federal R&D funding in the financial year 2020, with more than $2.6 billion allocated for basic research and $6 billion for applied research. As with procurement, centralization at the federal level facilitates investment in critically-important projects and allows access to benefits from economies of scale.

The Ministry of Defence sponsors a wide variety of activities related to military and technological advancements, and to infrastructure and materials. Funded projects must be justified by their impact on national security, support for military personnel, and new materials that could also have an impact on the ultimate welfare of the citizens. In many of these projects, particular attention is devoted to the interaction between multidisciplinary groups and integrated approaches aimed at translating scientific findings into useable products.

In the fiscal year 2019, the Congress funded 90% of state defence budgets. The Department of Defence had discretionary budget authority of $687.8 billion. As can be seen from Figure 8.8, a high percentage of this budget is allocated to procurement (21.2%) and to research and development (13.3%). The main figures are however Military Personnel (26%) and Operation and Maintenance (37.8%). In the EU, only 3.7% of the defence budget is allocated for R&D and 17% for procurement.

8.6.3. Comparison with our results

As discussed in Chapter 7, the European Union has 27 different armies with 27 different structures and all fundamental military decisions are taken by the national parliaments. Only minimal forces are under the direct control of the EU (e.g. EUFOR, Eurocorps and the EU battlegroups). The US military system also differs in terms of public expenditure and size of the army: in 2018, EU countries spent on average 1.2% of their GDP (Eurostat) for defence, while in the US defence accounted for 3.2% of GDP (OECD). European deployments reflect these limited capabilities.

There is no suggestion that the EU should create and manage an army to replace those of its MS. What we discuss is reinforced cooperation, more centralised procurement and common R&D, and the potential returns in terms of cost saving and effectiveness of defence and foreign policy from these actions could be significant.

European centralized procurement and investment in R&D, as exists in the US, would generate important scale economies and may facilitate important technology advances which could be useful also for non-military purposes. A centralized defence system could advocate more coherent and interoperable military capabilities, avoiding duplication in the research and development of weapons systems (Ginsberg and Penksa, 2012; Mogherini and Katainen, 2017). On average, EU countries develop three programs for each major US project, each of which receiving a third of the funds that it could have potentially secured in the case of joint development at continental level (CONE Report, 2019). Given the lack of open data about most of defence programs (see Chapter 7), it is very difficult to calculate the actual costs of duplication. As an example, we analyse the case of the aviation industry for the latest generation combat aircraft (Table 8.4). We notice that EU MS develop three different models of aircraft (Eurofighter, Gripen and Rafale) whereas the US have only one model (JSF). The joint cost of the three European models amounts to €29.57 billion delivering 1,205 units; the cost of the US model is €19.34 billion obtaining 3,003 units. The multiplication of assembly lines and the decision-making/administrative burden, poor economies of scale, combine to cause a loss in output for given expenditure, but here we also have a higher expenditure for a lower output fragmented across three models. The value added from assembling the research costs at federal level is huge, even if we take into account only the specific example of these aircrafts. In this example, if the EU had been able to build the 1,205 aircraft promised at the same unit cost of the US equivalent, it would have cost in total €7.8 ((19.34/3,003)· 1,205) billion which implies a saving of almost €22 billion.

Table 8.4: Aircraft and research costs.

Aircraft	Research costs (€ billion)	Units envisaged/produced
Eurofighter	19.48	707
Gripen	1.48	204
Rafale	8.61	294
Total EU	**29.57**	**1,205**
JSP	19.34	3,003
Total US	**19.34**	**3,003**

Source: Briani (2013).

8.7. Conclusions

Even when all the institutional differences are taken into account (Larcinese, Rizzo and Testa 2006; 2013a; 2013b), the US experiences provide support for our main empirical results.

The US health system is too different to provide a useful benchmark for Europe, but our proposal to centralize some procurement decisions and research in Chapter 4 is certainly supported by the US experience, which shows a greater number of medical technologies per inhabitant than the EU, even with a lower level of public procurement for medical goods with respect to GDP than EU. Large savings and better results would follow. In contrast the EU has little to learn from the US in terms of environmental policy, particularly concerning emission trade programs. The European system, extended to all EU countries and discussed in Chapter 5, is surely more efficient in internalizing externalities than the local systems employed inconsistently in the US, and is also administratively less costly. In line with our suggestions in Chapter 6, the unemployment insurance system operated federally in the US has features that one might wish to imitate at the EU level, in particular its ability to support state systems in case of severe crisis while allowing for large differences in the scheme at the state level. The scheme also helped to generate convergence among labor market institutions and local economies, which is an important goal for the EU. Finally, common defence policy is a thorny issue in Europe, for political reasons, but our analysis in Chapter 7 suggests that common procurement and R&D would allow for considerable savings whilst potentially making defence and foreign policy more effective. The US example of complete centralization for military procurement at the federal level is unreachable in the current European political environment but provides a useful benchmark.

Above all, the US experience suggests it is important to take a long view when discussing the possibility of centralizing functions and resources at the European level. The US federal system evolved in spikes as a response to profound and existential crises, which resulted in a re-organization of political powers and funding mechanisms across levels of government. Centralization of important functions was never easy nor uncontested. If it will survive, the EU will probably follow a similar path. Already, the European response to several crises (the financial crisis in 2008-9, the euro crisis in 2010-11, the COVID-19 crisis now) seems to point towards similar developments. At the same time, it is important to note that in some policy fields, such as environmental policy, in spite of its complex decision-making mechanisms the EU has been able to make better progress in centralizing policy than a structured federation such as the US.

9. Concluding remarks

In this Report, we have proposed and applied to selected policy fields a methodology to measure 'waste' in the production functions of public services by EU Member States, interpreted as the amount of inputs that could be saved to produce the same output if all countries produced at the efficient frontier. This methodology is grounded in well-established benchmarking techniques largely used in modern empirical economic analyses. For private firms producing for the market, as in our application to environmental policy, where the role of the public sector is mostly regulatory, the application of the methodology is quite straightforward. For public services, while typically 'input' is just the money invested, the definition of the relevant 'output' is more complicated because of the public good nature of many services provided by the public sector. We addressed this problem by experimenting with different definitions of input and output, and by applying different techniques, mostly regression analysis, to support our main results. The general findings appear quite robust to all these different specifications.

In our fields of application, we generally find quite large heterogeneity in the levels of efficiency across the different EU MS. We also find quite a high level of average waste, ranging from about 10% to over 50% of the invested resources in Health Care, Social Insurance and Defence. There is clearly still a high level of heterogeneity in the quality of the public sector and public spending in Europe. Results are more positive for our application to the environmental sector. We find that not only the EU Emissions Trading System (EU ETS) was instrumental in reducing CO_2 emissions in Europe, but we also do not find evidence that it has led to any economic cost of lost production, not even in phase 3, when regulations have been made more stringent. Indeed, although the problem of identifying a specific counter-factual is here very serious, our computations of monetary benefits suggest that the introduction of the ETS system in Europe offered important financial advantages to the EU economy. Convergence in efficiency across EU MS and sectors seems also to have generally improved through time, although we detect some divergence for the Manufacturing sector in recent years.

The fact that average waste in the national production of public services in many EU countries is large does not imply that common spending or common action at the EU level would necessarily reduce it. It depends on what causes the observed inefficiency. Building on the insights of the fiscal federalism literature presented in Chapter 2, we use our own methodology to estimate the relevance of returns to scale and cross-border spill-over effects in explaining this inefficiency. In some cases, but not in all of them, we do find that these elements play an important role. For example, although spending in Public Health Care is generally quite inefficient, this is not in general due to unexploited returns to scale or spill-over effects across countries. However, for specific sub-functions in Health Care, such as procurement and prevention, we do find that the higher level of waste could largely be absorbed by exploiting the strong role of returns to scale.

Similarly for Social Insurance: not only is the heterogeneity in efficiency level across MS large, but also the differences in preferences and institutions across countries are very significant, with up to a ten-fold difference in per capita spending. Moving responsibility of Social Insurance to the EU level would then not make much sense. However, the imperfect correlation between growth rates of the EU countries and the very high scale effects that we find in risk diversification, do suggest that some minimal level of EU insurance, or a co-insurance mechanism among EU countries to cover at least the large shocks, both symmetric and asymmetric, could play an important role in improving efficiency. Our simulation exercise, similar to many others presented in the literature, strongly supports this conclusion. According to our estimations, a limited amount of co-insurance, with a maximum expenditure of 0.2% of GDP per annum per country, introduced in the 2000s, would have reduced by 1.6% the standard deviation of consumption growth and by 11.4% the correlation of consumption growth with GDP growth. In the period 2009-2012, it would have implied a larger GDP (by €175 billion) for the six EU countries most hit by the financial crisis. The fact that the EU, faced with extreme health and economic shocks such as those caused by the COVID-19 virus, has been able to find mechanisms, although temporary, to cover risk and providing support to the countries more hit by the crisis, is encouraging in this respect.

Finally, and not surprisingly, we also find evidence of high inefficiency levels and unexploited strong returns to scale in the Defence sector, both in general spending relating to the deployment of troops and in procurement for military projects. Common action and common spending, saving on administrative costs and avoiding duplication in projects and research, could produce both cost savings and higher quality R&D expenditure with positive returns both in terms of the effectiveness in defence provision and in terms of the potential positive technological spill-over effects on the non-military private sector.

Our methods of analysis and even the policy fields we consider are different from the ones covered by previous attempts to discuss similar issues. Thus, it is difficult to compare results. We still argue that the general flavour of our results is in line with the findings of the previous literature. For instance, although techniques and the specific fields of application differ, our results on Defence and a European co-insurance system are in line with those found by Bertelsmann Stiftung (2017) who also support common spending at the EU level in these two policy fields. As argued in the previous chapters, it is also broadly in line with the CONE Report of the EU Parliament (CONE Report, 2019). Concerning Health Care and Environment, these are the new policy priorities for Europe, and they have not been analysed with the same interest by the previous literature, so it is harder to make a comparison.

One limitation of our analysis is the lack of a precise definition of a counterfactual to compare national with European provision (or vice-versa) of a given policy in the same field. Strictly speaking, in the fields of Health Care, Social Security and Defence, our counterfactual is simply the current level of 'output' offered by national countries. We limit ourselves to show that a policy maker that internalized cross-border spill-over effects and exploited the estimated returns to scale could provide in these policy areas the same output at a lower cost, or equivalently produce a higher level of output with the same resources. Trying to predict what would happen if that centralization were really to occur is very challenging, because it would clearly depend on future decisions of the EU and policy choices. On the other hand, fixing a specific counterfactual for European provision, as Bertelsmann Stiftung (2017) suggests, seems to be quite arbitrary and runs the risk of producing unreliable results if the counterfactual is chosen wrongly.

However, although the problem of the counterfactual is undoubtedly relevant conceptually, it should also not be exaggerated. In the specific policy areas where we find strong evidence of returns to scale (e.g. procurement in different sectors, unemployment co-insurance, environment regulations) it seems unlikely that the European 'production function' could be very different from the national production function we observe. Moreover, returns to scale, and more limitedly, cross-border spill-over effects seem to be very large in these policy domains, which suggests that EU production could produce relevant returns in terms of efficiency. Indeed, one could argue that they are so large that it should be possible to easily address any negative effects at national level.

Our comparison to the US case, with all the limitations due to differences in institutions between the US and the EU, also broadly supports this conclusion. The US federal co-insurance of state unemployment benefits (and more generally, the US federal budget) is protecting US states, and their citizens, from unusual large economic shocks, and it has been instrumental in increasing convergence in US state economies and labour market institutions. The fact that procurement in the US is mostly made at the federal level for medical technology, drugs, research and military equipment does imply a higher level of efficiency and a larger share of R&D expenditure. It is telling for example that, in spite of roughly similar spending in the EU, the endowment of per-capita medical equipment is more than one half larger in the US than in the EU. Similarly, for Defence procurement, where technology is characterised by strong returns to scale, the fact that on average EU countries develop three programmes for each major US project, each of which receiving a third of the funds, by itself could explain a large part of the difference in military capability between the two areas. Interestingly on environmental protection, possibly for political and constitutional reasons, the EU is actually more centralized and more efficient than the US.

In conclusion, it is worth stressing that the main task of the present Report was to provide a "methodology to compute and identify budgetary waste in Member States" to quote the title of the tender by the EU parliament. We chose some particular functions to analyse for their intrinsic interest at the current EU political and economic juncture and also because our resource constraint did not allow us to do more. However, clearly our methodology could and perhaps should be applied more generally. It is important that the political debate about what centralizing or decentralizing at the EU level be based on some hard evidence rather than just be left to general and often ideological discussion.

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A.4. Appendix to Chapter 4 (Health Care)

Table A.4.1 Efficiency scores by country (aggregate spending)

Country	Model A: outputs=f(input)					Model B: outcomes=f(input)				
	θ_{vrs}	θ_{crs}	rts	SE	%	θ_{vrs}	θ_{crs}	rts	SE	%
AT	1.00	1.00	crs	1.00	0.00	0.80	0.76	irs	0.95	0.05
BE	0.78	0.78	irs	0.99	0.01	0.81	0.80	irs	0.99	0.01
BG	.	.	.	.	.	0.56	0.53	irs	0.96	0.04
CZ	0.63	0.60	drs	0.95	-0.05	0.51	0.48	irs	0.95	0.05
DE	0.74	0.74	irs	1.00	0.00	0.64	0.62	irs	0.97	0.03
DK	.	.	.	.	.	0.87	0.83	irs	0.95	0.05
EE	0.80	0.78	irs	0.97	0.03	0.77	0.65	irs	0.85	0.15
EL	0.94	0.89	irs	0.95	0.05	1.00	1.00	irs	1.00	0.00
ES	0.98	0.78	drs	0.80	-0.20	0.93	0.92	drs	0.99	-0.01
FI	0.98	0.97	irs	0.99	0.01	0.93	0.88	irs	0.95	0.05
FR	0.67	0.66	irs	1.00	0.00	0.73	0.72	irs	0.99	0.01
HR	0.62	0.61	irs	0.99	0.01	0.58	0.52	irs	0.90	0.10
HU	0.67	0.66	irs	0.99	0.01	0.59	0.53	irs	0.90	0.10
IE	1.00	1.00	crs	1.00	0.00	1.00	1.00	crs	1.00	0.00
IT	0.78	0.73	irs	0.93	0.07	1.00	1.00	crs	1.00	0.00
LT	0.88	0.88	irs	0.99	0.01	0.69	0.61	irs	0.89	0.11
LV	1.00	0.95	irs	0.95	0.05	1.00	0.83	irs	0.83	0.17
MT	0.90	0.77	drs	0.86	-0.14	1.00	0.79	drs	0.79	-0.21
NL	0.91	0.72	drs	0.79	-0.21	0.76	0.73	irs	0.96	0.04
PL	0.65	0.64	irs	0.98	0.02	0.60	0.55	irs	0.93	0.07
PT	0.71	0.70	irs	0.99	0.01	0.80	0.77	irs	0.96	0.04
RO	0.73	0.71	irs	0.97	0.03	0.63	0.56	irs	0.89	0.11
SE	0.81	0.81	irs	1.00	0.00	1.00	0.95	drs	0.95	-0.05
SI	0.93	0.78	drs	0.84	-0.16	0.70	0.64	irs	0.91	0.09
SK	0.67	0.67	irs	1.00	0.00	0.59	0.49	irs	0.84	0.16
Total	**0.81**	**0.78**		**0.95**	**-0.02**	**0.78**	**0.73**		**0.93**	**0.05**

In the columns there are: θ_{vrs} - total technical efficiency with variable returns to scale, θ_{crs} - total technical efficiency with constant returns to scale, rts- returns to scale, SE- Scale efficiency, % change- % change in total efficiency moving from crs to vrs (+ for irs, - for drs).

Source: own estimates on Eurostat data.

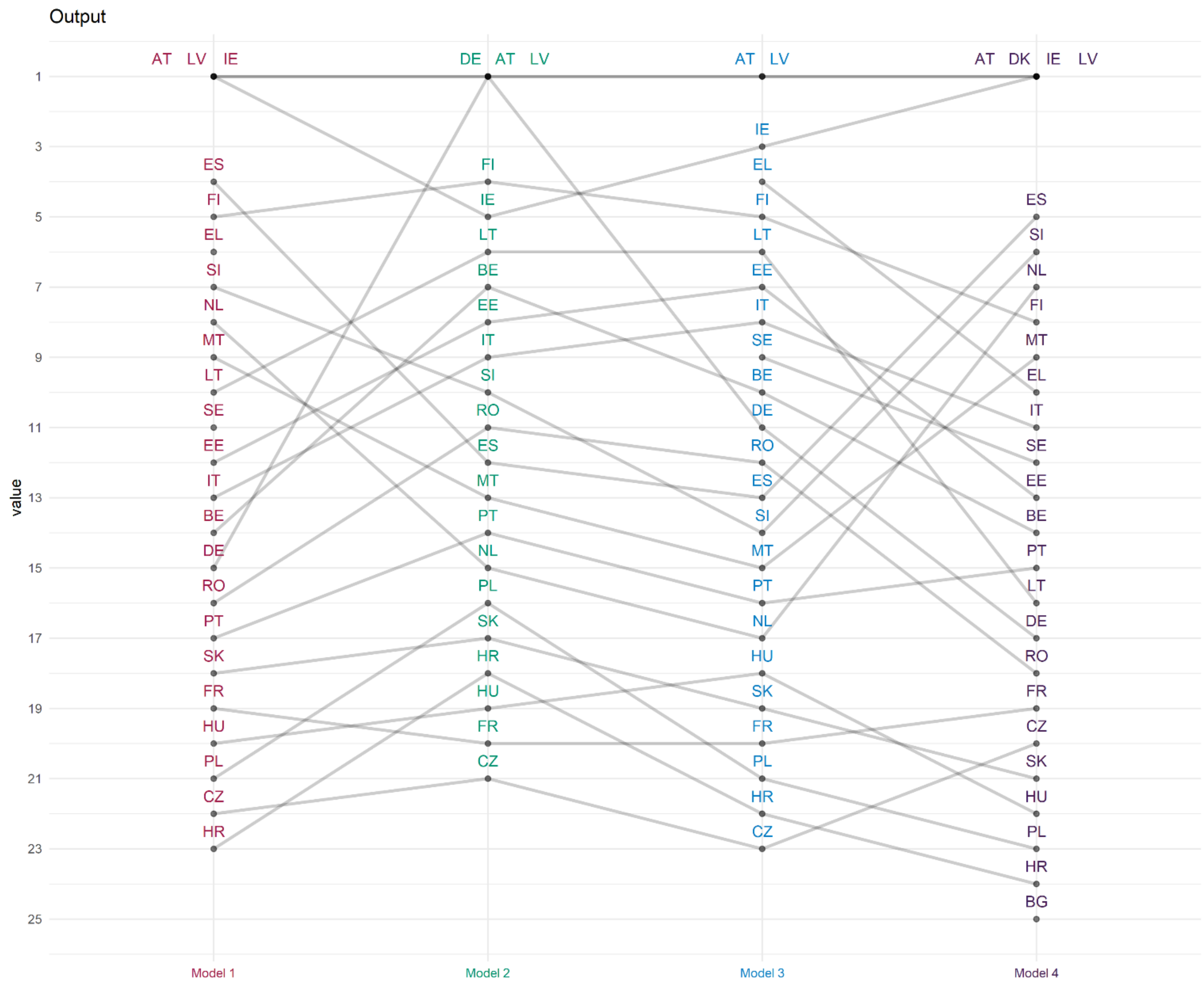
Table A.4.2 Efficiency scores by country (aggregate spending)

Country	Model A: outputs=f(input)				
	θ_{vrs}	θ_{crs}	rts	SE	% change
AT	1.00	1.00	crs	1.00	0.00
BE	0.88	0.84	drs	0.95	-0.05
BG	.	.	.	.	.
CZ	0.63	0.60	drs	0.95	-0.05
DE	1.00	0.76	drs	0.76	-0.24
DK	.	.	.	.	.
EE	0.80	0.78	irs	0.97	0.03
EL	1.00	1.00	crs	1.00	0.00
ES	1.00	0.95	drs	0.95	-0.05
FI	0.98	0.98	crs	1.00	0.00
FR	0.80	0.76	drs	0.94	-0.06
HR	0.62	0.61	irs	0.99	0.01
HU	0.67	0.66	irs	0.99	0.01
IE	1.00	1.00	crs	1.00	0.00
IT	1.00	1.00	crs	1.00	0.00
LT	0.88	0.88	crs	1.00	0.00
LV	1.00	0.97	irs	0.97	0.03
MT	1.00	0.79	drs	0.79	-0.21
NL	0.92	0.78	drs	0.85	-0.15
PL	0.65	0.65	irs	0.99	0.01
PT	0.82	0.81	drs	0.98	-0.02
RO	0.74	0.74	irs	0.99	0.01
SE	1.00	0.95	drs	0.95	-0.05
SI	0.93	0.78	drs	0.84	-0.16
SK	0.67	0.67	crs	1.00	0.00
Total	**0.87**	**0.82**		**0.95**	**-0.04**

The columns are: θ_{vrs} - total technical efficiency with variable returns to scale, θ_{crs} - total technical efficiency with constant returns to scale, rts- returns to scale, SE- Scale efficiency, % change- % change in total efficiency moving from crs to vrs (+ for irs, - for drs).

Source: own estimates on Eurostat data.

Figure A.4.1 Rank correlation of output model

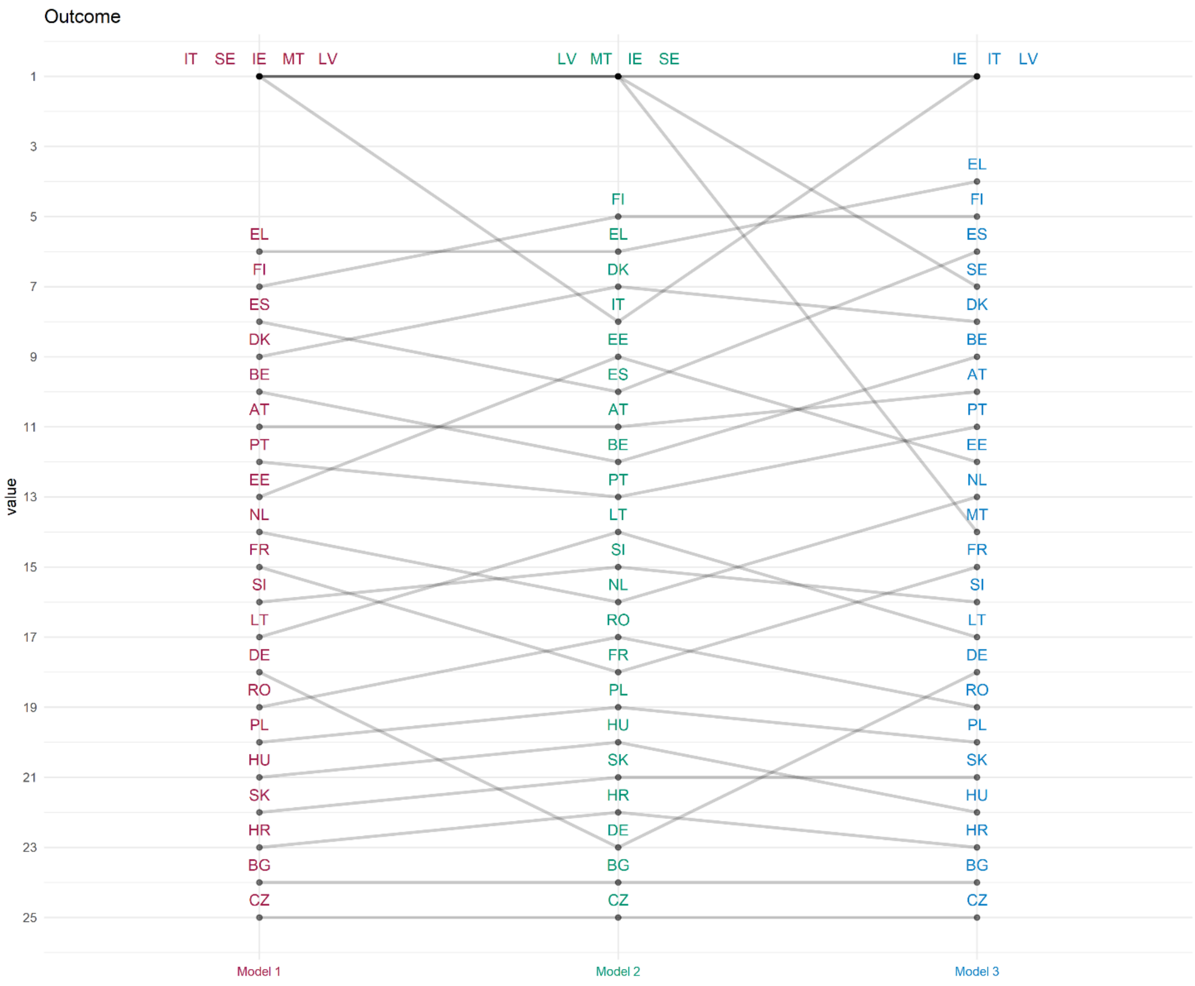


	rank_m1	rank_m2	rank_m3	rank_m4
rank_m1	1.0000			
rank_m2	0.7513	1.0000		
rank_m3	0.8169	0.9379	1.0000	
rank_m4	0.9648	0.6719	0.7441	1.0000

In all models the input is given by the public health spending as a percentage of the GDP, while outputs are different and are respectively equal to: discharges, meet needs (Model 1), bed-days (Model 2), discharges (Model 3), meet_needs (Model 4). The table below the figure reports the rank correlations between models.

Source: own estimates on Eurostat data.

Figure A.4.2 Rank correlation of outcome model



	rank_m1	rank_m2	rank_m3
rank_m1	1.0000		
rank_m2	0.9555	1.0000	
rank_m3	0.9382	0.8858	1.0000

In all models the input is given by the public health spending as a percentage of the GDP, while outcomes are different and are respectively equal to: HLY, NPM (Model 1), HLY (Model 2), NPM (Model 3). The table below the figure reports the rank correlations between models.

Source: own estimates on Eurostat data.

Table A.4.3 Simar and Wilson two stage estimation

```
Simar & Wilson (2007) eff. analysis      Number of obs              =        25
(algorithm #2)                           Number of efficient DMUs   =         0
                                         Number of bootstr. reps    =      1000
inefficient if theta_m2_sw < 1           Wald chi2(8)               =     42.53
twosided truncation                      Prob > chi2(8)             =    0.0000

------------------------------------------------------------------------------
Data Envelopment Analysis:               Number of DMUs             =        25
                                         Number of ref. DMUs        =        25
input oriented (Farrell)                 Number of outputs          =         2
variable returns to scale                Number of inputs           =         1
bias corrected efficiency measure        Number of reps (bc)        =       100
```

efficiency	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Percentile [95% Conf.	Interval]
theta_m2_sw						
educ	.017687	.0036359	4.86	0.000	.010278	.0249757
smoking	-.0006983	.0068132	-0.10	0.918	-.0141166	.0126575
bmi	.0079817	.0072304	1.10	0.270	-.0061982	.0223142
pop_y70	.0115797	.069731	0.17	0.868	-.1268476	.146475
voluntary	-.0116563	.0292294	-0.40	0.690	-.0694064	.0417296
hous_oop	-.0688999	.0586436	-1.17	0.240	-.1833936	.047805
doct	.067278	.0303243	2.22	0.027	.0113941	.124306
gdp	.0634849	.0915015	0.69	0.488	-.1057684	.2528586
_cons	-.7435955	.7511585	-0.99	0.322	-2.256643	.6975227
/sigma	.0949809	.0139535	6.81	0.000	.0484881	.1046352

The results of the second stage analysis are reported in the table, where as dependent variable is used the efficiency scores computed through the DEA model, while as explanatory variables there are: educ – percentage of people with tertiary education, smoking – percentage of daily smokers over the population, bmi – percentage of overweighed people over the population, pop_y70 – percentage of people aged 70 and more over the population, voluntary – amount of voluntary health spending, hous_oop - amount of household out-of-pocket health expenditure, doct – amount of doctors per 1,000 inhabitants, gdp – Gross Domestic Product (Purchasing Power Standard adjusted).

Source: own estimates on Eurostat data.

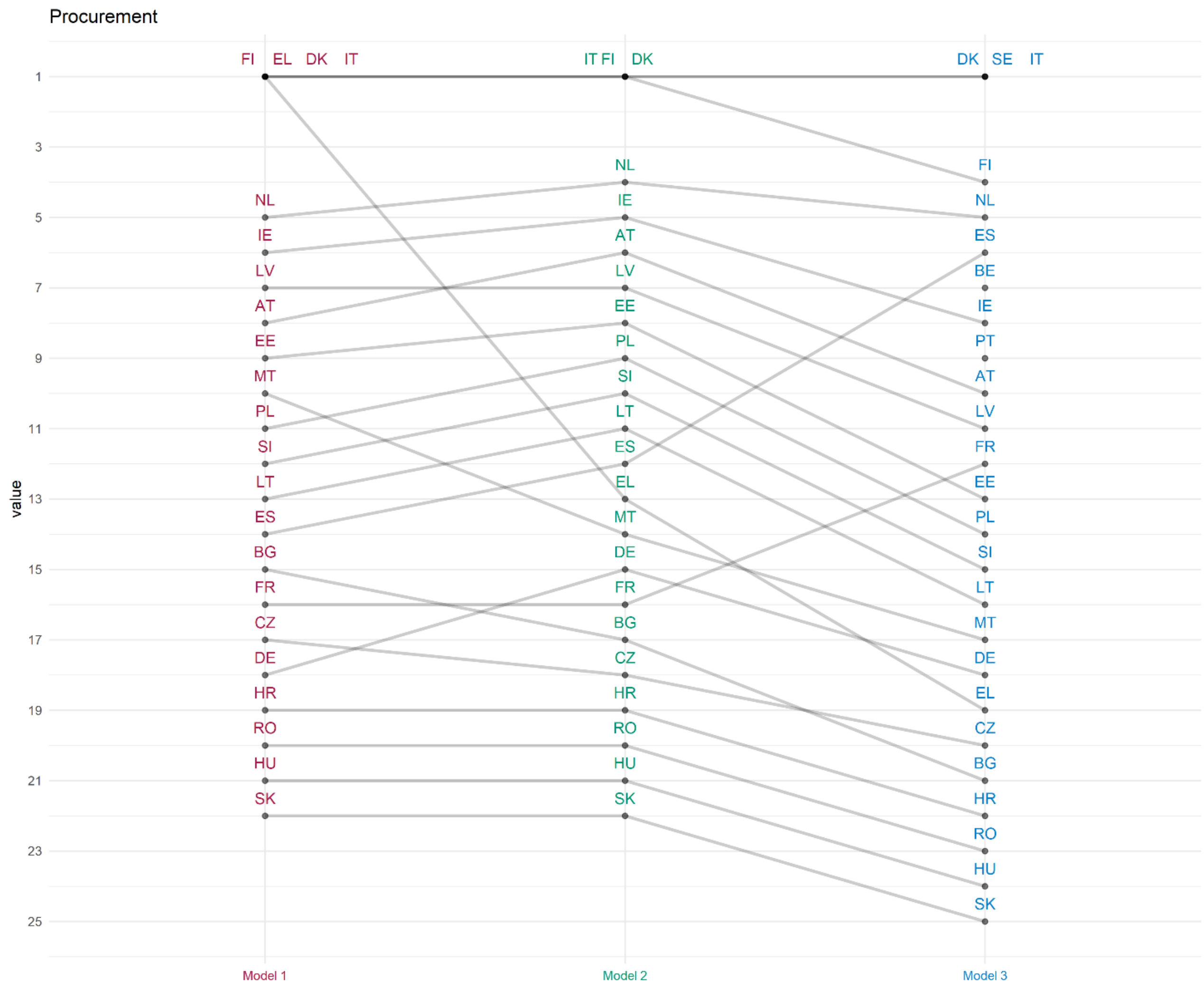
Table A.4.4 Gravity model (aggregate spending)

	(1) theta_m1_i	(2) theta_m2_i
eq1		
TS_cou_j	-0.00110	0.00197
	(-0.87)	(1.37)
TS_cou_j * contig	0.000674	-0.00100*
	(1.08)	(-1.85)
Observations	450	450

In the regression as dependent variables are used the level of efficiency scores computed through the DEA model A (column 1) and B (column 2). As explanatory variables we used the total spending for country j (TS_cou_j) and the interaction between the total spending of country j and a dummy indicating whether the country j share some borders with country i (contig). As control variables we include (for both country I and j): educ – percentage of people with tertiary education, smoking – percentage of daily smokers over the population, bmi – percentage of overweighed people over the population, pop_y70 – percentage of people aged 70 and more over the population, voluntary – amount of voluntary health spending, hous_oop - amount of household out-of-pocket health expenditure, doct – amount of doctors per 1,000 inhabitants, gdp – Gross Domestic Product (Purchasing Power Standard adjusted).

Source: own estimates on Eurostat data.

Figure A.4.3 Rank correlation of procurement model



	rank_m1	rank_m2	rank_m3
rank_m1	1.0000		
rank_m2	0.9070	1.0000	
rank_m3	0.8003	0.9268	1.0000

in all models the input is given by the public procurement spending as a percentage of the GDP, while outputs are different and are respectively equal to: MT (Model 1), MT_2 (Model 2), NPM (Model 3). In the first model MT (Medical Technology) is a proxy for the number of machineries, in the second model MT_2 is a proxy for the total value of machineries. The table below the figure reports the rank correlations between models

Source: own estimates on Eurostat data.

Table A.4.5 Gravity model (procurement spending)

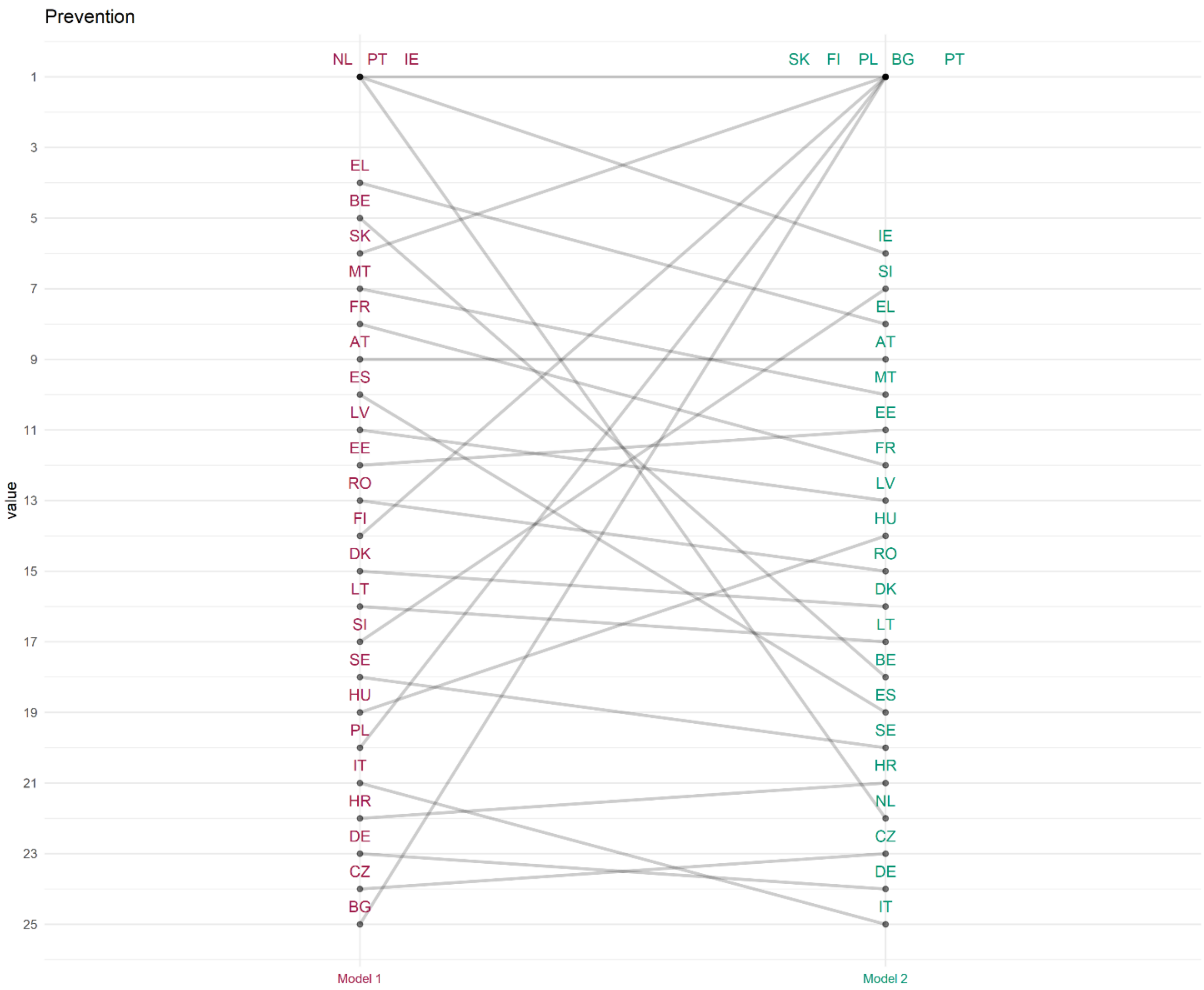
	(1) theta_m1_i	(2) theta_m2_i	(3) PS_cou_i	(4) NPM_i
main				
PS_cou_j	0.000134	0.00508	-0.0118	0.00963
	(0.28)	(1.57)	(-1.60)	(0.87)
PS_cou_j * contig	-0.0000936	-0.00374**	0.00825**	-0.00671
	(-0.27)	(-2.34)	(2.46)	(-0.86)
Observations	266	323	361	361

t statistics in parentheses
* p<.1, ** p<.05, *** p<.01

In the regression as dependent variables are used the level of efficiency scores computed through the DEA model A (column 1) and B (column 2) applied to the procurement subfunction, the procurement spending of country i (column 3), and the inverse ratio between preventable and treatable diseases and total deaths (column 4). As explanatory variables we used the procurement spending for country j (PS_cou_j) and the interaction between the procurement spending of country j and a dummy indicating whether the country j share some borders with country i (contig). As control variables we include (for both country i and j): educ – percentage of people with tertiary education, smoking – percentage of daily smokers over the population, bmi – percentage of overweighed people over the population, pop_y70 – percentage of people aged 70 and more over the population, voluntary – amount of voluntary procurement spending, hous_oop - amount of household out-of-pocket procurement expenditure, doct – amount of doctors per 1,000 inhabitants, gdp – Gross Domestic Product (Purchasing Power Standard adjusted).

Source: own estimates on Eurostat data.

Figure A.4.4 Rank correlation of prevention model



In all models the input is given by the public prevention spending as a percentage of the GDP, while outputs are different and are respectively equal to: vacc% (Model 1), IIM (Model 2).The rank correlation between the two models is equal to 0.3161.

Source: own estimates on Eurostat data.

Table A.4.6 Gravity model (prevention spending)

	(1) theta_m1_i	(2) theta_m2_i	(3) % vacc.	(4) IM	(5) PrS_cou_i
main					
PrS_cou_j	0.000000674	-0.000000370	0.000167*	3.02e-08	0.00445
	(1.62)	(-0.33)	(2.00)	(1.60)	(0.63)
PrS_cou_j * contig	-0.00000370	0.00000148	-0.000803**	-0.000000145*	-0.0214
	(-1.60)	(0.34)	(-2.50)	(-2.04)	(-0.63)
Observations	340	340	400	400	400

t statistics in parentheses
* p<.1, ** p<.05, *** p<.01

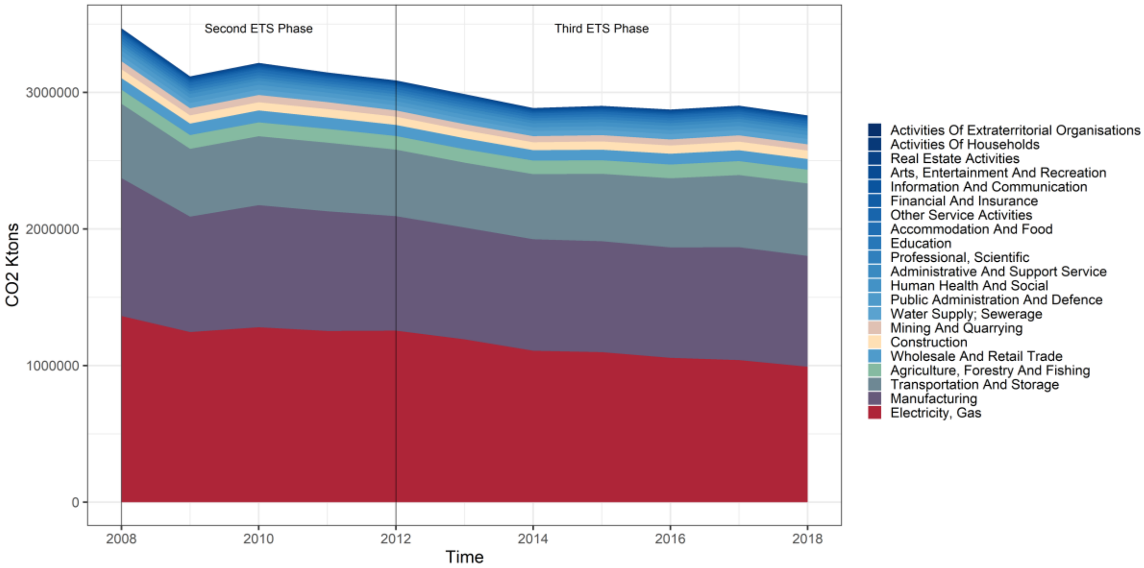
In the regression as dependent variables are used the level of efficiency scores computed through the DEA model A (column 1) and B (column 2) applied to the prevention subfunction, the percentage of people aged 65 and over vaccinated against influenza (column 3), the ratio between deaths for infectious diseases and total deaths (column 4), and the prevention spending of country i (column 5). As explanatory variables we used the prevention spending for country j (PeS_cou_j) and the interaction between the prevention spending of country j and a dummy indicating whether the country j shares some borders with country i (contig). As control variables we include (for both country I and j): educ – percentage of people with tertiary education, smoking – percentage of daily smokers over the population, bmi – percentage of overweighed people over the population, pop_y70 – percentage of people aged 70 and more over the population, voluntary – amount of voluntary prevention spending, hous_oop - amount of household out-of-pocket prevention expenditure, doct – amount of doctors per 1,000 inhabitants, gdp – Gross Domestic Product (Purchasing Power Standard adjusted).

Source: own estimates on Eurostat data.

A.5. Appendix to Chapter 5 (Climate and energy policy)

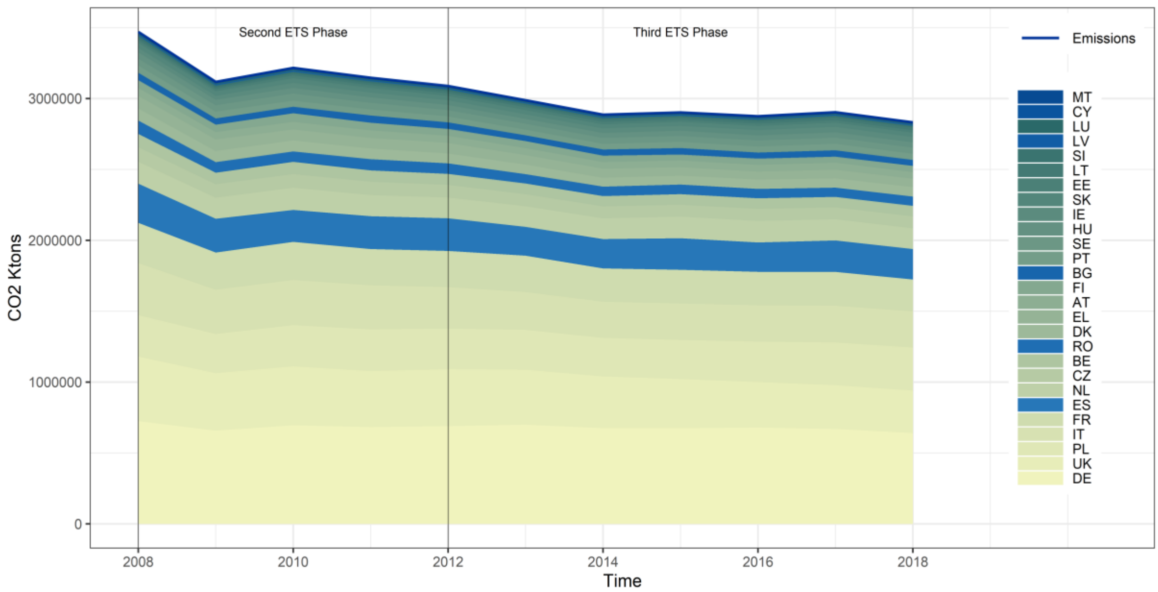
A.5.1. Appendix to section 5.3

Figure A.5.1: Emissions by Sector (Including not Available)



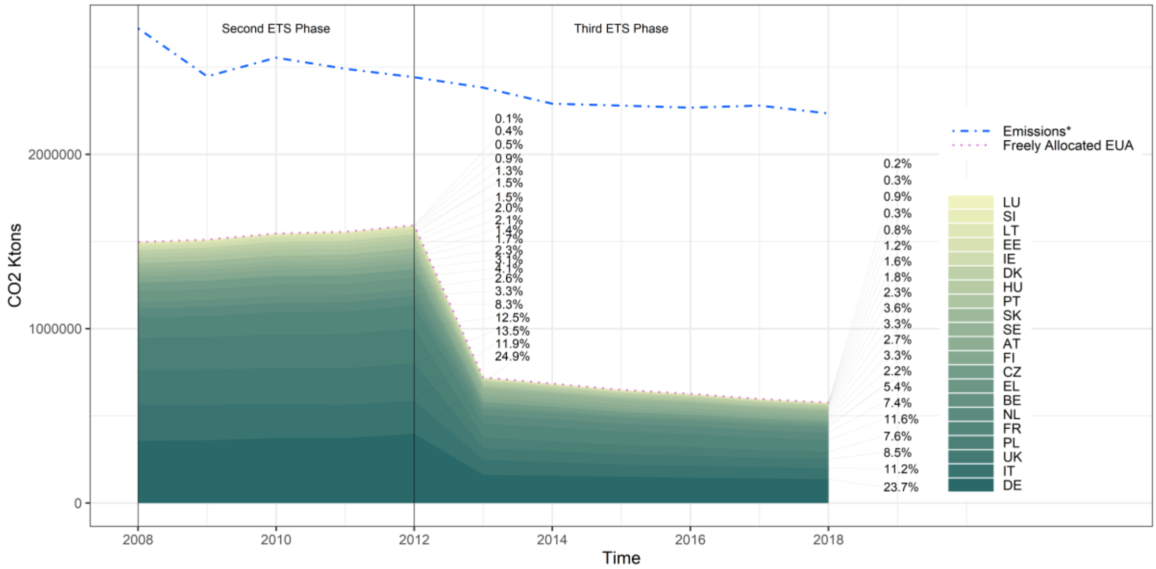
Source: Own elaboration based on Eurostat data.

Figure A.5.2: Emissions by Country (Including not Available)



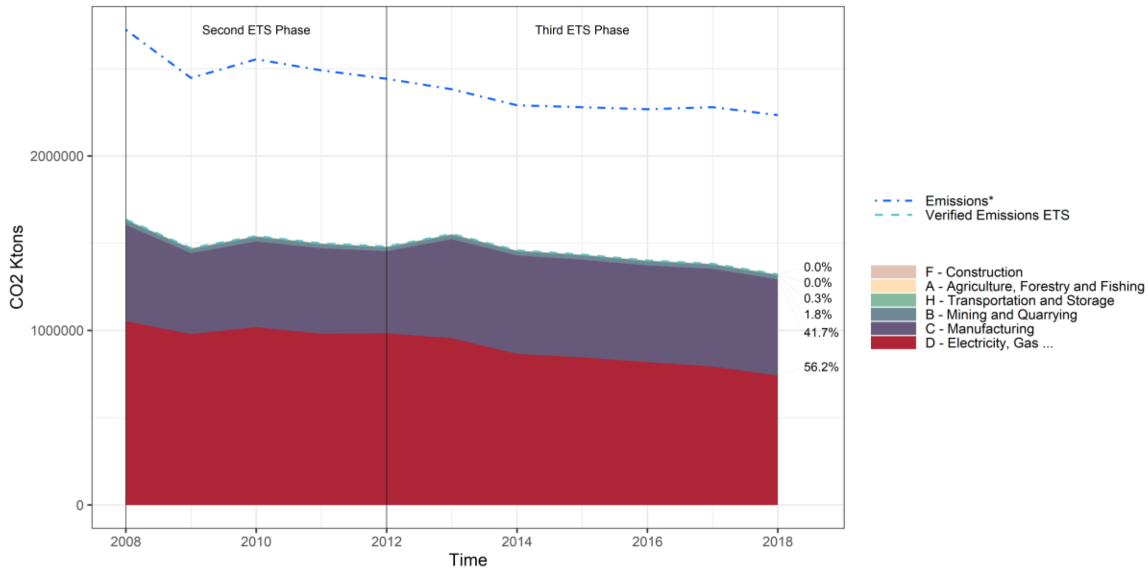
Source: Own elaboration based on Eurostat data.

Figure A.5.3: Freely Allocated EUAs by Country



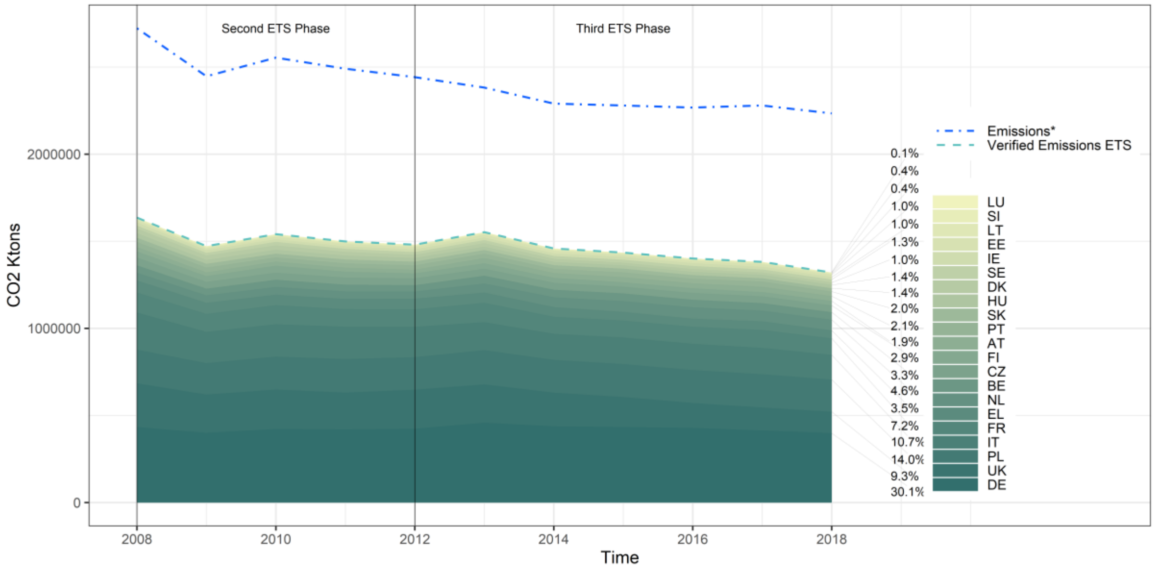
Source: Own elaboration based on Eurostat and Union Registry data.

Figure A.5.4: Verified Emissions by Sector



Source: Own elaboration based on Eurostat and Union Registry data.

Figure A.5.5: Verified Emissions by Country



Source: Own elaboration based on Eurostat and Union Registry data.

The methodology used in Section 5.3 follows the one in Goodman-Bacon (2018). The research design consists of a difference-in-differences model that compares sector-by-country CO_2 emissions in phase 2 and in phase 3 between sector-by-country observations with different levels of EU ETS incentives as measured by EU ETS intensity or purchased EUAs intensity. In the following we will illustrate the methodology in the case of purchased EUAs intensity as this can readily be extended to the case of EU ETS intensity.

Equation A.5.1 describes the event study specification (Jacobson et al.1993) for sector-by-country observation i in which pre/post treatment is defined by dummy variables that measure the time relative to phase 3 implementation $1\{t - t^* = y\}$ with $t^* = 2012$ (i.e., "event time"), and treatment/control groups are defined by the continuous value of initial (2008) purchased EUAs intensity, $purchEUAintens_i'$

$$CO2emiss_{it} = \boldsymbol{x_{it}\beta} + purchEUAintens_i' \left[\sum_{y=-4}^{-2} \pi_y 1\{t - t^* = y\} + \sum_{y=0}^{6} \theta_y 1\{t - t^* = y\} \right] + \theta_t + e_{it} \quad (A.5.1)$$

The dependent variable is sector-by-country emissions of CO_2 for each year t, $CO2emiss_{it}$. In our preferred specification the set of controls $\boldsymbol{x_{it}}$ includes GDP, employment, energy, labour and sector-by-country fixed effect. Year fixed effects θ_t are used to account for time shocks. The coefficients of interest π_y and θ_y measure the (covariate-adjusted) relationship between emissions and purchased EUAs intensity during phase 2 and phase 3 respectively. The dummy for the year before the shifting from phase 2 to phase 3 ($y = -1$, year 2011) is omitted, which normalizes the estimates of π_y and θ_y to zero in that year. Standard errors are clustered at the sector level to allow for arbitrary serial correlation within sectors. The π_y are falsification tests that capture the relationship between EU ETS in phase 2 and emissions. Their pattern and statistical significance serve as a test of the common trends assumption. The θ_y are intention-to-treat (ITT) effects of an additional percentage point of purchased EUAs intensity on aggregate CO_2 emissions. This specification identifies heterogeneity in EU ETS effects. The estimates will equal zero if EU ETS affected emissions equally across sector-by-country observations, and they will understate EU ETS total effect because they "difference out" common aspects of EU ETS effect (baseline effect).

$$CO2emiss_{it} = \boldsymbol{x_{it}\beta_k} + \sum_{y=1}^{6} \rho_y 1\{t - t^* = y\} + purchEUAintens_i' \sum_{y=1}^{6} \lambda_y 1\{t - t^* = y\} + \theta_t + e_{it} \qquad (A.5.2)$$

To quantify the impact on CO_2 emissions we exploit the reform taking place from phase 2 to phase 3 of the EU ETS to implement a difference-in-differences (DiD) empirical strategy. The reform provides treated and control groups for testing CO2 emissions responses from different levels of incentives provided by the EU ETS (here proxied by the purchased EUAs intensity). Phase 3 started in 2012 for all the companies under EU ETS. However, different sector-by-country observations have been subject to different extent to the treatment. So, the effect of the reform can be estimated as the difference in the outcomes stemming from the difference in treatment.

Equation A.5.2 describes our Diff-in-Diff specification that includes a dummy that is positive from the first year after the start of phase 3, and treatment by the continuous value of initial (2008) purchased EUAs intensity for the same interval of time. The coefficient of interest is λ_y that measures the average causal effect of the reform. The coefficient can be interpreted as the additional reduction in CO2 emissions for the period 2013-2018 that is induced by a 1% higher purchased EUA intensity in 2008 when passing from phase 2 to phase 3 of the EU ETS.

Figure 5.5 in the main text displays the evolution of π_y and θ_y coefficient over time for the treatment with EU ETS intensity. While effects are slightly positively significant over the pre-reform period, the coefficient are negative but not significant except for 2013. In other words, this figure shows no pre-trends, but also weak difference in the post-treatment period.

Figure 5.6 in the main text illustrates the evolution of π_y and θ_y over time in the case of purchased EUA intensity treatment. The plot consistently shows that CO2 emissions significantly decreased in the postreform years, while the effect was reversed pre-reform. So, while in phase 2 sector-by-country observations with higher purchased EUAs intensity tended to emit more than groups with low intensity, there has been a stark reversal in phase 3 after the reform.

As robustness checks to both analyses, we show in figures A.5.6 and A.5.7 that by switching position between CO2 emissions and control variables in the analysis, no effect can be observed. We also report the tables for the specification not including controls - Model 1 – that shows similar pattern to our preferred specification - Model 2 – but with higher uncertainty (wider confidence intervals).

Table A.5.1: Event Study – EU ETS Intensity

	Model 1	Model 2
Intensity 2008	45.857***	37.503**
	(8.356)	(12.265)
Treatment 2009	-3.454	8.096
	(3.595)	(5.396)
Treatment 2010	18.108**	18.825**
	(5.483)	(5.844)
Treatment 2012	0.594	0.797
	(8.834)	(7.041)
Treatment 2013	-9.621	-6.609**
	(4.952)	(2.073)
Treatment 2014	-42.253*	-32.772
	(18.475)	(20.550)
Treatment 2015	-55.328*	-41.988
	(24.242)	(22.877)
Treatment 2016	-66.470*	-50.114
	(28.915)	(28.487)
Treatment 2017	-73.792*	-56.986
	(35.220)	(34.435)
Treatment 2018	-85.844*	-67.284
	(39.678)	(38.099)
Capital		-0.165
		(0.138)
Employment		-0.001
		(0.003)
Energy		0.058***
		(0.010)
GDP		0.055
		(0.041)
year = 2009	-662.941	-5.578
	(522.342)	(398.708)
year = 2010	-479.928	-1.198
	(400.029)	(182.452)
year = 2011	-423.923	-84.296
	(400.824)	(139.742)
year = 2012	-827.061	-64.451
	(522.117)	(94.509)
year = 2013	-985.575	-235.583
	(657.011)	(177.810)
year = 2014	-705.730	29.534
	(681.374)	(373.807)
year = 2015	-386.963	382.931
	(638.244)	(551.543)
year = 2016	-136.088	299.137
	(599.847)	(598.922)
year = 2017	185.607	212.324
	(504.122)	(514.175)
year = 2018	197.184	29.148
	(526.740)	(541.209)
Constant	20,190.633***	12,601.443
	(428.994)	(7,277.607)
Observations	1,386	1,386
R-squared	0.34	0.41
Number of sector-by-country observations	126	126
Year FE	YES	YES
Sector-by-country FE	YES	YES

Robust standard errors in parentheses ; *** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration based on Eurostat and Union Registry data.

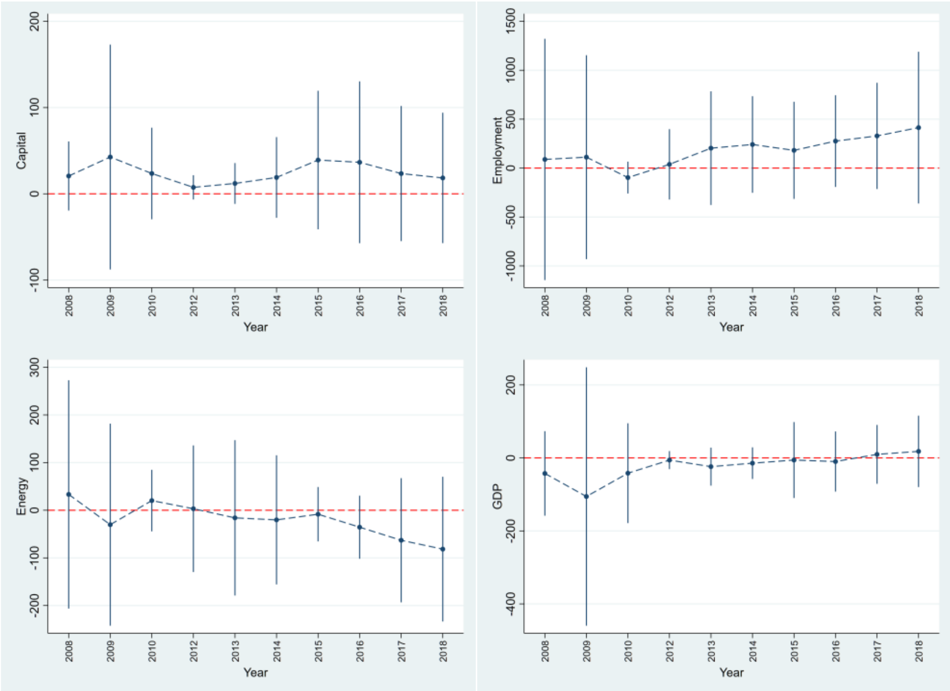
Table A.5.2: Event Study – Purchased EUAs Intensity

	Model 1	Model 2
Intensity 2008	265.125***	295.430***
	(61.010)	(27.595)
Treatment 2009	5.124	-30.345
	(13.484)	(20.742)
Treatment 2010	159.131***	152.880***
	(18.638)	(13.720)
Treatment 2012	154.380***	142.410***
	(19.105)	(27.790)
Treatment 2013	74.451**	56.982*
	(20.852)	(24.237)
Treatment 2014	-225.274***	-227.670***
	(33.234)	(12.939)
Treatment 2015	-403.557***	-373.662***
	(52.830)	(11.181)
Treatment 2016	-566.459***	-538.806***
	(72.033)	(27.145)
Treatment 2017	-739.505***	-697.460***
	(83.284)	(43.661)
Treatment 2018	-865.272***	-808.657***
	(98.815)	(52.641)
Capital		-0.125
		(0.095)
Employment		0.001
		(0.002)
Energy		0.065***
		(0.015)
GDP		0.027
		(0.023)
year = 2009	-1,595.754	-279.956
	(1,129.555)	(312.722)
year = 2010	-1,096.891	-266.115**
	(759.058)	(77.815)
year = 2011	-1,238.137	-494.829**
	(864.528)	(162.613)
year = 2012	-1,975.319	-757.850*
	(1,128.467)	(364.592)
year = 2013	-2,267.553	-956.684*
	(1,240.270)	(426.941)
year = 2014	-2,313.581	-850.643
	(1,260.389)	(450.218)
year = 2015	-1,992.526	-469.001*
	(1,298.377)	(213.197)
year = 2016	-1,714.643	-474.121
	(1,339.820)	(259.661)
year = 2017	-1,224.552	-364.315
	(1,246.034)	(257.276)
year = 2018	-1,298.933	-605.585
	(1,361.402)	(339.411)
Constant	21,004.847***	10,386.484
	(1,004.423)	(5,707.182)
Observations	1,386	1,386
R-squared	0.34	0.41
Number of sector-by-country observations	126	126
Year FE	YES	YES
Sector-by-country FE	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

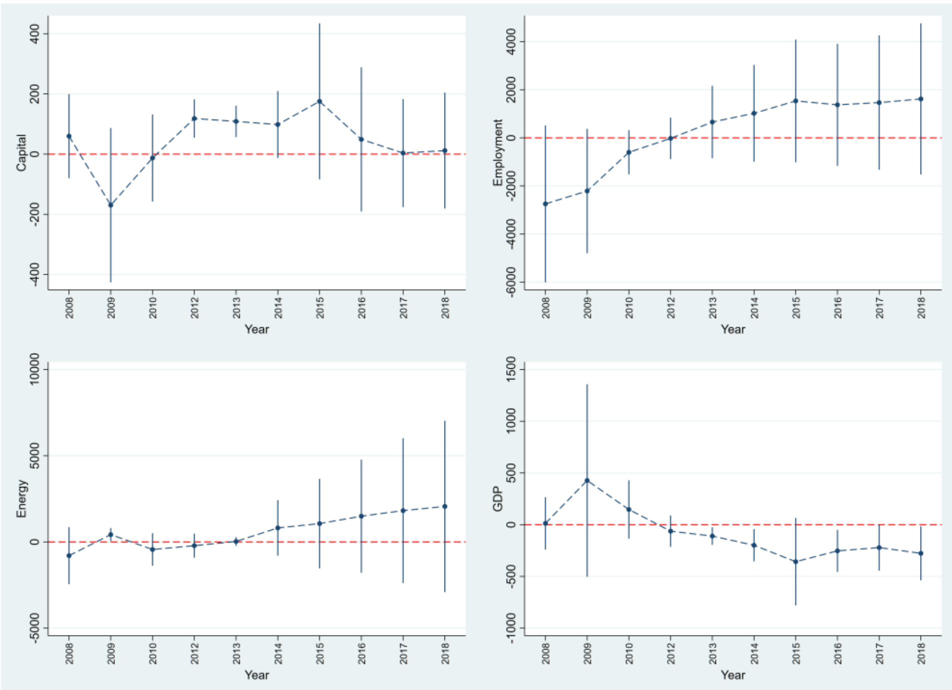
Source: Own elaboration based on Eurostat and Union Registry data.

Figure A.5.6: Robustness Checks Event Study – EU ETS Intensity



Source: Own elaboration based on Eurostat and Union Registry data.

Figure A.5.7: Robustness Checks Event Study – Purchased EUAs Intensity



Source: Own elaboration based on Eurostat and Union Registry data.

Table A.5.3: Diff-in-Diff - EU ETS Intensity

	Model 1	Model 2
Treatment Dummy	455.735	748.554
	(1,165.892)	(860.066)
Treatment Intensity	-67.772*	-55.068
	(27.412)	(27.924)
Capital		-0.169
		(0.144)
Employment		-0.000
		(0.003)
Energy		0.061***
		(0.009)
GDP		0.054
		(0.043)
year = 2009	-1,128.555	-290.225
	(574.640)	(311.899)
year = 2010, omitted	-	-
year = 2011, omitted	-	-
year = 2012	-1,167.387*	-558.912
	(539.419)	(331.900)
year = 2013, omitted	-	-
year = 2014	-730.263	-534.878
	(703.994)	(559.355)
year = 2015	-816.204	-457.059
	(906.650)	(458.612)
year = 2016	-910.205	-810.033
	(1,100.225)	(668.571)
year = 2017	-815.157	-1,122.039
	(1,360.012)	(1,016.675)
year = 2018	-1,176.648	-1,628.649
	(1,597.809)	(1,217.100)
Constant	20,549.345***	12,603.399
	(414.150)	(7,399.701)
Observations	1,386	1,386
R-squared	0.32	0.32
Number of sector-by-country observations	126	126
Year FE	YES	YES
Sector-by-country FE	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration based on Eurostat and Union Registry data.

Table A.5.4: Diff-in-Diff - Purchased EUAs Intensity

	Model 1	Model 2
Treatment Dummy	-338.520	349.509
	(1,060.978)	(565.944)
Treatment Intensity	-571.021***	-540.226***
	(70.549)	(20.052)
Capital		-0.136
		(0.110)
Employment		0.001
		(0.002)
Energy		0.066***
		(0.013)
GDP		0.032
		(0.030)
year = 2009	-1,128.555	-382.907
	(574.640)	(318.638)
year = 2010, omitted	-	-
year = 2011, omitted	-	-
year = 2012	-1,167.387*	-495.628
	(539.419)	(292.289)
year = 2013, omitted	-	-
year = 2014	-730.263	-538.391
	(703.994)	(597.310)
year = 2015	-816.204	-485.413
	(906.650)	(536.311)
year = 2016	-910.205	-873.158
	(1,100.225)	(751.808)
year = 2017	-815.157	-1,149.050
	(1,360.012)	(1,067.241)
year = 2018	-1,176.648	-1,652.916
	(1,597.809)	(1,264.547)
Constant	20,549.345***	10,209.528
	(452.856)	(5,808.105)
Observations	1,386	1,386
R-squared	0.22	0.41
Number of sector-by-country observations	126	126
Year FE	YES	YES
Sector-by-country FE	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Own elaboration based on Eurostat and Union Registry data.

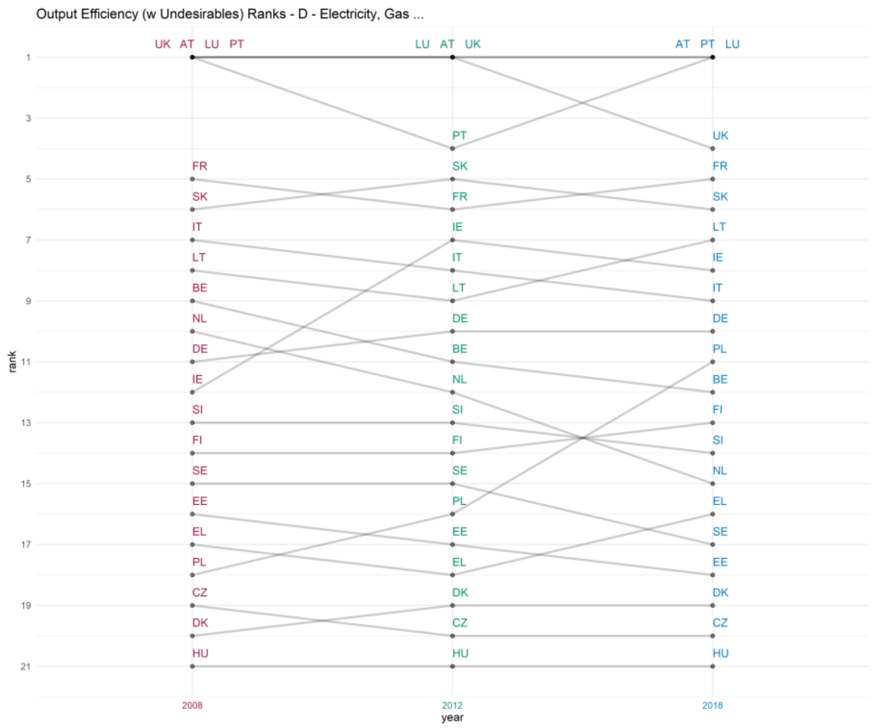
A.5.2. Appendix to Section 5.4

Figure A.5.8 shows the ranking of countries considering the energy sector only at three points in time,[59] 2008 (beginning of phase 2), 2012 (beginning of phase 3) and 2018 (last year of available data). Countries closer to the first rank, at the top of the graph, are the best performers while efficiency lowers going towards the bottom. The energy sector is characterized by a group of countries (Austria, France, Luxembourg, Portugal, Slovak Republic and UK) with high efficiency ranks during the whole period considered. Notable are also the improvements attained by Poland and the deterioration of Netherland's performance.

Figure A.5.9 depicts the efficiency ranking dynamic in the Manufacturing sector. Here the group of "best performers" consists of Germany and Ireland only, while marked progress can be observed for Estonia, Italy and Slovenia, and a pronounced worsening of performance affects Belgium, Greece and Poland.

Figure A.5.10 provides information on rankings in the Transportation sector. The group of most efficient countries is composed by Belgium, Estonia, Finland, France, Netherlands and Slovenia. Efficiency increases were obtained by Italy and Lithuania, while Greece and Ireland saw a deterioration of their performance.

Figure A.5.8: Efficiency Ranking - Energy



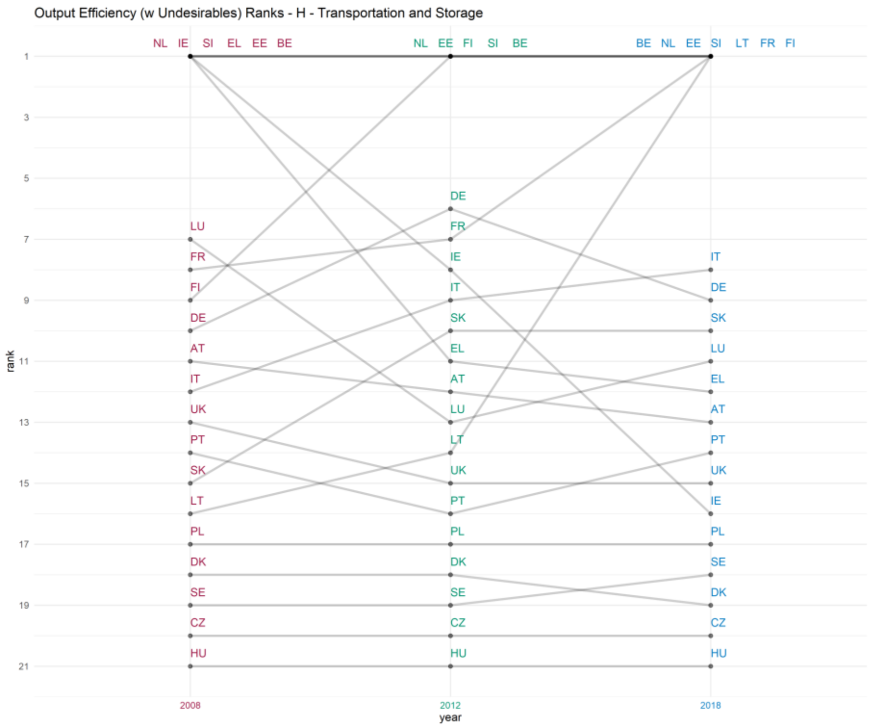
Source: Own elaboration based on Eurostat data.

[59] While the results for each year provide a more comprehensive view, they are hardly readable.

Figure A.5.9: Efficiency Ranking - Manufacturing

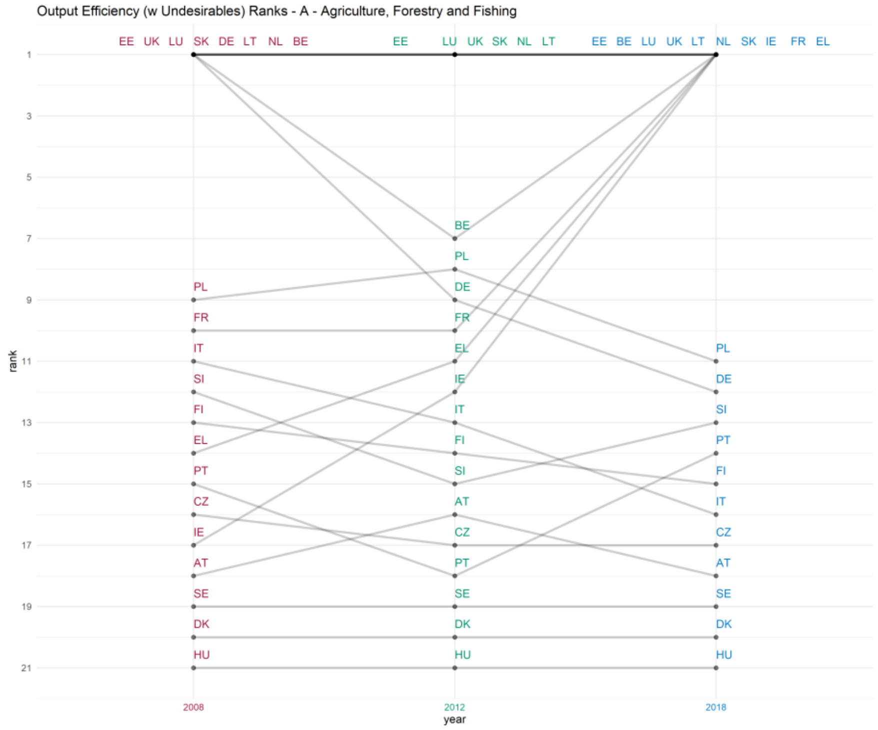
Source: Own elaboration based on Eurostat data.

Figure A.5.10: Efficiency Ranking - Transports



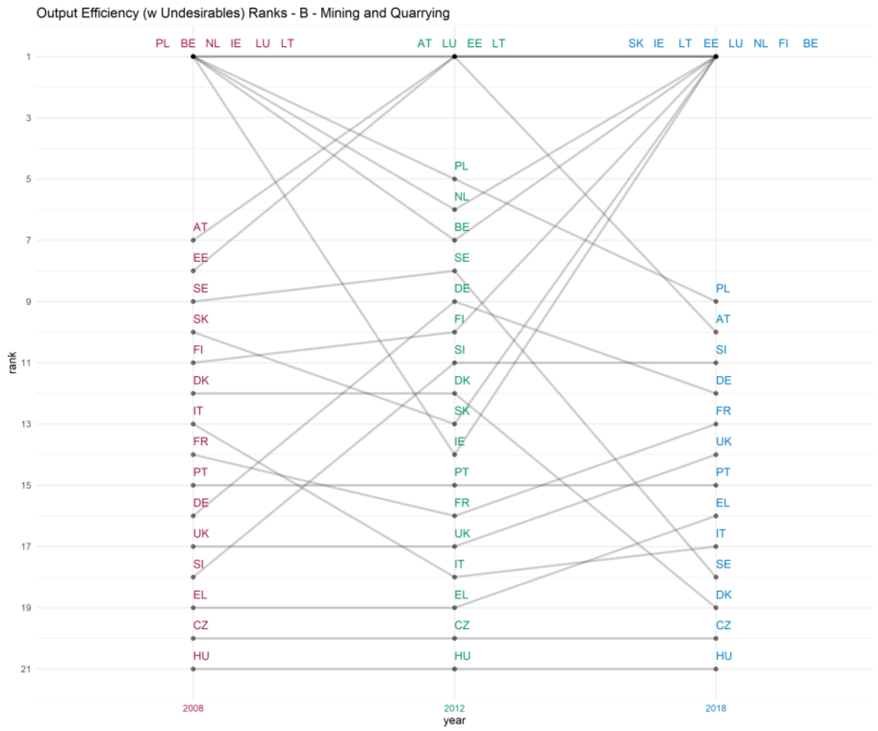
Source: Own elaboration based on Eurostat data.

Figure A.5.11: Efficiency Ranking – Agriculture, Forestry and Fishing



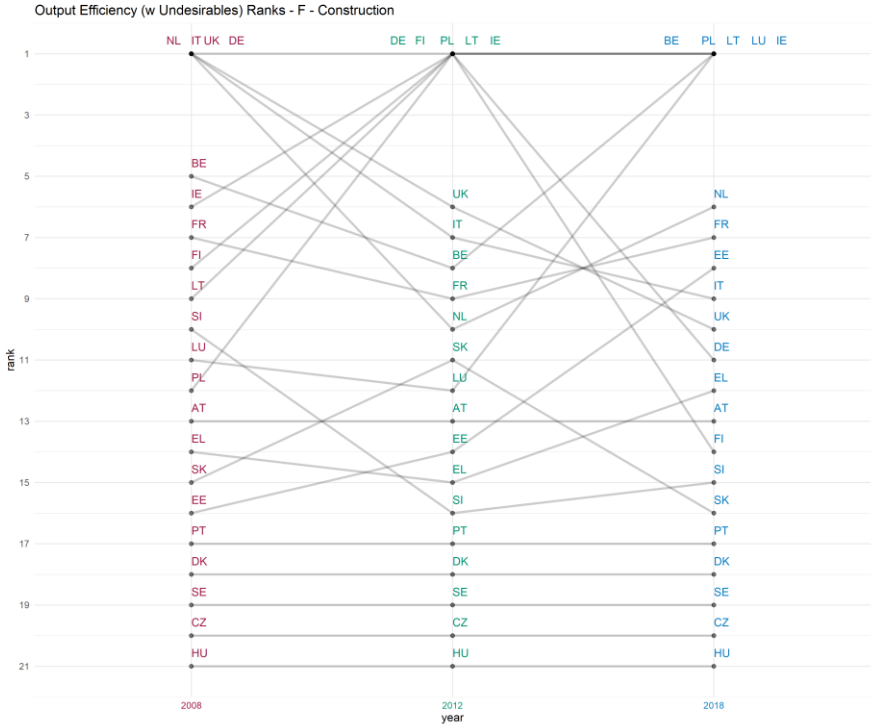
Source: Own elaboration based on Eurostat data.

Figure A.5.12: Efficiency Ranking – Mining and Quarrying



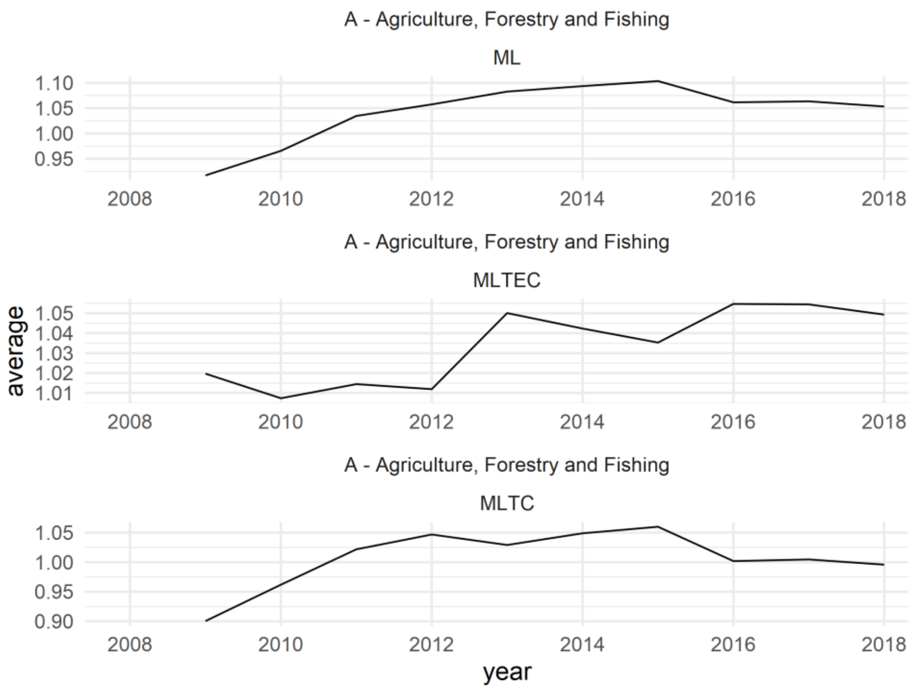
Source: Own elaboration based on Eurostat data.

Figure A.5.13: Efficiency Ranking - Construction



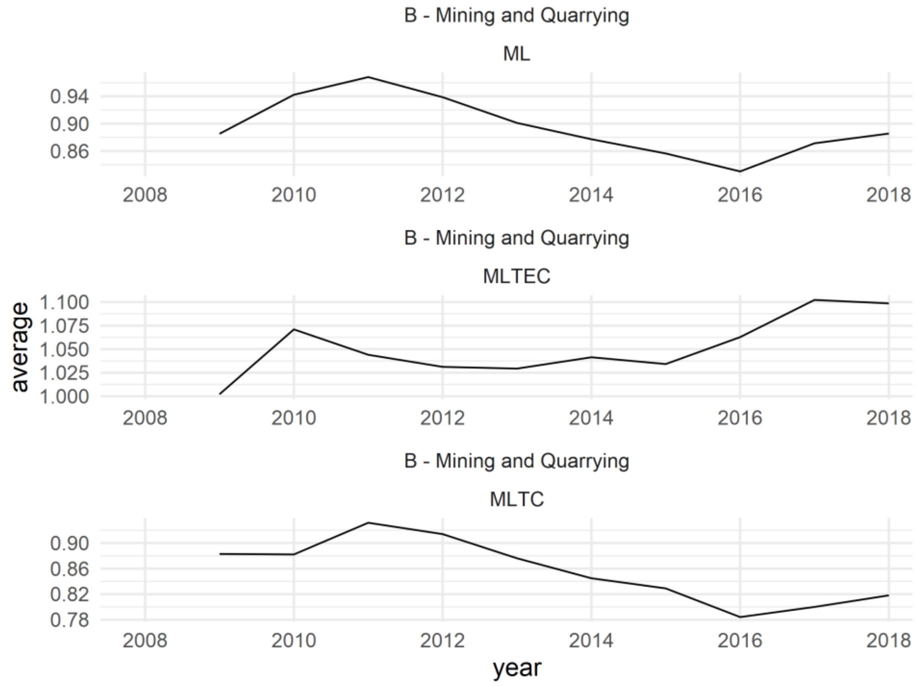
Source: Own elaboration based on Eurostat data.

Figure A.5.14: Productivity Growth - Agriculture, Forestry and Fishing



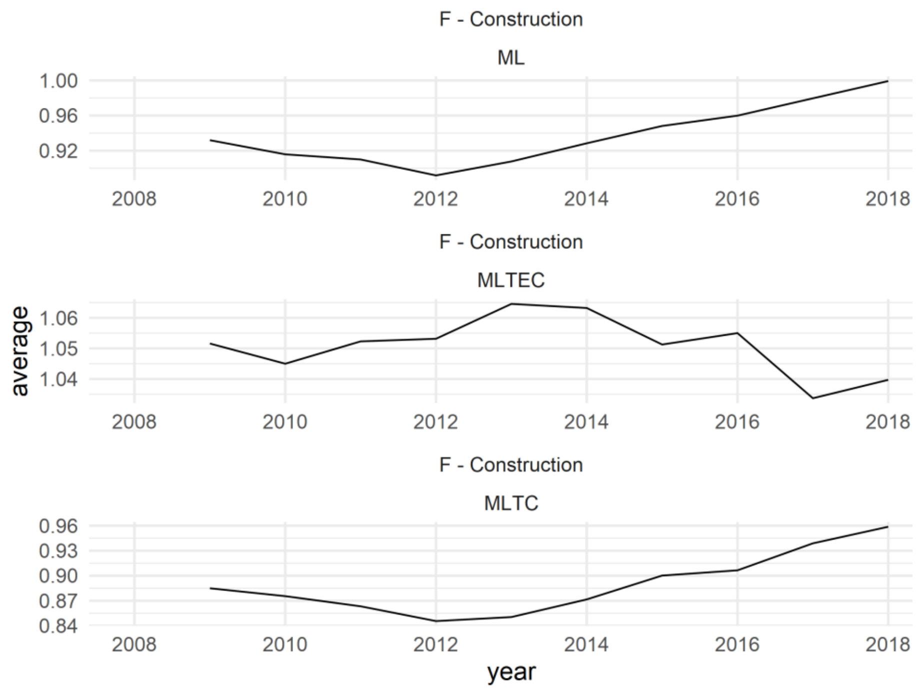
Source: Own elaboration based on Eurostat data.

Figure A.5.15: Productivity Growth - Mining and Quarrying



Source: Own elaboration based on Eurostat data.

Figure A.5.16: Productivity Growth - Construction



Source: Own elaboration based on Eurostat data.

A.6. Appendix to Chapter 6 (Social insurance)

A.6.1. EU unemployment insurance and COVID-19

Although data on unemployment-related expenditure for the first part of 2020 are not yet available, it is interesting to explore the possible effects of the above-designed EU insurance scheme on the COVID-19 crisis.

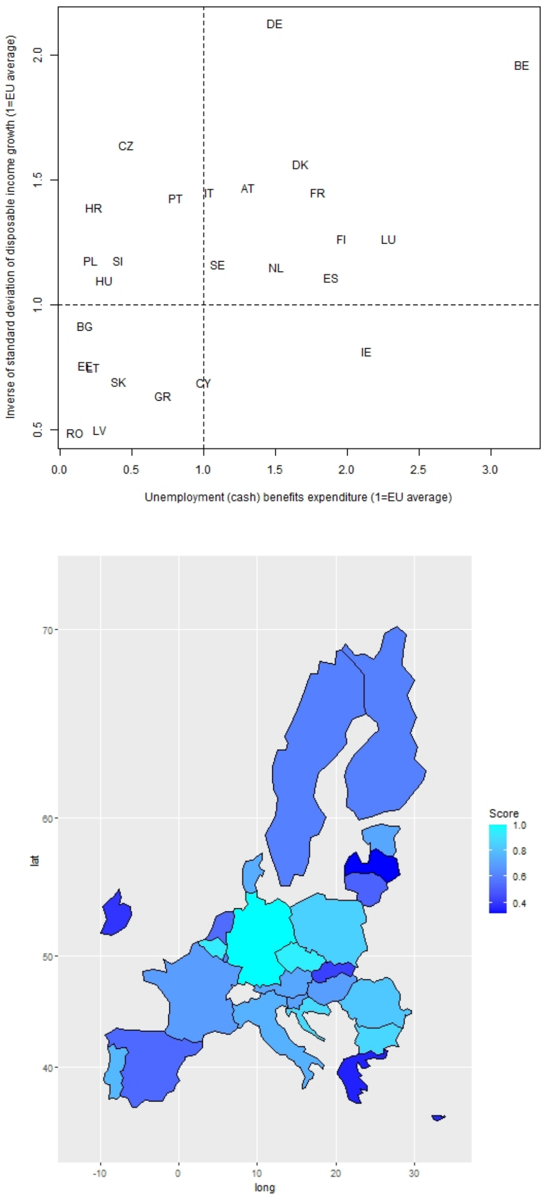
Perhaps surprisingly, despite the significant loss in GDP, the impact of the unemployment insurance fund on the first semester would have been tiny. This counterintuitive result is due to the fact that the unemployment rate had been reducing falling since the aftermath of the sovereign debt crisis; henceforth, in 2019 the unemployment rate was substantially below its 7-year moving average in all EU MS, and an huge shock was necessary to bring the unemployment rate above the moving average and trigger the EU-insurance-fund transfer. The second reason is that the SURE fund has been explicitly introduced in order to protect existing jobs. Most firms are, either voluntarily or compulsorily, hoarding labour instead of laying off workers, except for temporary ones. This has prevented the occurrence of an huge shock to the unemployment rate such as that observed in the United States, where the labour market is more flexible. Therefore, according to the most recent available data on the unemployment rate (May 2020,[60] source: Eurostat), in most countries the current unemployment rate is approximately the same as 2019; in some countries it is even lower, since discouraged workers have exited the labour force. Hence, relatively few countries would have triggered a transfer: Finland (2.3 pp over the moving average), Sweden (+1.8), Lithuania (+1.7), Luxembourg (+1.4) and to a lower extent Austria (+0.6), Latvia (+0.4) and Germany (+0.2).

According to the Spring Forecasts of the European Commission, an insurance fund, if it were in place, would probably intervene by the end of the year, by which time the unemployment rate is projected to increase in all MS (see the Spring Forecasts). It is difficult to provide a quantitative figure for the amount of resources that would be deployed by the proposed fund, since the actual value of unemployment rate increase is highly uncertain and will depend also on a potential second wave of COVID-19 and, more generally, on the state of the pandemic in non-EU trade partners such as, for example, the United States.

What is pretty certain is that this is a symmetric shock hitting all the MS, even if there are asymetric consequences; therefore, interregional transfers are not viable. The fund would either need to have large resources accumulated from the previous periods, or to have borrowing capacity and use the deposited resources as guarantees. However, if unemployment benefits could sustain disposable income for sure, it is not clear whether they would sustain consumption levels too: firstly because heightened uncertainty induces precautionary savings, and households may decide to save the unemployment benefit received rather than to consume it; and also because consumption habits have changed, both during and after countries' lockdown periods. The first point suggests that part of private demand has to be temporarily replaced by public demand; the second point suggests that relevant resources should be allocated to active labour market policies, in such ways that will allow unemployed workers to relocate into different jobs as quickly as possible.

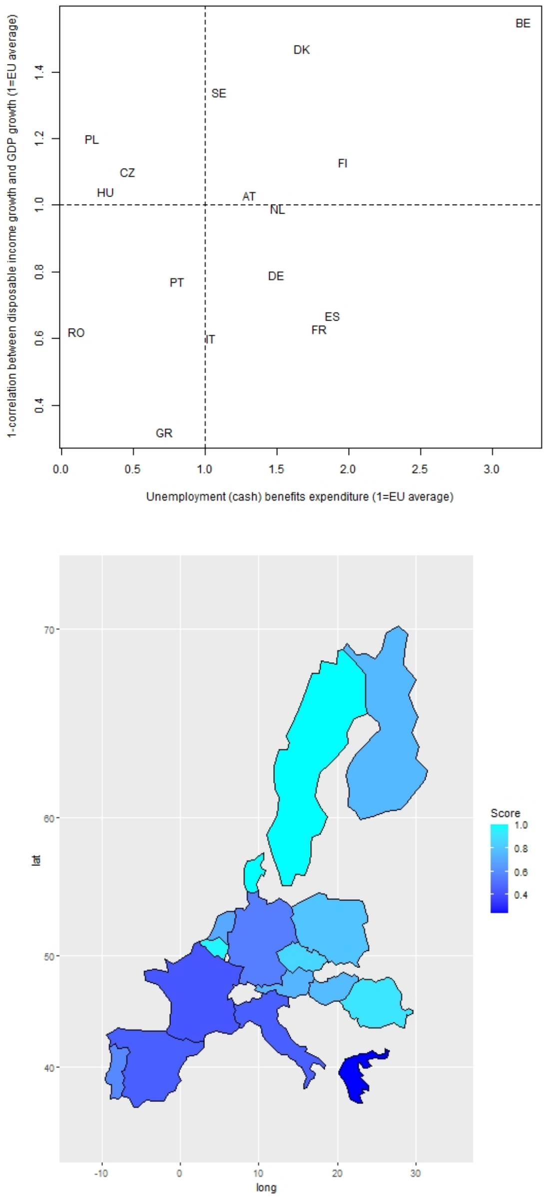
A.6.2. Robustness checks

Figure A.6.1: Unemployment cash benefits and standard deviation of the growth rate of disposable income



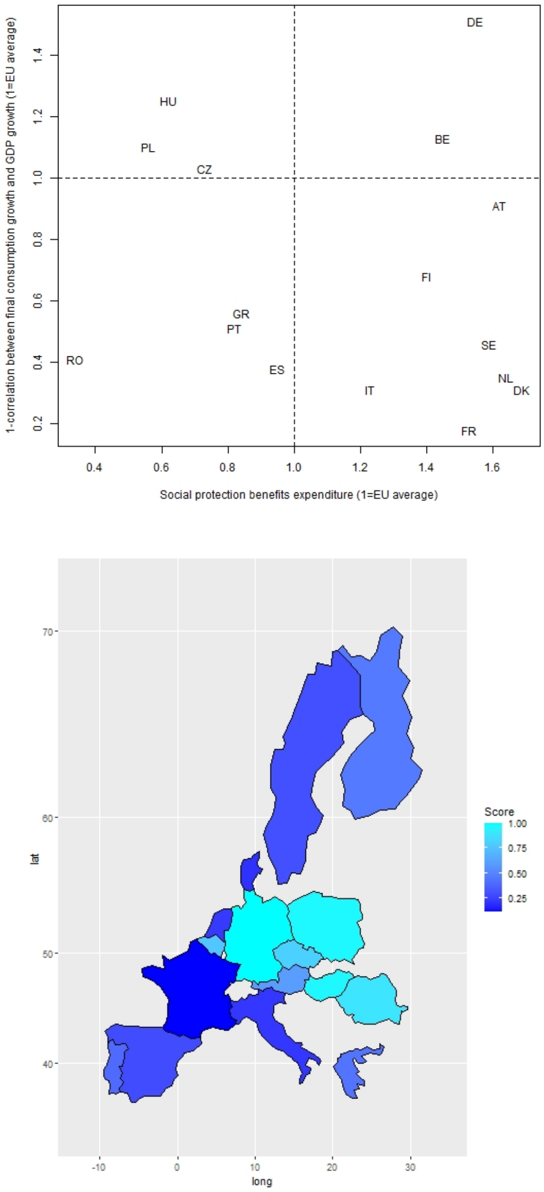
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.2: Unemployment cash benefits and the correlation of disposable income growth with GDP growth



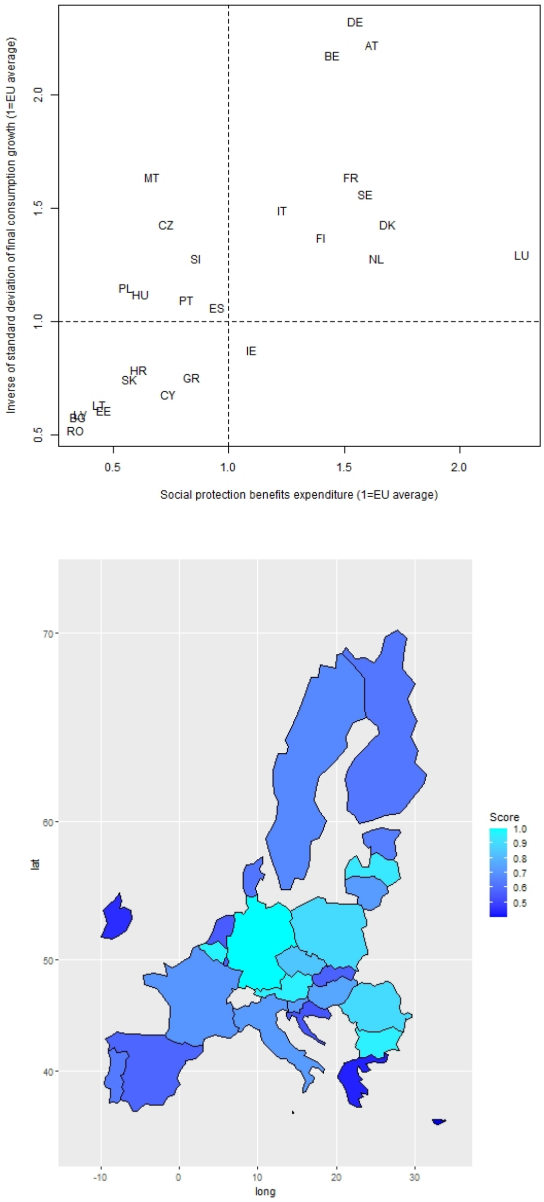
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.3: Social protection expenditure and the correlation of consumption growth with GDP growth



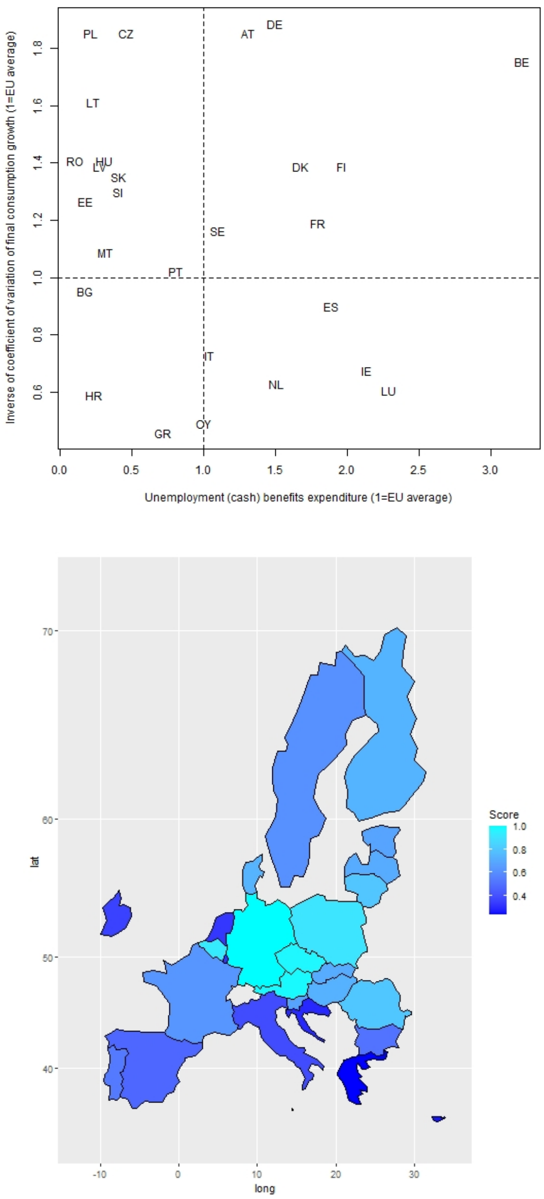
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.4: Social protection expenditure and standard deviation of the growth rate of consumption



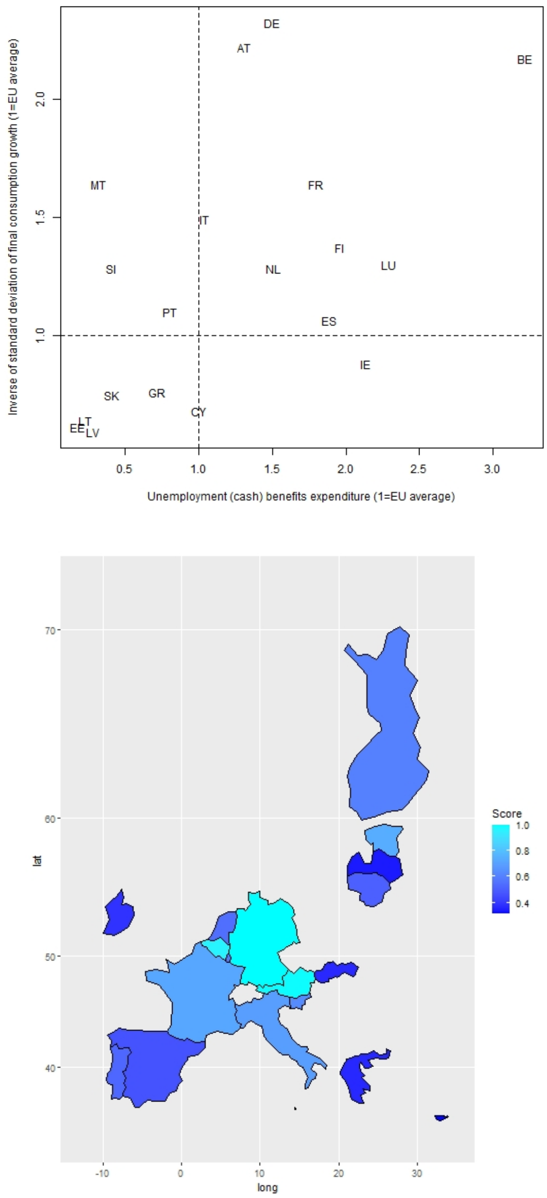
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.5: Unemployment cash benefits and coefficient of variation of the growth rate of consumption



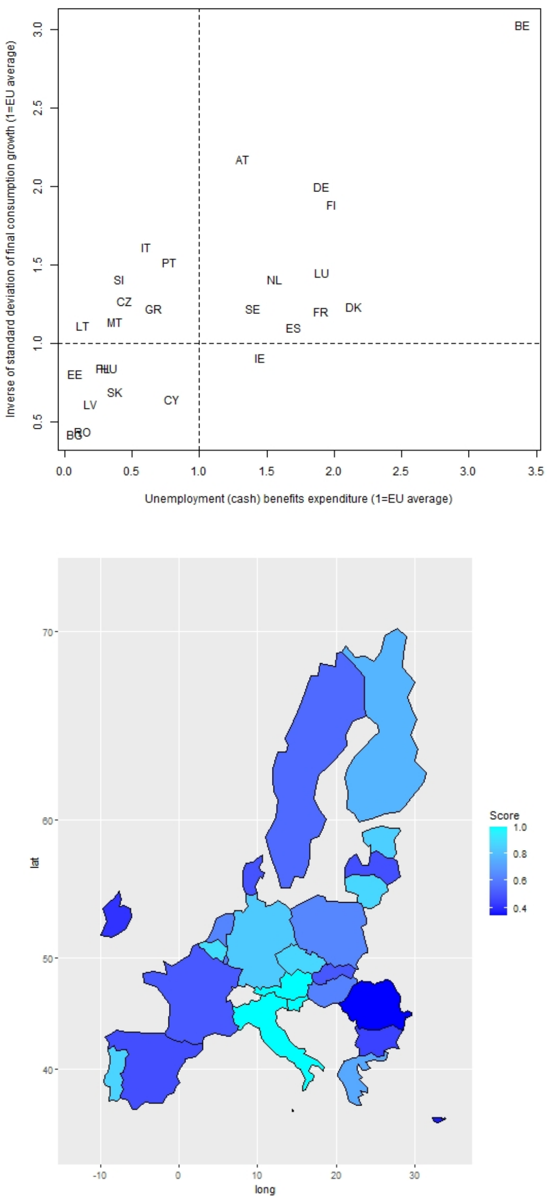
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.6: Unemployment cash benefits and standard deviation of the growth rate of consumption (EA countries only)



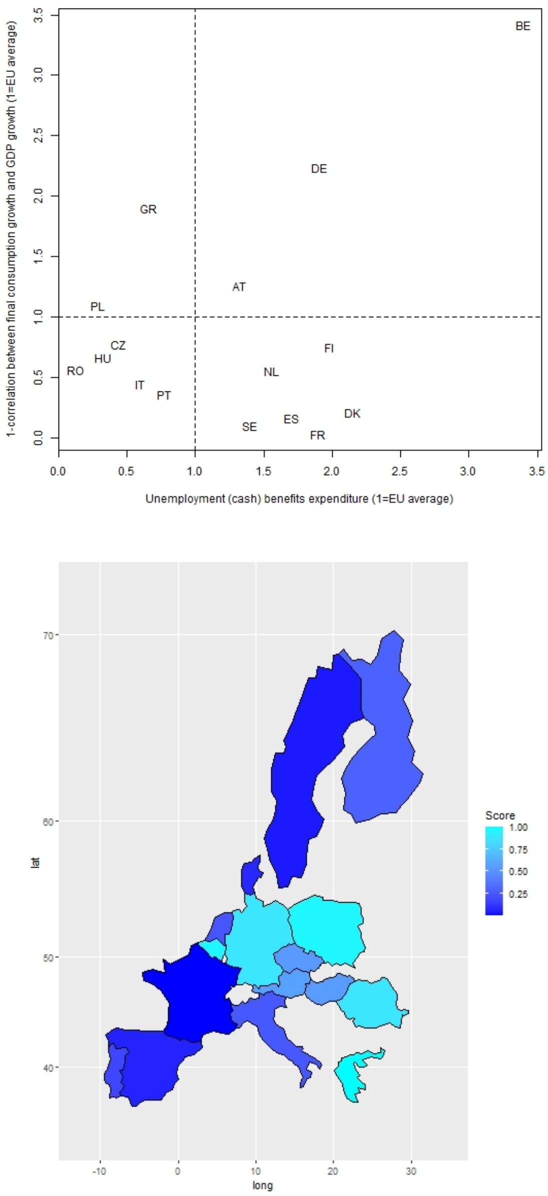
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.7: Unemployment cash benefits and standard deviation of the growth rate of consumption (2001-2008)



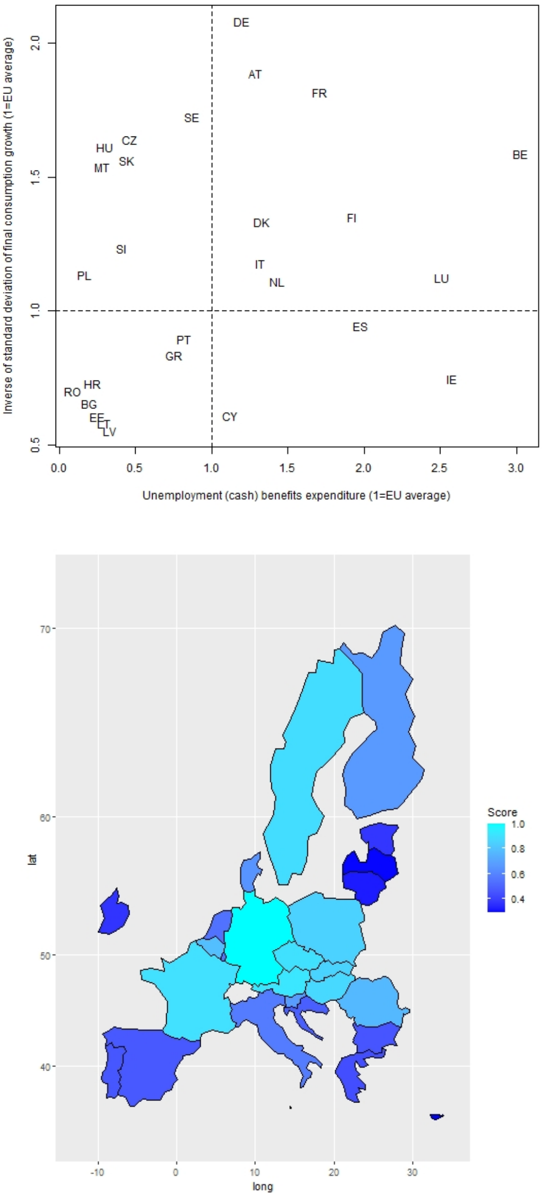
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.8: Unemployment cash benefits and the correlation of consumption growth with GDP growth (2001-2008)



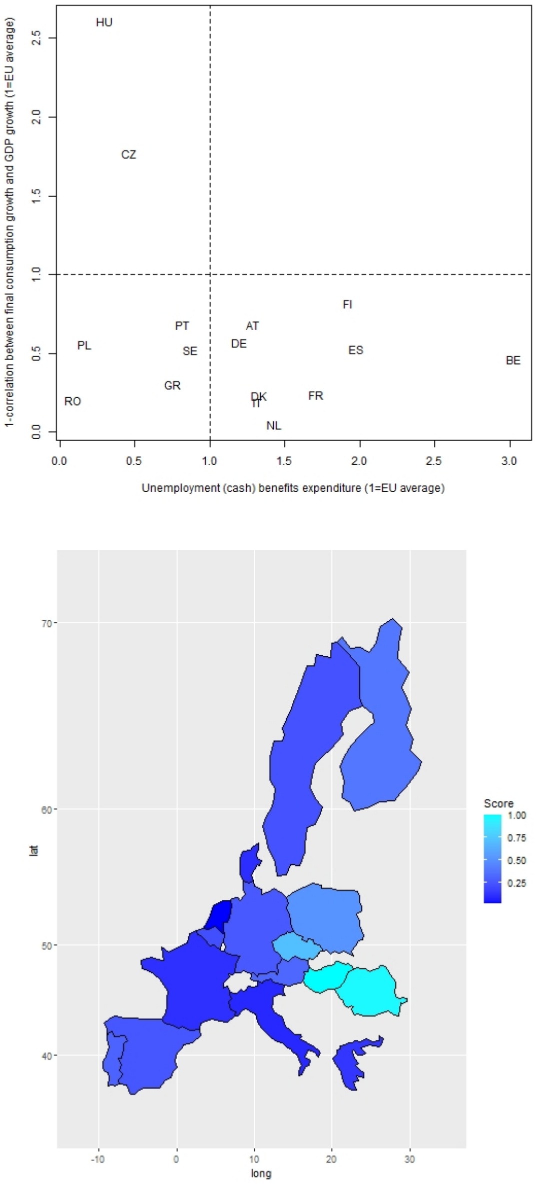
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.9: Unemployment cash benefits and standard deviation of the growth rate of consumption (2009-2017)



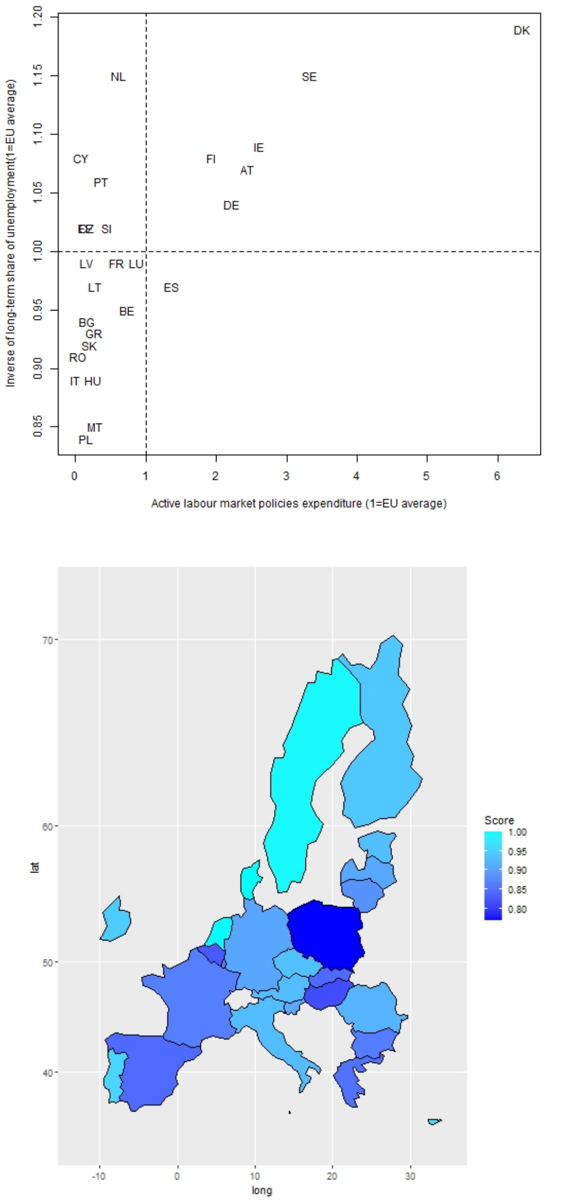
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.10: Unemployment cash benefits and the correlation of consumption growth with GDP growth (2009-2017)



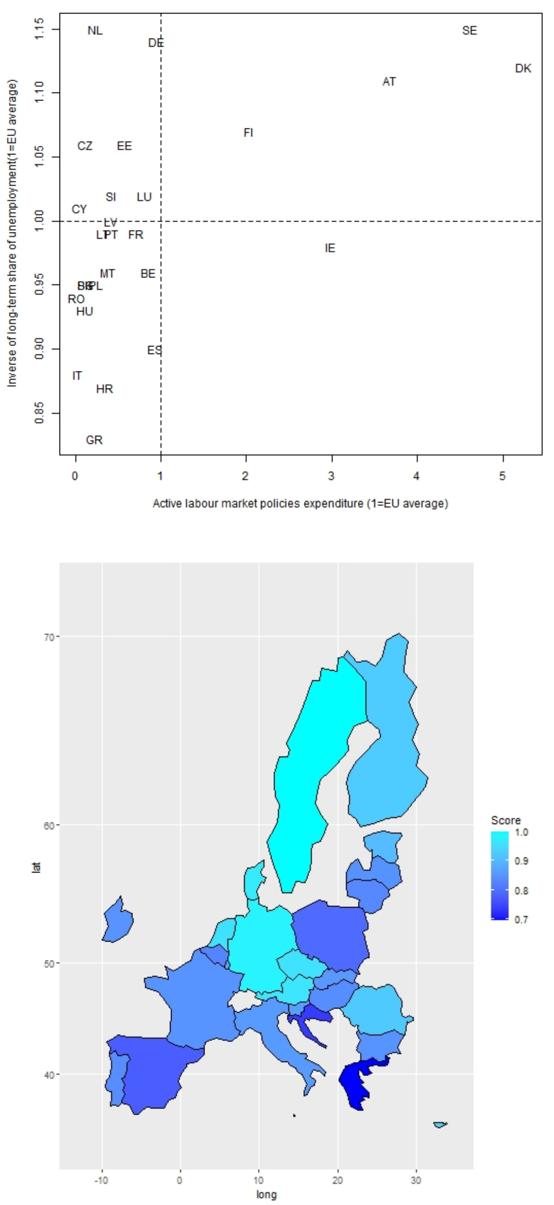
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.11: Active labour market expenditure and the employment rate (2001-2008)



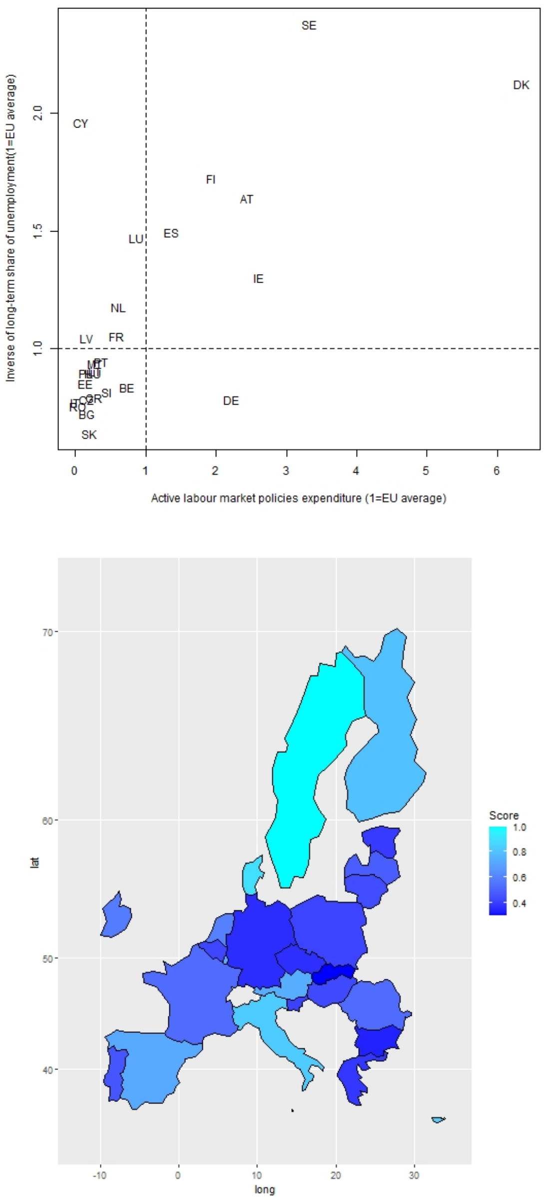
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.12: Active labour market expenditure and the employment rate (2009-2017)



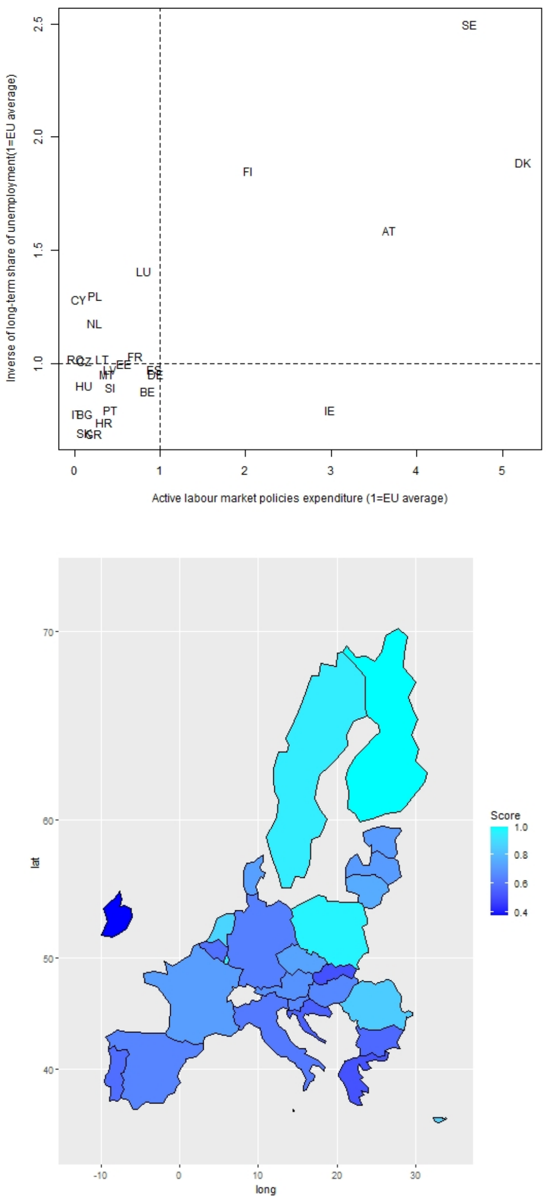
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.13: Active labour market expenditure and the long-term share of the unemployment rate (2001-2008)



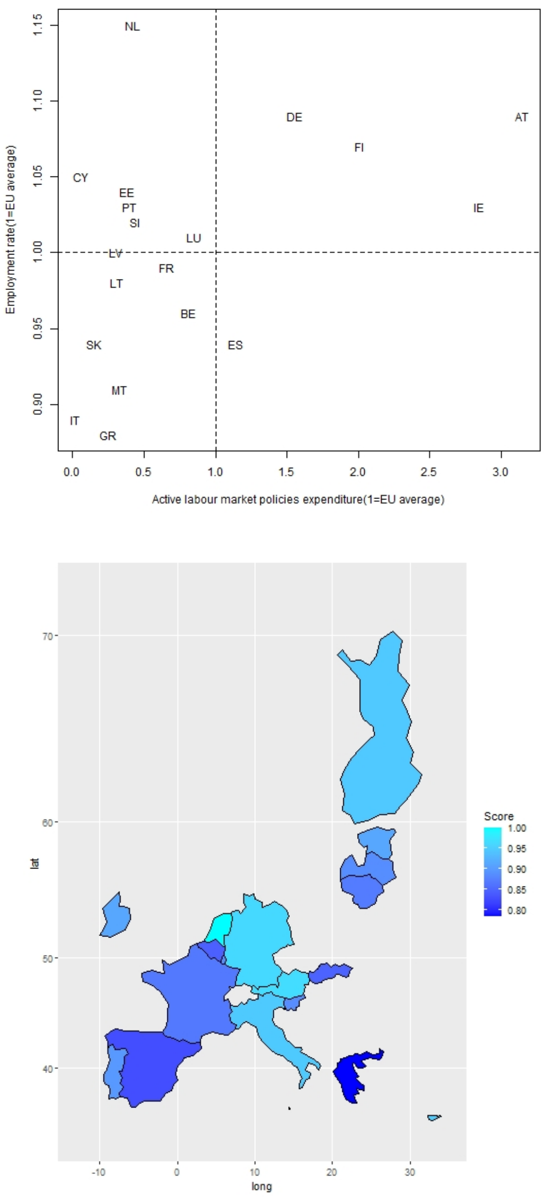
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.14: Active labour market expenditure and the long-term share of the unemployment rate (2009-2017)



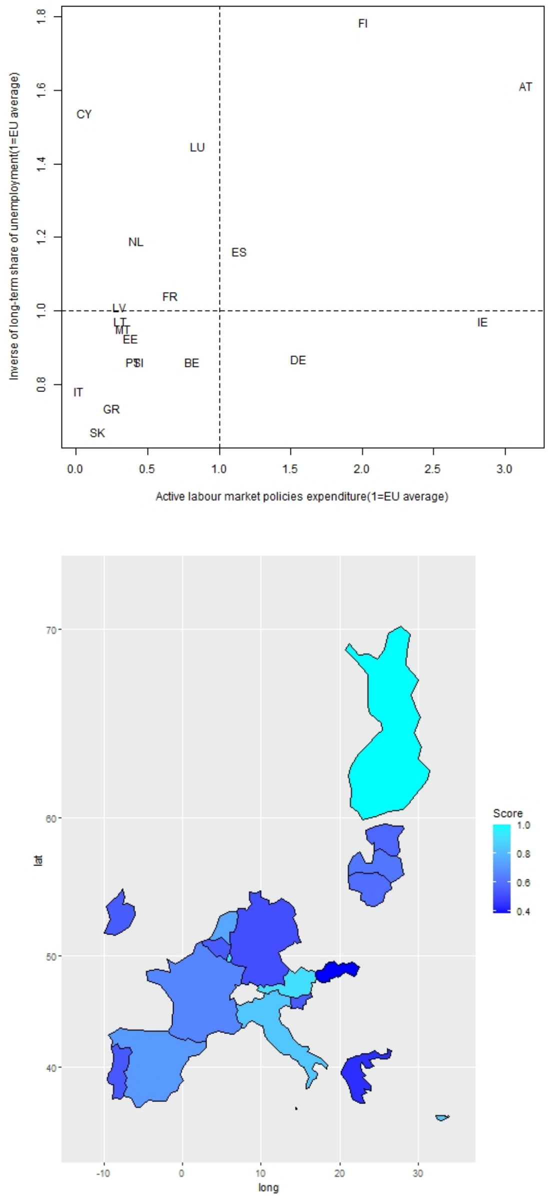
Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.15: Active labour market expenditure and the employment rate (EA countries only)



Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

Figure A.6.16: Active labour market expenditure and the long-term share of the unemployment rate (EA countries only)



Source: Author calculation on Eurostat data. Upper panel: scatter plot. Lower panel : scores of the two-stage DEA estimator (Simar and Wilson, 2007)

A.6.3. Simulation of EU unemployment insurance fund

In order to quantify the relationship between unemployment benefits expenditure and consumption stabilization, we run the following regressions:

$$SD\_CONS_{it} = \beta_0 + \beta_1\ UCB_{it} + \beta_2\ GROWTH\_GDP_{it} + \beta_3\ GDP_{it} + \varepsilon_{it}$$

$$CORR\_CONS\_GDP_{it} = \beta_0 + \beta_1\ UCB_{it} + \beta_2\ GROWTH\_GDP_{it} + \beta_3\ GDP_{it} + \varepsilon_{it}$$

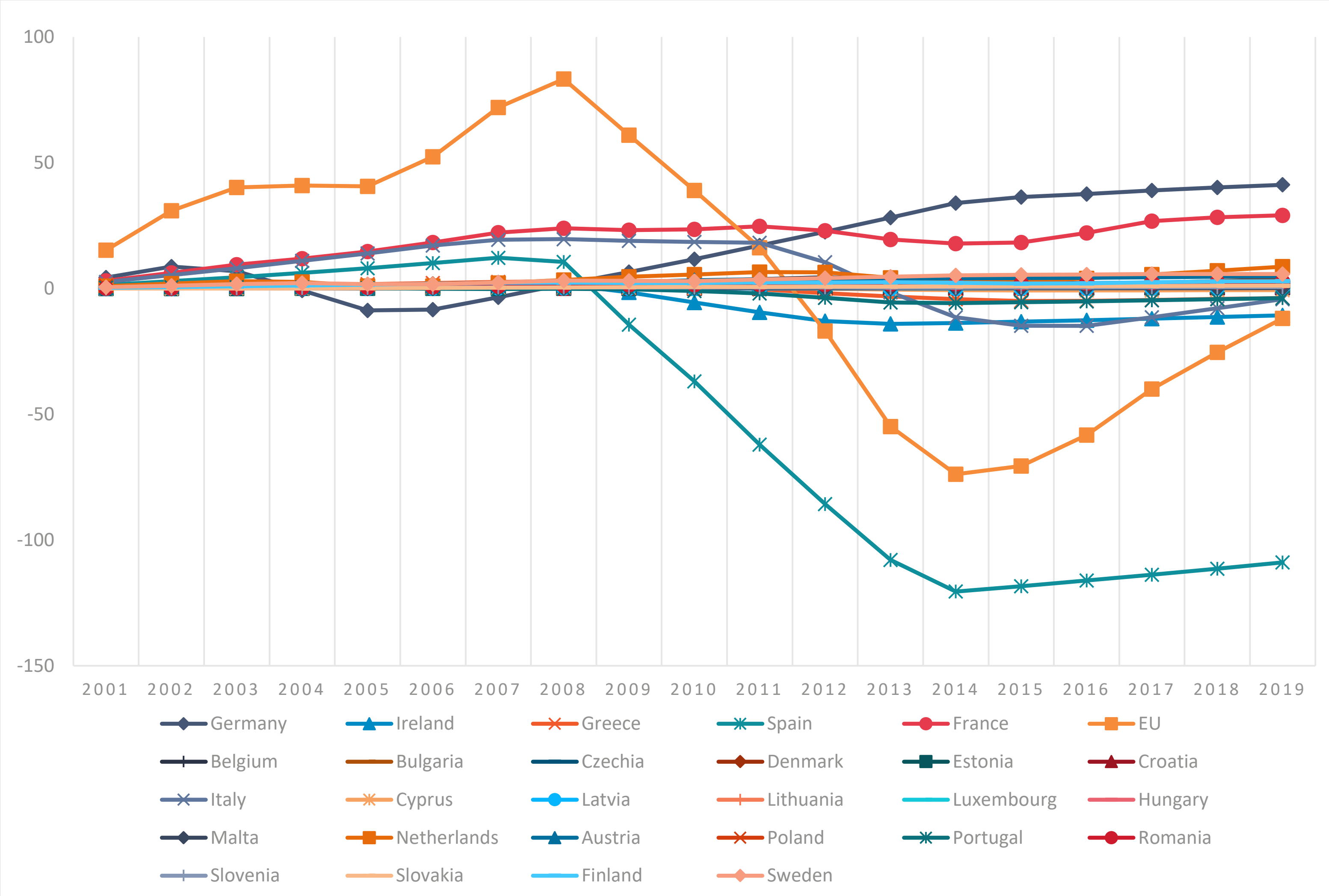
where SD_CONS_{it} is the standard deviation of per capita consumption growth in country *i* in the time interval *t-4* to *t*, $CORR\_CONS\_GDP_{it}$ is the correlation of per capita consumption growth with per capita GDP growth in country *i* in the time interval *t-4* to *t*, UCB_{it} is the per capita mean expenditure level on unemployment cash benefits in country *i* in the time interval *t-4* to *t*, $GROWTH\_GDP_{it}$ the mean per capita GDP growth and GDP_{it} the mean level of GDP, in billion of euro, in country *i* in the time interval *t-4* to *t*. All variables are expressed in Purchasing Power Standard terms.

Table A.6.1: Consumption stabilization effect of unemployment benefits expenditure. (2005-2017)

	Dependent: SD_CONSit (pp)	Dependent: CORR_CONS_GDPit (pp)
Intercept	4.381***	91.39***
UCB_{it} (x100)	-0.202***	-1.477**
$GROWTH\_GDP_{it}$ (pp)	-0.099**	-3.274***
GDP_{it} (bln € PPP)	-0.001***	0.004
N	312	312
Adjusted R^2	0.114	0.091

Source: Own elaboration based on Eurostat data.

Figure A.6.17: cumulative net contributions (bln €) to the EU insurance fund for all EU Member States, 2001-2019.



Source: Author elaborations on Eurostat data.

A.7. Appendix to Chapter 7 (Defence)

In order to confirm the relationship between defence equipment procurement expenditure and defence R&D some FE panel regressions have been run. The model adopted has been:

$$R\&D_{it} = \beta_0 + \beta_1 \text{ equipment procurement}_{it} + trend + trend^2 + \varepsilon_{it}$$

where R&D is the natural log of R&D expenditure of country *i* at time *t*, equipment procurement is the natural log of equipment procurement expenditure of country *i* at time *t* and *trend* denotes a time trend. For the sake of completeness, regressions have been run taking lagged values of the explanatory variable until *t= t-4*. The time period is 2005-2018. Results are summarised in the following table.

Table A.7.1: Equipment procurement and R&D.

	coefficients from panel regressions	expected change in R&D with respect to 1% change in equipment procurement
NO Lag	0.5019***	0.50%
1-year lagged	0.4231***	0.42%
2-years lagged	0.5397***	0.54%
3-years lagged	0.3472***	0.35%
4-years lagged	0.3468**	0.35%