What are the likely macroeconomic effects of the EU Recovery plan?

Fabio Canova
Norwegian Business School, CAMP and CEPR

Evi Pappa
Universidad Carlos III and CEPR *

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Abstract

We examine the macroeconomic effects of the two largest EU regional structural funds. ERDF has positive short term consequences on all regional variables, but gains dissipate within three years. ESF has negative impact effects on regional variables, but medium term multipliers are positive and significant. Regional asymmetries may induce differential transition paths and outlooks for economic transformation. Location, level of development, EU tenure, Euro area membership, and national borders account for the asymmetries. We interpret the facts with an equilibrium model and explain observed asymmetries. The policy implications for the newly created Recovery and Resilience facility are discussed.

Key words: Recovery and Resilience fund, countercyclical policies, regional inequalities, R&D investment, human capital investment, externalities.

JEL Classification: C32, E27, E32, H30.

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1 Introduction

July 21, 2020 is considered a historical date for the European Union (EU). On that day, the European Council has agreed to a new EU budget for 2021-2027 which, for the first time, includes funds that do not only come from national contributions, but are also borrowed from international financial markets. The Council has also made provisions to back the borrowing with future union-wide carbon emission, plastic use, and financial transactions taxes, among others. Thus, an embryo of a EU federal fiscal policy has been created. Apart from the regular budget, the agreement has produced the Next Generation EU (NGEU) funds, a package of programs which, through a combination of grants and loans, intend to support the recovery from the COVID-19 pandemic and foster investments leading the transformation to a greener, digital economy.

The largest instrument among the NGEU funds, the Recovery and Resilience Facility (RRF), has been especially designed to counteract the negative economic effects of COVID-19 and to help countries in difficulties, by covering a portion of the funds national governments have borrowed or will borrow to help workers and firms. It should facilitate the recovery, hopefully back to the growth path existing prior to the pandemic, by creating jobs and favoring the transition to sectors and activities with larger strategic potential. The expected fiscal expansion is huge. The total budget for 2021-2027 amounts to 13 percent and the RRF about 5.5 percent of EU gross national income (GNI). In comparison, the CARES recovery package in the US amounts to 15.9 percent of GNI (3061 billion US$) and the Chinese recovery package is only 4.2 percent of GNI (4.200 billion Yuan).

Will the effort succeed in creating jobs? Will the EU economy permanently go back to the trend after the unprecedented fall of the second quarter of 2020? Will the conversion to a greener economy be smooth? Will the programs jump start EU economies to a virtuous growth cycle? While policymakers' expectations are optimistic, the large costs and the uncertain benefits of the proposed programs, together with the unprecedented nature of the current economic situation, call for caution and care in thinking about the consequences of the fiscal expansions the EU will undertake.

The contribution of the paper This paper empirically studies the regional macroeconomic dynamics produced by EU structural funds over the last 30 years and presents a model highlighting the main transmission channels of EU funds to a typical European region. We collect stylized facts, provide a theory-based interpretation of the evidence, and offer an historical perspective that helps to evaluate the likelihood of the success of the planned fiscal expansion.

The empirical analysis focuses attention on the production, investments, and labor market dynamics generated by the two major past EU funds: the European regional development fund (ERDF), launched to foster innovation and research, to favor the digital agenda, and to support small and medium-sized enterprises; and the European Social Fund (ESF), whose aim was to support investments in education and health; and to fight poverty. We shed light on four important questions:

what are their macroeconomic effects? Are they uniform across regions? What may account for the differences? Is the RRF likely to succeed?

To answer these questions we construct a novel database of regional funds and exploit the information contained in the main regional macroeconomic aggregates of 279 European NUTS2 units. We employ an instrumental variable Bayesian approach to measure the dynamic multipliers of the two structural funds, region by region. With the time profile of the distribution of multipliers, we summarize its characteristics using cross-sectional averages and cluster regional statistics along economic, geographical, institutional, or national dimensions.

We study federal fiscal expansions in a standard New Keynesian model with endogenous growth and externalities. R&D and human capital accumulation are allowed to be affected by the federal expenditure and labor productivity may also be altered. The mechanisms we build into the model are crucial to understand the stylized facts we collect and to generate realistic growth responses to the spending disturbances we consider. We highlight the structural parameters that may generate dynamic heterogeneity and differential transition and growth prospects.

The empirical results The two funds have different growth effects. ERDF has statistically significant and economically relevant average positive short term impact on all regional macroeconomic variables, making it potentially useful for countercyclical purposes. These funds temporarily boost productivity and lead to an expansion of employment, compensation, investments and production. Nevertheless, the positive impact dies out quickly and gains dissipate almost entirely within three years. Instead, ESF has a negative, although often insignificant, impact consequences but it exercises positive average effects on all regional variables after 2-3 years, suggesting that it could be a good instrument to achieve medium term transformation objectives. These funds temporarily affect labor markets, increasing compensation and hours for education. However, the increase in labor productivity they produce in the medium run, induces positive and economically important effects on investments, employment, and production.

Quantitatively, an increase in ERDF equaling to one percent of regional gross value added (GVA) makes GVA growth jump, on average, and cumulatively over three years by 1.0%, while employment growth is 0.9% and investment growth is 1.3% over the same horizon. A similar increase in ESF leads to 5% cumulative increase in GVA growth, to a cumulative increase of 1.6% in employment growth, and to a cumulative increase of 4.3% in investments growth, on average, over three years. Thus, if employment, production, and investments growth are the yardstick to measure the success of the two programs, ESF dominates EDRF in the medium run.

Average figures mask considerable regional heterogeneity in macroeconomic responses. For example, for all horizons and all variables, about 50% of the units have multipliers which are smaller than half of the mean multiplier; and about 30-35% have multipliers larger than twice the mean multiplier. We find that membership in the Euro, location, national borders, and tenure in the EU matter. For instance, in southern regions, ERDF has positive medium term cumulative growth effects, while these effects are negative in northern regions; and ESF has larger and more significant medium term repercussions. Similarly, for regions belonging to older EU member countries, EDRF produces less negative and ESF more positive medium term growth effects. The level of development is also important and regions whose per-capita income is in the central portion of the distribution benefit most from both programs. Hence, although the distribution of EU funds is skewed towards poorer, peripheral, and less developed regions, their asymmetric effects across regions may lead to an increase in polarization and regional inequality (see Canova [2004] for an earlier evaluation of income polarization in EU regions). If regional inequality is an important consideration for policymakers, ESF is superior also in this dimension, as it benefits a larger number of regions in the medium run in a variety of EU countries.

Spillovers across regions within a country are important. Both programs, in fact, generate average national multipliers estimates larger than average regional multipliers estimates.

The insights of the model In addition to the standard bells and whistles present in a two-region New Keynesian model of a monetary union, our theoretical framework has one feature, which is crucial to understand the effects of EU funds. Federal spending on R&D and human capital affects either labor productivity or factor accumulation generating an externality on the aggregate level of these services. In such a setup, temporary federal spending shocks produce persistent dynamics, even without agglomeration effects: they boost aggregate demand, because government absorption of goods and services increases; and they alter aggregate supply, because the productivity of factors of production increases. Changes in the timing of demand and supply effects help to account for a number of the stylized facts we collect across different groups of regions.

The increase in demand induced by federal R&D spending shocks causes an impact increase in regional output, employment, physical capital investments, and labor productivity. Whether the multiplier effect on regional economic activity is long lasting or not depends on how R&D expenditures shocks affect the regional economy. When the growth rate of federal spending enters the aggregate production function, the accumulation equation or the profit function of wholesale firms the model generates zero or negative cumulative medium term effects. When it enters with a lag, multipliers display a hump. If instead, the level of R&D expenditure affects productivity with a lag persistent medium term multipliers could be created, as demand effects become larger and more persistent.

Federal government spending in education enhances the accumulation of private human capital. In the short run, federal increases in education spending decrease employment and increase real wages, as workers take advantage of the funds to change their time allocation and acquire better skills. Since human capital enhances effective labor productivity, investment demand increases and the shock generates second round effects on production and employment, through the accumulation of both human and physical capital. The model is rich also in response to these shocks and a variety of patterns can be generated, depending on how free parameters are set. In particular, to generate persistent medium term effects, human capital should depreciate relatively fast in the steady state. In addition, physical capital should be relatively free to adjust, so as to produce an investment boom at the time when higher human capital is more extensively used in production. When human capital depreciates slower than physical capital or physical capital adjustment costs are sufficiently large, negative medium term effects could be generated also in response to these shocks.

Given the small open economy nature of NUTS2 regions, the model economy features trade in goods and services and the home region is taken to be small relative to the rest. The small open economy assumption has implications for the dynamics we obtain, as the demand effect on aggregate inflation is limited. Thus, the reaction of the interest rate, which is set by the central bank as function of the aggregate inflation rate, is reduced relative to the case when the regional economy is large, because the demand effect of the shock is subdued. This implies that the private output and employment multipliers are smaller than would be obtained when the regional unit is larger, thus partially accounting for the spillover effects we document in the empirical analysis.

Relationship with the literature As far as we know, there has been no study analyzing neither countercyclical nor the medium term effects of EU grants, at regional or at country level. Thus, the paper brings together two unrelated strands of literature. The first studies the effects of EU transfers on income inequality or long-term growth, see e.g. Boldrin and Canova [2001], Canova [2004], Mohl and Hagen [2009], Becker et al. [2013]. We complement this literature by analyzing the cyclical consequences of EU funds on product and labor markets, explicitly taking a regional focus, and differentiating funds by their aim. In the process, we create a usable data set of real per-capita funds; and document the extent of regional heterogeneities in response to different programs.

The second type of literature examines the dynamic effects of fiscal expansions in monetary unions, see e.g. Canova and Pappa [2007], Nakamura and Steinnson [2014], Dupour and Guerrero [2017], Auerbach et al. [2020]. This literature is concerned primarily with US fiscal expansions, both at federal and local level, and takes into consideration military expenditure, federal transfers to states and counties, or local state expenditure. Recently, the focus has been on federal transfers due the special events, e.g. 2008 financial crisis or natural disasters, see Chodorow-Reich [2019], Deryugina [2017]. We contribute to this literature by employing EU regional data; providing a theoretical perspective about transmission channels, and collecting information about the dynamics of variables typically unavailable in US studies.

Coelho [2019] empirically examines the effects of EU structural funds on employment and production. Our exercise differs in a number of dimensions. First, she uses nominal rather than real funds data; second, she limits attention to the last two budget cycles (2000-2006 and 2007-2013), while we take a longer perspective; third, the average effects she estimates are biased because the econometric procedure she employs is invalid. Finally, we provide a model to explain the dynamics; she does not.

Policy Implications. Structural funds have important short and medium term macroeconomic effects on the regional economies of the EU. The dynamics they generate differ making them potentially useful for different policy purposes. One type may be used for countercyclical purposes, with the understanding that it could temporarily support regional income, at the cost of producing reverse effects in the medium run. The other type has longer lasting and more homogeneous medium term effects. The higher regional skills that this fund induces imply higher workers' compensation, but also higher private investments, and this may potentially ignite a virtuous growth cycle. Given that NGEU funds combine features of the two structural funds we consider; and given that in Spain, France, and Italy, who were severely hit by the pandemic, private output and employment multipliers are positive, on average at the three years horizon for both funds, there is hope that the new programs will support the recovery and foster economic transformation.

However, at least one of the funds produces asymmetric regional medium term dynamics. EU funds may create jobs, foster investments, boost private activity, and improve productivity, but do so in an heterogeneous manner, leading to polarization and larger regional inequalities. Moreover, macroeconomic variables in different countries react differently to the flow of funds, and this may account for the tense negotiations taking place in the European Council when NGEU funds were created. Thus, to produce Pareto improving allocations and dynamics, the new funds need to be combined with specific measures that help poorer, newer, and peripheral regions to transform their economies and, perhaps, their public administrations.

The outline of the paper. The next section describes the novel regional funds data and the regional macroeconomic data we employ. Section 3 discusses the econometric methodology. Section 4 presents the average multipliers. Section 5 studies regional heterogeneity. Section 6 presents the model and analyzes the dynamics of transmission of federal spending shocks. Section 7 concludes with some implications for the planned EU fiscal expansion. The appendix describes the nature of the EU structural funds and has some graphical statistics of the newly constructed data set.

2 The data

The data we use comes from official EU sources. The first source, called ARDECO online, is available at https://ec.europa.eu/knowledge4policy/territorial/ardeco-online_en and includes main macroeconomic aggregates for 314 European NUTS2 units. The NUTS2 classification indicates regions of Europe and is intermediate between NUTS1 (covering macro regions) and NUTS3 (covering provinces).

It is, thus, comparable to a classification based on states in the US, which is intermediate between macro regions and counties classification. The database contains information for EU members and for Albania, Norway, Serbia, Montenegro, Macedonia. In the exercises we run we focus attention on the 279 regions belonging to the EU, singling out, when relevant, the UK, or Euro area regions.

We use annual data on real private GVA, employment, real workers' compensation, population and labor force (which we use to construct the participation rate), real gross fixed capital formation, and construct series for labor productivity. The starting date of the sample is 1980 and the final date is 2017. For the regions belonging to East Germany, Eastern European countries, or the Baltic states, the sample is shorter and starts only in 1990.

The second official source of data we employ reports the allocation of European structural funds. It is named "Historical data on structural funds by member state", and it is available at https://cohesiondata.ec.europa.eu/Other/Historic-EU-payments-regionalised-and-modelled/tc55-7ysv As detailed in appendix A, there are four types of grants EU regions have received over the sample: the Cohesion fund (CF), the Agricultural fund (EARDF), the Regional development fund (ERDF), and the Social Fund (ESF) [1]. Because CF grants are assigned at country level and the EAFRD targets agricultural support, in our exercises we employ data for ERDF, which is concerned with investments in innovation and research, the digital agenda, and with the support for small and medium-sized enterprises; and for ESF, which is directed to support investments in education, health, and in projects fighting poverty. There are a number of issues with the way the data is reported in the official sources. The data are estimated because there is a time gap between the expenditure by the regional government (which are not available) and the payments made by EU over each budget cycle; there are mistakes in the coding of the data; and the numbers come in nominal terms. Information about how regional expenditure are estimated is in appendix B. Details concerning the construction of a comparable data of real structural funds across regions are in Canova et al. [2020].

3 The econometric procedure

To examine the dynamic effects of ERDF and ESF on regional macroeconomic variables we employ a Bayesian framework. Given the potential endogeneity of structural funds to EU economic conditions, we use their innovations as instruments in the dynamic regression equations. Innovations are constructed as the residuals of a regression of each real structural fund series on a constant and five aggregate Euro area variables: GDP, employment, GDP deflator, nominal interest rate, and nominal effective exchange rate. This way we account the fact that available EU funds are affected by the economic conditions in the region as they come as transfers from national governments [2]. Annual

[1] Since the 2014-2020 budget cycle a Fishery fund (EMFF) is also available.

[2] Ideally one would like to use EU variables to construct innovations. For our purposes, Euro area variables suffice since there is a very high correlation in the economic cycle of Euro and non-Euro area EU members

Euro data goes from 1980 to 2017 from the same EU sources mentioned above. Because the sample is short, the prior helps to regularize individual and average estimates we construct.

The dependent variable in regression equations is the cumulative growth rate at horizon h of the macroeconomic variable of interest, i.e, $y_{i,t,h} = \sum_{j=1}^{h} \frac{Y_{i,t+j-1} - hY_{i,t-1}}{Y_{i,t-1}}$. The independent variable is the cumulative change in the relevant fund, scaled by regional GVA, i.e. $x_{i,t,h} = \sum_{j=1}^{h} \frac{G_{i,t+j-1} - hG_{i,t-1}}{GVA_{i,t-1}}$. We scale the grant variable by regional GVA rather than regional income, as it is common in the literature, see e.g. Dupour and Guerrero [2017] or Ramey and Zubairy [2018], since the measurement of the regional component of the public sector is problematic. The equation includes a constant and one lag of the dependent variable only, as degrees of freedom are scarce. Formally, for each macroeconomic variable, the estimated equation is

$$y_{i,t,h} = a_{i,h} + b_{i,h} y_{i,t-1,h} + c_{i,h} x_{i,t,h} + e_{i,t,h} \tag{1}$$

where i refers to region, t to time, and h to the horizon. Because of the way the predicted value $\hat{x}_{i,t,h}$ is constructed, $c_{i,h}$ represents the average cumulative multiplier at horizon h of an unexpected increase in a structural fund at each t (Euro change in private income per Euro change of grants). The advantage of using innovations as instruments is that we avoid typical biases in the estimates of $c_{i,h}$ due to the persistence exhibited by $x_{i,t,h}$, see e.g. Canova [2020b].

Given the short time dimension of the sample, we limit attention to h=1,2,3. We employ a normal prior for $(a_{i,h}, b_{i,h}, c_{i,h})$ with zero mean and fixed variance. This is equivalent to smoothly shrinking IV estimates to zero and produces estimates which are the same as those of a IV ridge estimator. The prior on the coefficients and the covariance matrix of the error term of the instrumental variable equation are non-informative.

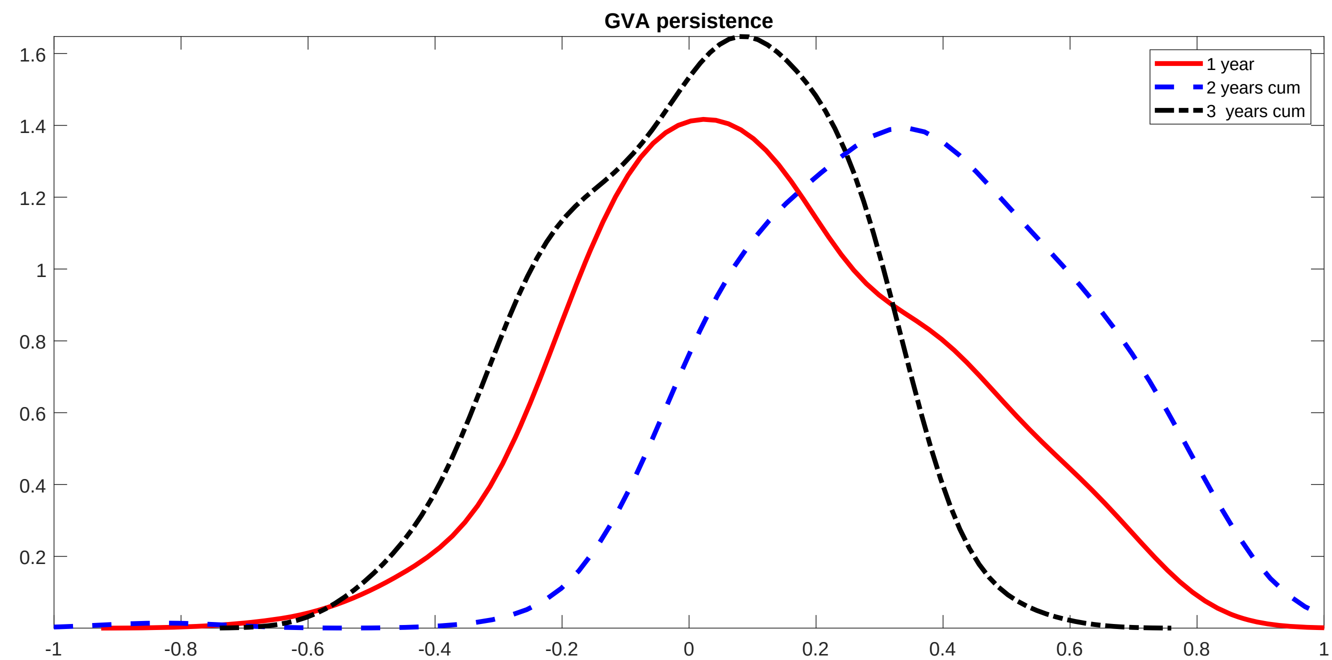
Once estimates of $c_{i,h}$ are obtained for each i and h, we compute cross-sectional averages by trimming the top 10 and bottom 10 percent of the estimates [3]. To characterize other features of the distribution of regional multipliers we group estimates in a number of ways. In particular, we group regional multipliers by location and tenure in the EU and report the average trimmed multipliers at horizon h for each of the two groups. We also cluster regional estimates using the level of regional development, as measured by the average level of GDP per-capita and report the average multipliers at horizon h in each quartile of the per-capita income distribution. Finally, we cluster multipliers using national borders and, for each horizon, we report average multipliers within a country.

Two important issues deserve some discussion. The first is one of predictability. The EU budget works in seven years cycles and an allotment of funds to the country for the whole fiscal cycle is made at the beginning of each cycle. Regional projects need to be approved by federal authorities, reimbursements of (a portion of) the expenditure are made when national authorities provide receipts, and at that point expenditures are recorded in the EU budget. Thus, there two types of issues that

[3] While magnitudes change, the qualitative features we discuss remain unchanged if median values are used as location measures.

one needs to control. First, real expenditures occur prior to the appearance in the official EU data. The EU tries to account for this feature of the data by constructing expenditure profiles of different regions and spreading yearly recorded expenditure differently according to the these profiles. Thus, for example, if a region typically asks for reimbursements only in the last two years of the budget cycle, expenditures are smoothly spread in the previous years. Second, expectations of expenditure may be produced that induce private agents act prior to the actual expenditure taking place. However, because of the length of EU budget cycle and the need of EU approval for the projects, these anticipatory effects may occur one or at most two years in advance. We examine whether this second type of predictability occurs by shifting the time index in independent variable of (1) one or two years forward and proceeding similarly for the corresponding instrument.

Figure 1: Distribution of the b_h, GVA equation, different h



Coelho [2019] employs expenditure commitments, rather than estimated expenditure entries, to account for predictability. This selection, however, fails to address the problem because commitment data refer to the aggregate assigned to a country in a specific year and not to a specific project. For example, in 2000 commitments do not represent anticipation of 2001 projects as they may contain commitments for projects approved in 1999 which may be undertaken in 2002.

Second, when constructing average multipliers, especially with a short time dimension as ours, it is common to proceed pooling cross sectional units when running regressions like (1), see e.g. Nakamura and Steinnson [2014] or Chodorow-Reich [2019]. That is, one would omit the subscript i from all the coefficients in (1), include a time effect and omit the lag dependent variable. However, if the dependent variable in (1) is serially correlated and the dynamic evolution of $y_{i,t}$ in response to EU funds is different across regions, such an approach leads to inconsistent estimates of the quantities of interest, see Canova [2020b].

To show that, for the data we consider, the problem is relevant, Figure 1 plots the cross sectional distribution of b_h when the dependent variable is GVA and $h = 1, 2, 3$. Clearly, dynamic heterogeneity is important - there is no evidence that the distribution for each h collapses at one point or that becomes more concentrated as h increases; hence, an alternative approach is needed to compute average multipliers which retain some consistency properties. For this reason, we estimate (1), region by region, and take the trimmed mean of the cross-sectional distribution of $c_{i,h}$ for different h as our location measure. This average estimator corresponds to the (trimmed version) of the mean group estimator suggested by Pesaran and Smith [1995], which is very commonly used when a panel features dynamic heterogeneity. Note that, if the regions are dynamically homogeneous, the average multiplier we construct would asymptotically approach the multiplier constructed with a pooled estimator, for the appropriate choice of the prior mean, but would be less efficient. Thus, the estimator we employ works, when dynamic homogeneity holds in the cross section or not.

4 Average multipliers

Table 1 reports one, two and three year cumulative average multipliers for the six regional variables of interest, separately for ERDF and ESF programs, when all 279 EU regions are considered.

Table 1: Average cumulative multipliers, all EU regions

	ERDF funds			**ESF funds**		
Horizon	1 year	2 years	3 years	1 year	2 years	3 years
GVA	1.83	1.58	1.08	-0.51	2.57	5.09
	(0.19)	(0.32)	(0.32)	(0.64)	(0.80)	(0.83)
Employment	0.85	0.37	0.88	-0.31	1.23	1.61
	(0.16)	(0.28)	(0.29)	(0.23)	(0.37)	(0.27)
Compensation	2.19	0.70	0.98	2.10	2.79	3.54
	(0.36)	(0.68)	(0.80)	(0.39)	(0.58)	(0.69)
Investments	5.89	3.46	1.28	0.30	5.60	4.25
	(1.70)	(2.92)	(2.28)	(1.60)	(1.33)	(2.17)
Labor productivity	2.41	0.42	-1.02	2.81	1.77	3.59
	(0.37)	(0.77)	(0.75)	(0.70)	(0.90)	(0.91)
Participation	0.99	1.57	1.61	2.67	4.32	4.03
	(0.17)	(0.20)	(0.19)	(0.30)	(0.77)	(0.36)

Standard deviations of the estimates are in parenthesis.

Innovations in the grants distributed by the two funds have different dynamic effects. ERDF is, on average, expansionary in the short run: the multipliers for all variables are positive and significantly different from zero on impact. Quantitatively, in response to an increase in ERDF equals to one percent of regional GVA, private GVA grows by 1.8%, investments by 5.9% and labor productivity by 2.4%, and the growth rate of employment is 0.85%. Hence, ERDF seems more effective in boosting the production side than the labor market side of the average European region.

The expansionary effects of ERDF is, however, temporary and after three years little remains of the initial expansion: the three years cumulative employment multiplier is about the same as the one year multiplier; the three years cumulative GVA multiplier is half of its one year counterpart; and the investments, compensation, and labor productivity cumulative multipliers are insignificant different from zero. Only the participation multiplier seems to increase persistently and significantly in response to the shock.

The dynamics of regional investments appears to be key to understand the outcomes. ERDF shocks, in fact, temporarily boost investment growth and induce an outward shift in labor demand; in the midterm, investment growth becomes negative and employment demand falls. The medium term labor market slackness is confirmed by the response of compensation growth, which turns negative after the initial increase.

One possible explanation for these dynamic patterns has to do with the momentum created by the funding of projects that the federal government supports. Public expenditure may decrease private R&D unit costs and, and because of externality effects, increase the expected profitability of privately funded R&D projects. Hence, subsidized firms have an incentive to invest more in R&D activities and this additional investment, which comes over and above the level firms would have undertaken without public support, may generate an indirect positive effect, explaining why the output multiplier is large on impact. However, when public support is reduced or eliminated, firms might be prone to decrease their private R&D investment, wiping out the dynamic gains that were previously generated or, if the project requires a number of years, to finance the remaining portions with funds which would be otherwise used for perhaps more profitable activities. In both cases, output, labor productivity, and investments would be considerably reduced, leading to reduced medium term multipliers. We formalize these considerations in section 6.

ESF shocks directly affect the labor market in the short run, increasing workers' compensation and decreasing employment, albeit not significantly. Since these funds are primarily designed for education and human capital accumulation, they induce a backward shift in the labor supply, as households take advantage of the programs to acquire a higher skill level. This substitution crowds out private GVA and increases labor productivity on impact. Investments do not significantly react while participation surprisingly increases, perhaps because discouraged workers restart search activities to try to take advantage of the new available funds.

In the medium run, the dynamics change. The cumulative GVA and employment multipliers become positive and economically important; the investment multiplier is significantly positive at the three years horizon, while the compensation, the labor productivity, and participation multipliers increase and remain significant. Thus, after the initial fall, job creation does take place, the productivity (and the compensation) of workers further increases, investments take off, and the private sector expands as the result of the increased productivity of labor services.

Quantitatively, the medium-term effects of ESF grants are larger than those of ERDF grants. For example, an increase in ESF equals to one percent of regional GVA, in response to a ESF shock, induces a three years GVA multiplier of 5.09%, an employment multiplier of about a 1.6% and an investments multiplier of 4.2% with the bulk of the GVA and employment growth taking place in the years after the arrival of the funds.

Thus, the reaction of the regional economies to the two funds are different. Conditional on the quality of the available data, ERDF seem to have an important countercyclical role, as it expands economic activity in the short run on average; but its macroeconomic effects are temporary and the medium term gains in investments and job creation are quite limited. On the other hand, ESF has minor production, employment, or investments effects in the short run, but has economically significant medium term effects. In fact, it boosts the average growth rate of private output, investments, and productivity; it exercises a statistically significant influence on the growth rate of employment and of workers' compensation. Interestingly, both type of funds incentivate labor market participation, probably in expectation of higher job creation in sectors targeted by the programs.

Some robustness exercises. Table 1 consider all regions belonging to EU, as of 2020. Because the UK will not benefit from NGEU grants, and because it is also the country with the largest number of regions (40, about 1/7th of the total), multipliers estimates may look different if UK regions are omitted from the computations. The top panel of Table 2 shows that the qualitative patterns we described for ERDF do not change if we omit the UK regions. For example, one year multipliers are generally positive and significant and three years cumulative multipliers are generally smaller than one year multipliers, confirming that the expansionary effects of this fund is temporary. However, two quantitative differences are noticeable. First, the whole term structure of multipliers is shifted upward and if we exclude investments, all medium term multipliers are now significantly positive. Second, the three years compensation multiplier is now larger than the one year multiplier.

For ESF the conclusions are similar. Qualitatively, there is no difference and while the impact effects of the program is negligible, the medium term effects are statistically significant and economically important. Quantitatively, the average medium term effects are enhanced and an increase of ESF grants equal to one percent of regional GVA, in response to an innovation in ESF, produces a cumulative GVA multiplier of 6.4%, a cumulative employment multiplier of 1.9%, and a cumulative investment multiplier of 8.4% at the three years horizon.

Table 2: Average cumulative multipliers, robustness

	ERDF funds			ESF funds		
Horizon	1 year	2 years	3 years	1 year	2 years	3 years
	Without the UK					
GVA	1.83	1.55	1.23	-0.17	4.09	6.44
	(0.23)	(0.36)	(0.36)	(0.75)	(0.94)	(0.97)
Employment	0.77	0.11	0.66	0.00	1.61	1.87
	(0.19)	(0.23)	(0.30)	(0.27)	(0.44)	(0.32)
Compensation	1.28	0.26	2.33	-0.39	2.95	4.90
	(0.37)	(0.67)	(0.55)	(0.46)	(0.66)	(0.62)
Investments	6.37	2.68	2.40	1.46	9.40	8.42
	(1.99)	(3.42)	(2.67)	(1.88)	(1.56)	(1.65)
Labor productivity	1.91	1.32	1.08	1.07	3.49	6.17
	(0.35)	(0.55)	(0.51)	(0.82)	(1.06)	(1.06)
Participation	0.95	1.40	1.40	2.72	4.01	3.85
	(0.19)	(0.24)	(0.23)	(0.35)	(0.31)	(0.25)
	Only Euro area					
GVA	1.49	1.45	2.33	-0.69	4.78	8.02
	(0.30)	(0.48)	(0.47)	(0.97)	(1.22)	(1.27)
Employment	0.59	0.29	1.21	-0.33	1.89	2.42
	(0.17)	(0.30)	(0.39)	(0.35)	(0.57)	(0.42)
Compensation	-0.19	0.61	3.63	-0.90	4.08	6.98
	(0.35)	(0.69)	(0.72)	(0.56)	(0.85)	(0.81)
Investments	3.18	1.87	2.78	-1.95	8.92	10.57
	(2.61)	(4.48)	(3.50)	(2.44)	(2.04)	(2.14)
Labor productivity	0.92	0.48	1.72	0.04	3.63	7.03
	(0.34)	(0.58)	(0.61)	(1.07)	(1.38)	(1.38)
Participation	1.01	1.73	1.58	2.98	4.44	4.35
	(0.17)	(0.28)	(0.30)	(0.46)	(0.41)	(0.32)
	After 2000					
GVA	1.44	2.43	2.01			
	(0.37)	(0.41)	(0.34)			
Employment	0.22	1.32	1.23			
	(0.15)	(0.29)	(0.29)			
Compensation	3.58	4.89	1.80			
	(0.31)	(0.60)	(0.63)			
Investments	2.44	5.35	3.89			
	(2.01)	(3.41)	(2.99)			
Labor productivity	3.50	2.56	3.24			
	(0.41)	(0.64)	(0.62)			
Participation	1.60	3.34	3.08			
	(0.14)	(0.33)	(0.28)			

Standard deviations of the estimates are in parenthesis.

Monetary policy is centralized in the Euro area, but not in the EU. Although the space for monetary independence for the smaller EU countries, such as Denmark and Sweden, or newly added EU members is limited, it is possible that domestic monetary policy, by manipulating the real rate of interest in response to the fiscal expansion, may change the magnitude of the real gains EU funds produce in the regions of these countries. For this reason, the middle panel of Table 2 recomputes the average multipliers using only Euro area regions.

The effects of ERDF on GVA, employment, and labor productivity change: they are smaller on impact, but become more persistent and the multipliers are significantly positive in the medium run. Moreover, if we exclude investments, the three years multipliers are larger than one year multipliers. Quantitatively, at the three years horizon, ERDF grants induce a cumulative GVA multiplier which is four times larger in the Euro area than in the EU; and a cumulative employment multiplier which is three times as large. Hence, while the expansionary effects are more moderate on impact, they become more economically important in the medium run. We investigate in section 6 what regional characteristics could drive the differences.

The qualitative features of ESF grants are instead unchanged, but as with ERDF, the term structure of cumulative multipliers is tilted with impact effects being more negative (albeit not always significant) and medium terms effects being typically larger. For example, the three years cumulative GVA, employment, and investment multipliers are now 8.0%, 2.4% and 10.5%, respectively.

Overall, EU funds appear to have stronger medium term effects in the average region of the Euro area. While the tilted pattern we uncover need not be connected with differential central bank responses to macroeconomic dynamics, it suggests that regional heterogeneities could be important when evaluating the success of the programs, a theme we will come back in the next section.

Finally, the effectiveness of EU funds may have changed over time, in particular if regional governments have improved their ability to identify projects which could receive EU support. Thus, it is worth examining if the conclusions are altered when post 2000 data are used. Considering post 2000 data is also useful because it makes the comparison between the two programs fair, as ESF is available only from that date. While the sample is short, and the uncertainty around point estimates larger, the bottom panel of Table 2 indicates that the medium term reversal noted in the full sample, is absent if only the last three budget cycles are considered. For example, GVA, employment and investments growth multipliers at the three years horizon are all positive and larger than those at the one year horizon. This occurs because the peak response is shifted at year two. Thus, since 2000, the private sector takes advantage of federal government R&D activities only with a delay.

Discussion Chodorow-Reich [2019] suggested a simple formula to convert output multipliers into employment multipliers when only one of the two series is available. The formula requires knowledge of the average output-per-worker, of the share of labor in the production function, and of the elasticity of hours-per-worker to total employment; and has some empirical support in the estimates reported by Nakamura and Steinnson [2014]. Under a standard parameterization of the labor share and of the elasticity of output-per-worker, the formula simplifies to:

$$c^Y_{i,h} \approx (Y/E)_i c^E_{i,h} \tag{2}$$

where $c^E_{i,h}$ is the employment multiplier and $c^Y_{i,h}$ the output multiplier of region i at horizon h. Because for EU regions, $(Y/E)_i$ varies between 2.5 and 5, (2) roughly rationalizes the average employment and GVA multipliers reported in Tables 1 and 2. This is comforting because the formula makes two assumptions which, at first look, may appear to be inconsistent with the dynamics we have described. First, (2) is constructed assuming that capital is constant over the adjustment path, while Tables 1 and 2 demonstrate that there are sizable and economically relevant investment dynamics, both in the short and the medium run. Second, in many EU regions hours-per-worker is, to a first approximation, constant over time and adjustments occur on the extensive rather than the intensive margin (workers rather than hours are adjusted). Thus, our results confirm that the formula has a certain appeal, even for economies like the EU, where labor markets behave differently and capital accumulation may be an important driver of the dynamics of regional variables.

The multipliers presented in Tables 1 and 2 are larger than those typically reported for the US, see e.g. Dupour and Guerrero [2017]. However, for a proper comparison, one should keep in mind three different issues. First, in analyses with US regions or counties, one employs military expenditure, see e.g. Auerbach et al. [2020]; infrastructure investment, see e.g. Ramey [2020b], state expenditure Canova and Pappa [2007] or even the federal disaster grants, see Deryugina [2017] to compute multipliers. Because EU funds are meant for investment projects that foster R&D, education and economic transformation, they are fundamentally different from the types of government expenditure analyzed with US data. In particular, important externality effects on the supply side economy may boost the demand effects of the shocks and this may make the multipliers larger. Second, EU grants require regional governments to pledge part of the total costs of the project. Thus, there is both ''federal" and ''state" expenditures taking place and this also may account for the larger size of the multipliers. Finally, while studies employing US data compute multipliers scaling government expenditure by total income (so that the units are dollar change in regional income per dollar change in regional expenditure), our multipliers are computed scaling expenditure by GVA, making the scale of the multiplier naturally larger, even when the first two effects discussed above are absent. We use GVA as scaling factor since the measurement of the regional component of government expenditure is difficult and regional price deflators for the government sector are not readily available. Hence, the different nature of EU funds, the co-financing feature they require, and the alternative scaling we employ make the magnitude of the multipliers we present non-comparable to those in the literature.

Spillovers The estimates reported in Tables 1 and 2 are likely to provide only a lower bound to the regional effects of EU funds, since they disregard spillovers in regional economic activity. For example, firms taking advantage of ERDF may employ workers living in neighboring regions, and ESF may use teachers living outside of the region where the funds accrued, thus depressing regional activity elsewhere. Alternatively, the additional wages the funds generate could be spent on goods produced in other regions, hence boosting production, employment and perhaps, investments elsewhere.

Because both labor and product markets may be affected, quantifying the magnitude of the spillovers is complicated, as the overall effect may be larger or smaller than the regional effect, depending on whether other regions are crowded out or crowded in by the increase in local activity. Nevertheless, two observations may allow us to simplify the computation. Because of language barriers and of institutional constraints, labor mobility is typically restricted to national markets. In addition, transportation costs for delivery of regionally produced goods in national markets are probably smaller then the costs for delivery in international markets. Hence, an approximate estimate of the magnitude of the spillovers can be obtained by comparing the average multipliers that regional EU funds have on regional vs. national variables. If spillovers are small or negative, the multipliers computed using average national growth rates should be considerably smaller than those computed using regional growth rates. On the other hand, if the boost in economic activity in a region positively affects a number of neighboring regions, the opposite should occur. We compute national variables by weighting regional variables by their size in the nation.

Table 3: Average cumulative multipliers with national spillovers, all EU regions

	ERDF funds			**ESF funds**		
Horizon	1 year	2 years	3 years	1 year	2 years	3 years
GVA	2.07	2.15	0.60	-0.64	2.22	3.73
	(0.11)	(0.23)	(0.25)	(0.25)	(0.45)	(0.55)
Employment	1.24	0.63	-0.10	0.09	0.90	1.12
	(0.06)	(0.11)	(0.22)	(0.09)	(0.22)	(0.29)
Compensation	1.80	0.40	0.62	2.05	2.05	2.82
	(0.32)	(0.64)	(0.67)	(0.37)	(0.55)	(0.61)
Investments	6.72	3.47	1.52	-0.34	-0.02	-1.47
	(0.28)	(0.57)	(0.74)	(0.47)	(1.13)	(1.39)
Labor productivity	3.46	1.92	1.17	2.24	1.15	1.93
	(0.28)	(0.57)	(0.58)	(0.34)	(0.53)	(0.63)
Participation	0.89	0.99	0.98	2.03	2.98	3.33
	(0.05)	(0.09)	(0.09)	(0.07)	(0.15)	(0.14)

Standard deviations of the estimates are in parenthesis.

Table 3 shows that ERDF multipliers obtained with average national growth rates are larger on impact for most variables than those obtained with regional growth rates. Thus, spillovers via acquisition of new goods and services for consumption or investment purposes may be important. Still, the qualitative patterns present in table 1 are unchanged: multipliers are larger on impact than in the medium run; and except for output, investments and participation three years multipliers are insignificantly different from zero. Thus, spillovers are present but are short lived, and reinforce average regional effects. On the other hand, the cumulative three years multipliers of ESF are somewhat smaller than those shown in Table 1, suggesting that these funds have some positive spillover effect but their magnitude is limited. Very noticeable is the effect on investments: here the multiplier at the three years horizon is negative, although not significant. Thus, while these grants tend to crowd in labor markets and private production, they crowd out investments in other regions, perhaps because of geographical substitution.

Anticipation As we have already mentioned, the issue of anticipation is far from straightforward in our data because of the EU budget cycle, the way expenditures are accounted for, and the adjustments the EU performs on the data before releasing them. Furthermore, announcements or commitments of expenditure can not used as these would require the dates in which each project is approved by the EU, which are not available. To try to understand whether and to what extent anticipation issues are important for the results we run regression (1) with one lead of $x_{i,t,h}$, instrumenting it with one lead of ERDF or ESF innovations. The results are presented in Table 3.

Table 4: Average cumulative multipliers, one year anticipation, all EU regions

	ERDF funds			**ESF funds**		
Horizon	0 year	1 years	2 years	0 year	1 years	2 years
GVA	0.78	1.10	1.37	2.14	6.16	4.13
	(0.26)	(0.53)	(0.42)	(0.63)	(0.84)	(1.07)
Employment	0.25	-0.26	-0.46	0.36	0.68	-0.39
	(0.14)	(0.30)	(0.31)	(0.22)	(0.41)	(0.55)
Compensation	-0.62	-1.20	-2.58	-0.56	2.82	0.96
	(0.36)	(0.77)	(0.84)	(0.46)	(0.74)	(2.01)
Investments	1.19	1.73	3.00	1.73	3.54	1.77
	(1.87)	(3.88)	(3.47)	(1.50)	(3.08)	(2.01)
Labor productivity	0.00	1.46	-1.65	0.23	8.06	7.93
	(0.37)	(0.76)	(0.80)	(0.69)	(0.95)	(1.22)
Participation	0.89	0.82	1.20	0.91	2.49	1.48
	(0.27)	(0.29)	(0.30)	(0.37)	(0.82)	(1.13)

Standard deviations in parenthesis.

The pattern of responses changes relative to Table 1. For example, for ERDF grants, the profile of output multipliers is increasing over time, employment and investment multipliers at all three horizons are insignificant, and compensation multipliers are negative at all horizons. The changes are less dramatic when we consider ESF grants. Still, even in this case, the peak response of output, employment, investment and compensation occurs after two years horizon and the three years employment and investment multipliers are now basically zero. In addition, as compared with Table 1, standard errors are larger and outliers are more frequent.

We interpret this evidence as suggesting that the information about the anticipatory effects of these kind of spending shocks in our data is scarce and that the adjustments performed by the EU account to a large extent for those predictable effects economists care about.

5 A closer look at regional heterogeneity

Table 2 implicitly suggests that there are important heterogeneity in the dynamics induced by EU funds across regions. For example, at the three years horizon, and for ERDF in Euro area regions, the interquartile range for cumulative GVA multipliers is [-2,5] and for cumulative employment multipliers is [-0.5, 2.3]. Furthermore, in all panels of Table 2 and for all variables, the median multiplier is about half of the mean multiplier, and less than 20 percent of the distribution at all horizons is located between half and twice of the mean value. Hence, not only the distribution of regional multipliers is quite spread out; non-normal differences exist across regions. The task of this section is to explore, on the one hand, potential asymmetric effects of EU funds and, on the other, search for the reasons leading to the asymmetries. To do this, we cluster regional multiplier estimates using indicators that reflect geographical, political, and economic development of each region.

Location and tenure grouping. Table 5 reports the average cumulative multipliers when regions are grouped according to their geographical position (North vs. South) or their tenure with the EU (old vs. new members). In the southern group we include regions belonging to Bulgaria, Cyprus, Greece, Spain, Croatia, Hungary, Italy, Portugal, Romania and Slovenia; young EU members are from "new accession countries"; thus, regions belonging to Bulgaria, Cyprus, Czech Republic, Estonia, Croatia, Hungary, Latvia, Poland, Romania, Slovenia and Slovakia are included in this group.

Location is important when evaluating the macroeconomic success of ERDF. In fact, at the three years horizon, cumulative multipliers for all variables in southern regions are positive on average, while those for northern regions are generally negative. Differences are large and economically significant. For example, there is an almost two percentage points difference in the cumulative GVA and employment multipliers at the three years horizon. Large differences are also present in response to ESF. Here, southern regions tend to positively respond even on impact and multipliers at the three years horizon are quite large. Furthermore, differences in medium term multipliers are important: for GVA, employment, and investments the cumulative multiplier in southern regions is at least four percentage points larger than in northern regions.

Tenure in the EU similarly matters. For instance, for ERDF the GVA and employment cumulative

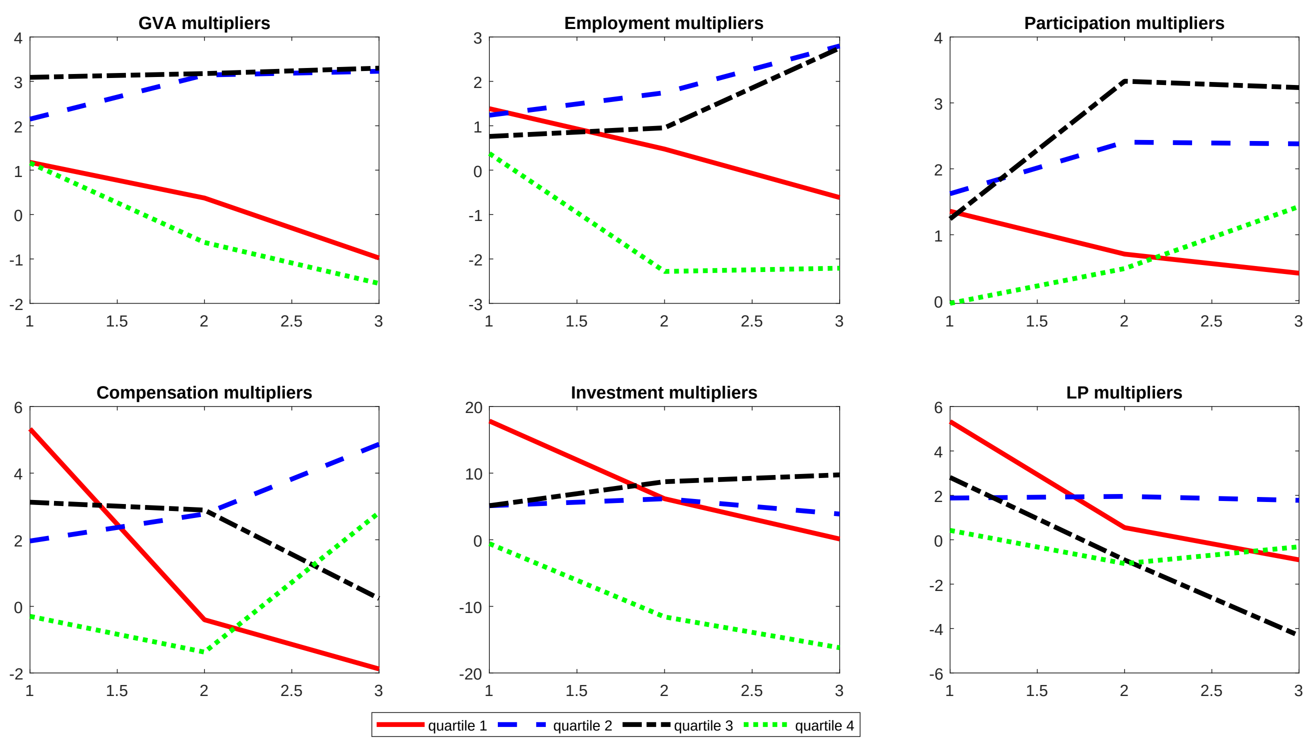
Table 5: Average cumulative multipliers

Northern vs. southern regions							
		ERDF funds			ESF funds		
		1 year	2 years	3 years	1 year	2 years	3 years
GVA	North	2.33	1.27	-0.02	-1.45	0.89	3.82
	South	2.63	2.21	1.86	2.96	6.90	7.85
Employment	North	0.66	-0.01	-0.64	-1.03	-0.04	0.61
	South	2.15	2.10	1.66	2.34	4.69	6.06
Compensation	North	6.15	1.56	-4.80	4.92	2.73	3.31
	South	0.45	-0.50	6.04	0.38	2.37	3.44
Investments	North	3.40	0.62	-1.28	-1.98	-2.41	0.69
	South	16.50	5.75	2.20	8.09	9.89	8.73
Labor productivity	North	5.79	-0.58	-7.61	4.72	-0.19	0.93
	South	2.21	1.62	4.86	3.31	6.18	4.32
Participation	North	1.03	3.19	3.39	2.33	5.19	3.85
	South	1.71	1.49	1.31	3.95	3.07	4.43
Older vs. younger tenure regions							
		ERDF funds			ESF funds		
		1 year	2 years	3 years	1 year	2 years	3 years
GVA	Old	2.58	2.10	1.63	-0.82	2.78	6.02
	Young	1.86	-0.37	-3.32	2.78	2.75	1.53
Employment	Old	0.97	0.37	1.39	-0.64	1.68	3.76
	Young	1.68	1.62	-2.82	2.56	0.92	-3.14
Compensation	Old	2.97	1.60	0.34	2.84	4.11	5.84
	Young	9.50	-1.89	-7.88	5.99	-3.04	-6.07
Investments	Old	2.34	0.98	-0.27	-1.27	6.60	8.50
	Young	26.25	6.75	0.07	10.45	-2.27	-16.86
Labor productivity	Old	3.13	0.05	-3.90	3.96	-0.18	1.49
	Young	10.17	0.28	-3.06	9.29	9.30	3.89
Participation	Old	1.38	3.13	3.48	3.09	5.61	5.02
	Young	0.71	0.94	0.05	1.87	0.41	0.26

multipliers at the three years horizon are positive on average for regions belonging to old EU members, but negative on average for regions in newer member countries. For ESF, sign differences occur for employment, compensation and investments and the medium term cumulative multipliers are, on average, positive for regions with older tenure and negative for regions with more recent tenure. However, even when multipliers have the same sign in the two groups, magnitude differences are important. Regions with older tenure have a medium term average cumulative GVA multiplier that exceeds by four percentage points the one of regions with more recent tenure. In general, in regions with younger tenure, ESF shocks have some impact effect but the economic impulse dies out quickly. Thus, for these regions, ERDF and ESF have similar dynamic repercussions.

Income quartile groupings. The regional distribution of economic development may also shape multipliers dynamics. For example, poor regions may be unable to take full advantage of the funds because they lack local entrepreneurship; they may not have enough local funding to qualify; or the effects in terms of private investments may be temporary or limited in scope. One can also conceive the possibility that in certain regions education improvements may be small, because of the lack of sufficient average skills. All these factors may contribute to generate differences in multipliers estimates, even factoring in the fact that poorer regions receive larger amounts of per-capita funds.

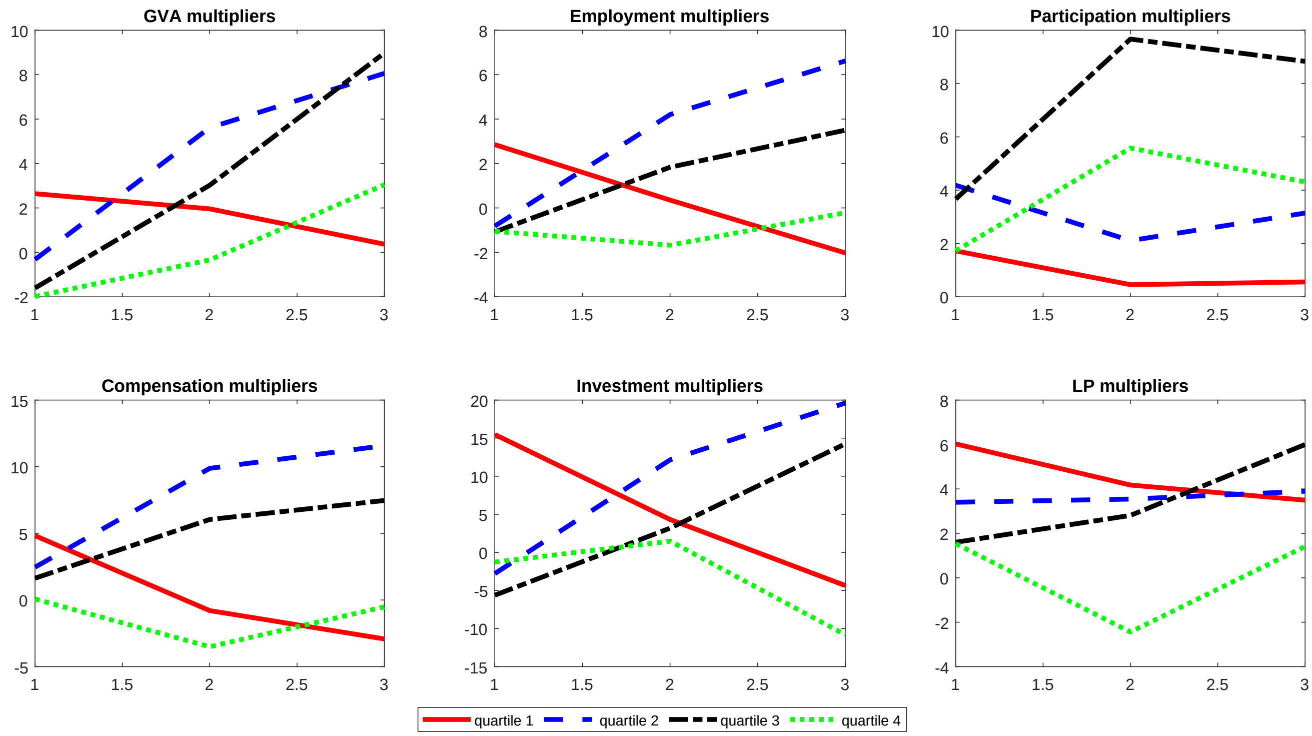
Figure 2: Cumulative multipliers by quartiles, ERDF



Figures 2 and 3 plot the profile of the average multipliers for income quartiles, separately for ERDF and ESF, where quartiles are computed using the average regional per-capita GDP.

Regions in the central portion of the income distribution benefit most from ERDF: their GVA, employment, participation, and investments cumulative multipliers are all positive in the medium term. Since the cumulative multipliers for these variables in regions belonging to the top quartile of the income distribution are negative, catch up around some common long-run value in response to ERDF shocks seem to take place. However, regions belonging to the first quartile of the income distribution feature positive GVA, employment, participation, compensation and labor productivity impact multipliers which turn negative at the three years horizon. For these regions only investments multiplier remains positive after three years, albeit quite small.

Figure 3: Cumulative multipliers by quartiles, ESF



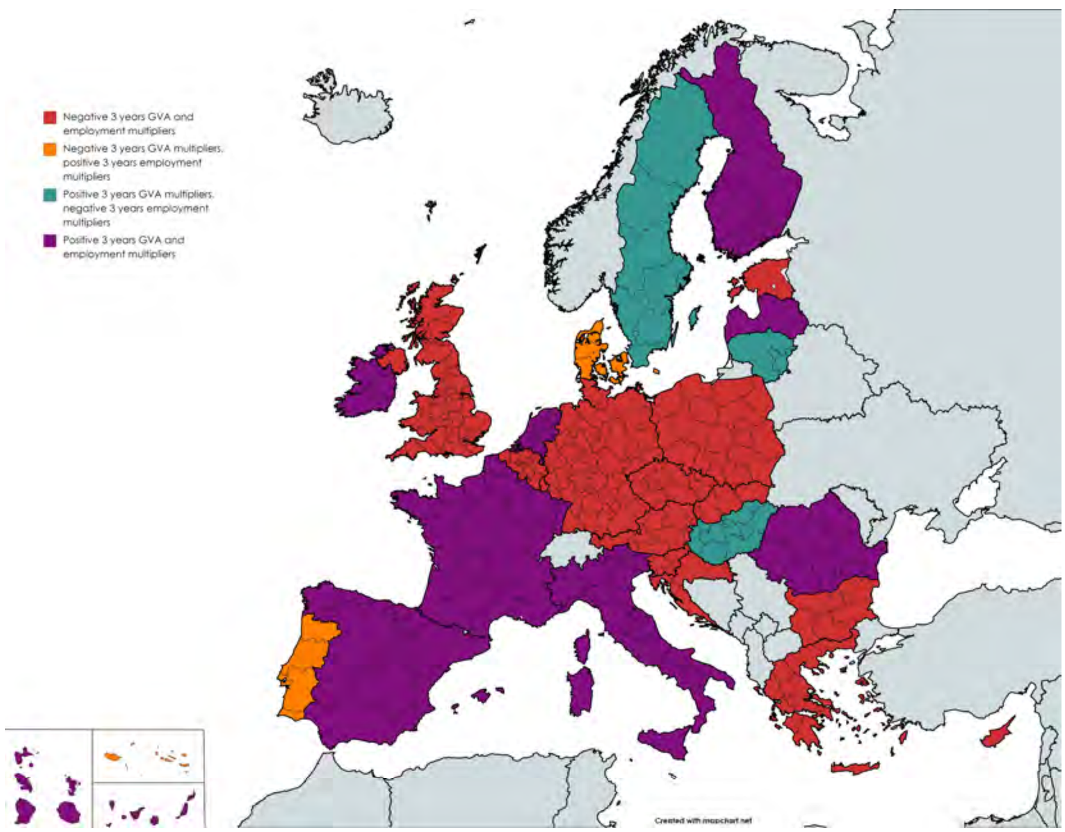
Hence, over the adjustment path, income and labor market differences among regions in the top three quartiles of the income distribution tend to narrow, but those between these regions and those in the bottom quartile tend to increase. These medium term adjustments are consistent with the long run polarization of income per-capita in EU regions estimated in Canova [2004], where the poor remain poor, and the rest of the regions converge toward a common higher standard of living. They also suggest that ERDF may lead to increased long run regional inequalities, unless it is combined with measures that persistently revamp the economy of poorest regions.

For ESF, quartile differences are also evident. Regions belonging to two central quartiles of the income distribution benefit most in terms of GVA, employment, participation, compensation, and investments at the three years horizon. The employment and the investment multipliers for the other two quartiles are instead negative in the medium term and GVA and participation multipliers are positive but considerably smaller. Notably, regions in the bottom quartile are not able to extract substantial medium term benefit from ESF grants. Thus, ESF also tends to twist the regional income distribution along the adjustment path, favoring regions in the central portion of the distribution, and leaving poor regions behind.

Country groupings. To better identify the losers and winners of the two programs, we cluster regional multipliers using national borders. There are institutional and cultural reasons for grouping regions this way. If, say, labor markets institutions matter, regions of a country should respond more homogeneously to the fiscal stimulus, as far as GVA and employment multipliers are concerned, and country specific labor market outcomes should explain differences in national dynamics.

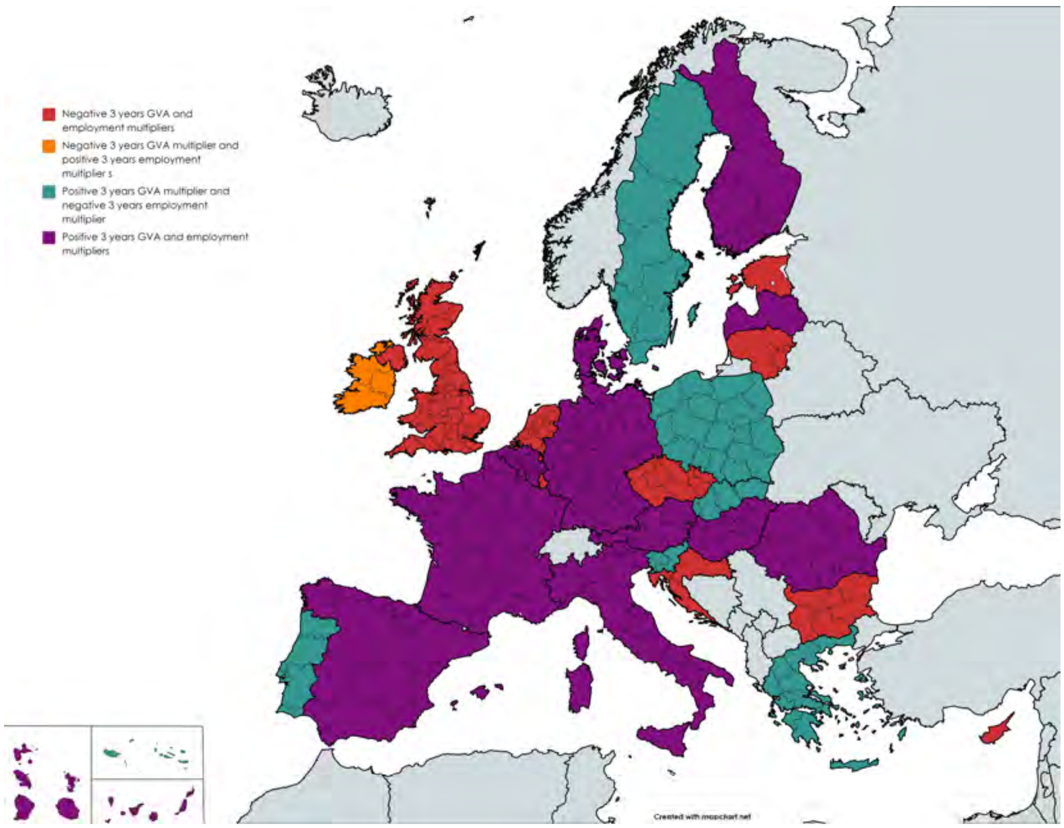
Indeed, there is more homogeneity in the macroeconomic responses to shocks in the funds within a country. Furthermore, there are important similarities in the joint dynamics of GVA and employment growth within a country. Figures 4 and 5 map on a NUTS2 chart the joint distribution of GVA and employment multipliers by country at the three years horizon, separately for the two types of funds.

Figure 4: Country multipliers ERDF



For ERDF grants, there is considerable concordance in the signs of GVA and employment multipliers. For instance, the UK, Belgium, Germany, Austria, Slovenia, Croatia, Poland, Czech Republic, Slovakia, Bulgaria, Greece, Estonia, Luxembourg, and Cyprus have significantly negative average three years cumulative GVA and employment multipliers. On the other hand, Spain, the Netherlands, Italy, France, Finland, Ireland, Romania and Latvia feature a positive and significant average three years cumulative GVA and employment multipliers. The remaining countries display either negative GVA and positive employment multipliers (Portugal and Denmark), or positive GVA and negative employment multipliers (Sweden, Lithuania, Hungary and Croatia). Thus, apart from the UK and some peripheral contries (Greece, Cyprus, Estonia, and Bulgaria), ERDF shocks have negative medium term effects primarily in the central regions of the EU.

Figure 5: Country multipliers ESF



For ESF, the number of countries displaying positive and significant average cumulative medium term GVA and employment multipliers increases (Austria, Hungary, Germany and Denmark join the club) and now only the UK, the Czech Republic, Croatia, Lithuania, Luxembourg, The Netherland, and Bulgaria display cumulative three years multipliers that are both negative.

Perhaps more interesting for the purpose of evaluating NGEU grants is the fact that in Spain, Italy and France, three of four major Euro countries, both ERDF and ESF create jobs, increase GVA, boost investments, and lead to productivity improvements. Because these three countries are also among the most battered by the COVID-19 pandemic, one may be mildly optimistic that the new RRF, which combines features of ERDF and ESF, will be able to jump start those economies, help with the transformation to a greener economy, and drive the EU back towards the pre-2020 growth path. Furthermore, given that ESF benefits a larger number of EU countries and that part of these funds are used for health care, there is also hope that efforts to invest more intensively in this sector will pay off down the road.

It is useful to provide a simple back of the envelope calculation to put some numbers into the argument. Spain is expected to receive from RRF 140 billion Euros over three years; this is a considerable amount, given that the Spanish GVA in 2019 was 1035 billion Euros (according to World Bank calculations). If the ESF multipliers we obtained give reliable estimates of the dynamic effects of NGEU grants, one should expect Spanish GVA to go up, roughly, by 1.2% and employment by 0.5% cumulative over a three years period. Since according to INE (Instituto Nacional de Estadistica) 19,75 million people were employed in Spain on average in 2019, the RRF will create about 98,750 new jobs in the next three years. This does not compensate the job loss due the COVID-19 pandemic (currently estimated by INE at around 500,000), but it will make up for one-fifth of it. With the recovery of the service and tourism sectors, employment figures should look even better.

As Figures 4 and 5 demonstrate macroeconomic outcomes are far from uniform across countries and this may explain the hard negotiations taking place at the EU Council in July 2020. Note that in central European nations, the expected GVA benefits from NGEU grants are moderate, and those in terms of employment are small. In the past, job creation, in particular, in response to ERDF, did not happen in these countries and the subdued investment growth may be responsible for it. Furthermore, a number of peripheral and recently added to the EU members, have not (yet) benefited from the flow of structural funds either in terms of GVA or employment; and again, this is particularly true for ERDF. Thus, the new programs may have an unpleasant side effect: there may be a differential "recovery and transformation" process, exacerbating cross country inequalities.

Summing up Our empirical investigation uncovered four important facts. First, the two types of funds may serve different purposes: while ERDF seems useful for short run stabilization purposes, ESF is better suited to foster medium term objectives.

Second, the macroeconomic effects of the ERDF are less persistent than those of ESF. While care needs to be employed, as excluding regions or using a shorter sample may alter the extent of the medium term propagation of ERDF, the mechanics of transmission of the unexpected changes in the two funds appear to be different and work along different margins.

Third, regional dynamic responses are heterogeneous and country specific features, location, tenure in the EU, and level of development are, in part, responsible for these differences. Fourth, in response to the programs, lower income, peripheral, and newly tenure regions of the EU do not take full advantage of the funds and tend to lag behind the others in terms of recovery and transformation.

Given that NGEU funds combine features of both ERDF and ESF, they have a good probability of success on average. Thus, one can be moderately optimistic that they will be effective counter-cyclical tools to fight the pandemic and useful medium term instruments to foster regional economic transformation. The current downturn could be contrasted as long as the measures help to enhance the production possibility frontiers of the regional economies, either along the R&D, human capital, or health margins. When this happens, the chance that regions will go back to the pre-2020 growth path is non-negligible, and the transformation of the EU economies is a solid possibility.

Nevertheless, historical evidence suggests that NGEU funds will not have uniform effects, nor help, in particular, those who currently lag most behind. In these regions the recovery and the transformation process may not happen, even if a larger amount of funds is channeled to them, perhaps because of government inefficiencies, lack of medium term planning, shortage of entrepreneurship, or low average level of education and of skills. Thus, the threat that income polarization and regional inequalities will increase, and the "recovery and transformation" process will be a multi-gear one is not trivial, unless important social transformations will take place correcting for these distortions.

Finally, it is important to note that our analysis considers the effects of structural funds, which are grants from the EU central authority to finance specific projects. Since the Recovery and Resilience Facility includes both grants and loans, estimates should be interpreted with caution as is not clear whether loans have similar macroeconomic effects (even though some countries have already decided not to use them). In addition, the RRF rules require the grant component to be committed by the end 2023 (with payments available until 2026). This tight deadline might be challenging in terms of absorption capacity, since it assumes that member states have or will be able to develop a pipeline of investment projects of a sufficient large scale and quality, centering on economic transformation, to absorb the funding. Hence, with limited planning time, there is a risk that a portion of the funding will remain unused and a careful cost-benefit analysis is needed to decide among alternatives.

6 Interpreting the dynamics

This section uses a dynamic equilibrium model to understand the mechanics of propagation of unexpected changes in the flow of EU funds to the regional economies, and to identify the features that may account for the heterogeneity we documented.

To limit the dimensionality and the cross-sectional complexities, we make three simplifying assumptions. First, we focus attention on a monetary union. Given that the exchange rate of many countries in the EU with the Euro is fixed, this seems a reasonable working assumption. Second, we consider two regions: the one of interest, the "home" economy, and the other, the "foreign' economy, which is interpreted as an conglomerate of all other regions in the union. Third, we do not explicitly model participation decisions, even though they are probably relevant in the EU context, as these require a specification with a home production sector and region specific labor market frictions.

The basic features of the model are similar to many proposed in the literature, see e.g. Benigno and Benigno [2003], Pappa and Vassilatos [2007], Gali and Monacelli [2008], Nakamura and Steinnson [2014], and Corsetti et al. [2017]. We differ in two important aspects: we allow a number of margins along which the regional economy can adjust in response to the shocks; we examine the effects of federal spending R&D and education disturbances, rather than federal consumption, infrastructure investment, or military expenditure shocks. Short run nominal rigidities allow us to capture demand effects due to increases in fiscal absorption on production; and endogenous growth through R&D and human capital accumulation create supply side effects in response to federal expenditure disturbances.

Time represents years. Each region is populated by a continuum of identical, infinitely lived agents. Union-wide population is normalized to one and the share of home economy population is $0 < n << 1$. Regions are identical in terms of preferences and technologies. The representative household in each region is endowed with one unit of time and derives utility from consuming a basket of goods, produced in both regions, and from leisure. The remaining time is split between working and educational activities. Labor and capital are immobile. Firms produce output using effective capital and labor inputs and labor productivity may be affected by federal expenditure. Disturbances are observed before firms and households make their optimal decisions.

There is a complete financial market where households can trade state-contingent nominal bonds. A central bank sets the union wide interest rate as a function of aggregate variables. Tax collection occurs at the local level; there is no local spending and the proceeds of the tax collection are transferred to the federal government, which uses the funds to finance consumption, R&D, and human capital expenditures and subsidies. This setup mimics how funds for the EU budget are pledged, and the fact that funds are used for productive and non-productive purposes.

Households. Their utility function is represented by:

$$E_0 \sum \beta^t \frac{(C_t(1 - L_t - M_t)^{\chi})^{1-\sigma}}{1 - \sigma} \tag{3}$$

where $0 < \beta < 1$ is the discount factor, and χ controls the Frisch elasticity of labor supply, σ is a risk aversion parameter; C_t is consumption of the composite good, L_t is working hours, M_t is education hours and E is the expectation operator. This utility function is compatible with balanced growth, see e.g Boppart and Krussel [2020].

Households own human capital and choose how much to invest in education. The law of motion of human capital is:

$$H_{t+1} = (1 - \delta_{H,t}(u_{H,t}))H_t + \Theta(H_t M_t)^{\vartheta}(\bar{H}_t \psi_t^{HK})^{(1-\vartheta)} \tag{4}$$

where $\delta_{H,t}$ denotes the human capital depreciation rate. We assume it depends negatively on its utilization in production, $\delta_{H,t} = \delta_H u_{H,t}^{\xi_H}$, where ξ_H controls the concavity of the depreciation function. The second term on the right hand side of (4) is the quantity of human capital produced at t. It consists of four terms: Θ is a productivity parameter; $H_t M_t$ is effective human capital chosen by the household at t; $\bar{H}_t$ is the aggregate stock of human capital that households take as given, and $\psi_t^{HK} = \tilde{G}_t^{HK}/\tilde{G}_{t-1}^{HK}$ is the gross growth rate of the federal expenditure in human capital where $\tilde{G}_t^{HK} = \frac{G_t^{HK}}{\bar{H}_t}$ is R&D expenditure measured in per-human aggregate capital units. $0 < 1 - \vartheta < 1$ is an externality parameter regulating the combined effect of the aggregate level of human capital, $\bar{H}_t$, and of the growth of federal expenditure in human capital, ψ_t^{HK}, for human capital production.

Households purchase consumption goods and state contingent bonds with after-tax labor, profit and financial income. The maximization problem is subject to the constraint:

$$C_t + T_t + E_t \pi_{t+1} \Lambda_{t,t+1} B_{t+1} = (1 - \tau_t) w_t H_t L_t + s_t^M H_t M_t + B_t + \Xi_t \tag{5}$$

where B_{t+1} are holdings of the state contingent nominal bonds paying one unit of currency at $t+1$ if a specified state is realized, $\Lambda_{t,t+1}$ is the period$-t$ real price of these bonds, π_t the inflation rate, w_t is the real wage rate, τ_t is a labor income tax, T_t is a lump-sum tax/transfer; Ξ_t is profit income from the monopolistic competitive domestic firms. s_t^M is a schooling subsidy the federal government provides to incentivate individual human capital accumulation choices.

Letting C_{Ht} be a composite of domestically produced goods, C_{Ft} a composite of imported goods, and $0 < \eta < 1$ is the weight of the imported goods in home consumption, the consumption basket is

$$C_t = \frac{C_{Ht}^{1-\eta} C_{Ft}^{\eta}}{(1-\eta)^{1-\eta} \eta^{\eta}} \tag{6}$$

When $\eta < 0.5$ there is home bias in consumption. We assume that total federal expenditure G_t, is also composite and aggregates the public goods produced across regions analogously to (6).

Home and foreign produced consumption goods are aggregated into the composite with a standard CES aggregator, and elasticity of substitution is $\varepsilon > 1$. For $0 < z < 1$, the optimal allocation of expenditure yields the demand functions:

$$C_{H,z,t} = \left(\frac{P_{H,z,t}}{P_{Ht}} \right)^{-\varepsilon} C_{Ht}, \quad C_{F,z,t} = \left(\frac{P_{F,z,t}}{P_{Ft}} \right)^{-\varepsilon} C_{Ft} \tag{7}$$

$P_{it} = \left(\int_0^1 P_{i,z,t}^{1-\varepsilon} dz \right)^{\frac{1}{1-\varepsilon}}$, $i = H, F$ is the price index of domestically produced and imported goods.

Optimal allocation in the home country implies $P_{Ht} C_{Ht} = (1-\eta) P_t C_t$, $P_{Ft} C_{Ft} = \eta P_t C_t$ where P_t, the home CPI price index used by the households to deflate variables in (5), is given by:

$$P_t = P_{Ht}^{1-\eta} P_{Ft}^{\eta} \tag{8}$$

We assume that firms set prices in the sellers' local currency and the law-of-one-price holds. Thus, $P_{Ht} = P_{Ht}^*$ and $P_{Ft} = P_{Ft}^*$, as the cost of imported goods in the home consumption basket is the price charged by foreign exporting firms, given that the nominal exchange rate is fixed. The real exchange rate is determined by:

$$Q_t = \frac{P_t^*}{P_t} = \left(\frac{P_{Ft}}{P_{Ht}} \right)^{1-2\eta} \tag{9}$$

Note that, even under the law of one price, Purchasing Power Parity (PPP) may not hold, i.e., $P_t \neq P_t^*$, since the two regions may consume goods in different proportions due to home bias.

Retail sector The problem of the firms in the retail sector is standard: they purchase wholesale goods at nominal price $P_{Ht}\varpi_{Ht}$ and convert them into differentiated final goods sold to domestic and foreign households and governments. Monopolistic retailers are indexed by z on the unit interval, each produce one differentiated good aggregated into the final composite good, Y_t according to the technology:

$$Y_t = \left(\int_0^1 Y_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{10}$$

where ε is the elasticity of substitution of retail goods. The representative firm solves:

$$maxE_t \sum_{\tau=0}^{\infty} \Lambda_{t,t+\tau} \Xi^R_{t+\tau}(z), \tag{11}$$

where real profits are given by:

$$\Xi^R_t(z) = \left\{ \left(\frac{P_{H,z,t}}{P_{Ht}} - \frac{P_{Ht}\varpi_{Ht}}{P_{Ht}} \right) - \frac{\Psi_P}{2} \left(\frac{P_{H,z,t}}{\pi_H P_{H,z,t-1}} - 1 \right)^2 \right\} Y_{z,t} \tag{12}$$

subject to the demand function

$$Y_{z,t} = \left(\frac{P_{H,z,t}}{P_{Ht}} \right)^{-\varepsilon} Y_t \tag{13}$$

where $\left(\frac{P_{H,z,t}}{\pi_H P_{H,z,t-1}} - 1\right)^2$ are Rotemberg-style price adjustment costs per unit of output. Note that future profits $\Xi_{t+\tau}(j)$ are discounted by the discount factor $\Lambda_{t,t+\tau}$.

Wholesale sector Each wholesale firm has the same production function. It produces goods according to $Y_t = f(u_{k,t}, K_t, Z_t, u_{H,t}, H_t, L_t)$ where Z_t is labor augmenting technological progress which, as we will see, depends on the firm choices and aggregate R&D and human capital expenditure, $u_{q,t}, q = K, H$ are utilization rates, and $H_t L_t$ is effective labor input. Firms own physical and R&D capital and face adjustment costs when accumulating them:

$$\begin{aligned} K_{t+1} &= (1 - \delta_{K,t}(u_{K,t}))K_t + \Phi_K\left(\tfrac{I_t}{K_t}\right) K_t \\ D_{t+1} &= (1 - \delta_{D,t}(u_{D,t}))D_t + \Phi_D\left(\tfrac{S_t}{D_t}\right) \Omega_t D_t \end{aligned} \tag{14}$$

where I_t is the amount invested and K_t is the stock of physical capital; S_t is the amount invested and D_t is the stock of R&D; $\delta_{q,t} = \delta_q u_{q,t}^{\xi_q},\ q = K, D$, where ξ_q controls the concavity of the depreciation function and $\Phi(q)$ is a non-negative concave adjustment cost function, specified as in Jermann [1998].

$$\Phi_K\left(\frac{I_t}{K_t}\right) = \varphi_{K,1} + \frac{\varphi_{K,2}}{1-\frac{1}{\psi_K}} \left(\frac{I_t}{K_t}\right)^{1-\frac{1}{\psi_K}} \tag{15}$$

$$\Phi_D\left(\frac{S_t}{D_t}\right) = \varphi_{D,1} + \frac{\varphi_{D,2}}{1-\frac{1}{\psi_D}} \left(\frac{S_t}{D_t}\right)^{1-\frac{1}{\psi_D}} \tag{16}$$

where $\varphi_{j,l}$, $j = 1, 2$ and and ψ_q, $q = K, D$, are parameters. These adjustment cost functions capture the idea that changing the stock of capitals rapidly is more costly than changing them slowly. Because of adjustment costs, the shadow prices of physical and R&D capital are time varying.

Finally, Ω_t is a R&D accumulation externality which we model as:

$$\Omega_t = \omega \left(\psi_t^{HR}\right)^{\omega_H} \tag{17}$$

where $\psi_t^{HR} = \frac{G_t^{HR}/\bar{D}_t}{G_{t-1}^{HR}/\bar{D}_{t-1}}$, with $\omega \geq 1, \omega_H \geq 0$ and $\bar{D}$ is the aggregate stock of R&D.

Wholesale firms sell their goods to retailers at the relative price $\varpi_{Ht} P_{Ht}$ and chose effective labor, physical and R&D capital and investment, to maximize shareholder real profits:

$$\varXi_t^W = \varpi_{Ht} Y_t - \frac{W_t}{P_{Ht}} (u_{Ht} H_t L_t) - I_t - (1 - s_t^D) S_t \tag{18}$$

where s_t^D is a federal subsidy for investing in R&D. Firms optimize subject to the law of motions for R&D and physical capitals, and the production function.

Fiscal authorities The economy has two local and one federal fiscal authorities. The local fiscal authorities levy labor income and lump-sum taxes, and transfer the tax collection to the federal government which uses them to finance expenditure and subsidies. Thus, the federal budget is balanced by varying local lump sum taxes.

In per-capita terms, federal spending in region $i = H, F$ is $G_{it} = (G_{it}^C) + G_{it}^R(1 + \epsilon_{R,t}) + G_{it}^{HK}(1 + \epsilon_{HK,t})) + s_t^D S_t + s_t^M M_t H_t$ where G_{it} is expenditure for (wasteful) consumption, the ϵ_t's are zero mean AR(1) and s_t^D, s_t^M are constant mean AR(1) processes. Since G_{it} is per-capita regional spending, total spending in the home region is nG_{Ht}.

Our assumption of perfect financial markets implies that any risk associated with regional variation in lump-sum taxes is absorbed through risk sharing. Ricardian equivalence holds in our model.

Monetary Policy The central bank sets the interest rate, R_t according to:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\vartheta_R} \left(\frac{\pi_t^u}{\pi}\right)^{\vartheta_\pi} \tag{19}$$

where $\pi_t^u = n\pi_t + (1 - n)\pi_t^*$, is the union-wide inflation rate; π_t and π_t^* are domestic and foreign CPI inflation rates, while R and π are, respectively, the steady state nominal rate and inflation rate. Finally $\vartheta_R, \vartheta_\pi$ are parameters.

Risk sharing Combining the home and foreign consumption Euler equations, the assumption of complete financial markets yields the risk sharing condition:

$$\frac{u_c(C_t^*, L_t^*, M_T^*)}{u_c(C_t, L_t, M_t)} = \left(\frac{C_t^*(1 - L_t^* - M_t^*)^\chi}{C_t(1 - L_t - M_t)^\chi}\right)^{-\sigma} \left(\frac{(1 - L_t^* - M_t^*)}{(1 - L_t - M_t)}\right)^{\chi} = \varpi_0 Q_t \tag{20}$$

where ϖ_0=1, so that, initially, the representative households in the two regions have equal amounts of wealth; and asterisks denote variables of the foreign region. The risk sharing condition links the real exchange rate and the marginal rate of substitution between consumption in the two regions. Hence, all households face identical relative prices of consumption goods in the world market.

Equilibrium We consider a symmetric equilibrium, such that for all z, and all variables, $X_{z,t} = X_t$. We assume that contingent bonds are in net zero supply, $B_t = 0$. The resource constraint for the home economy is

$$Y_t = nC_{Ht} + (1-n)C^*_{Ht} + I_t + S_t + nG_{Ht} + (1-n)G^*_{Ht} + \frac{\Psi_P}{2}\left(\frac{\pi_{Ht}}{\pi_H} - 1\right)^2 nY_t, \tag{21}$$

where $\frac{\Psi_P}{2}\left(\frac{\pi_{ht}}{\pi_h} - 1\right)^2 Y_t$ is the per-capita domestic output cost of adjusting prices.

The specifications of preferences and technologies allows for a balanced growth path solution. This is true even when the two regions grow differently in the steady state. Since the aggregate consumption baskets are Cobb-Douglas in domestic and foreign goods, differences in consumption growth rates ware neutralized by the secular trend in relative prices. Notice also that while the growth of the domestic production depends on the domestic factor accumulation, the growth rate of private and public consumption reflect both domestic and foreign accumulation of R&D and human capital. These trend growth differences will appear as differences in the steady state inflation rates of the two regions, which in turn, implies a secular trend in the real exchange rate. Thus, as in Abbritti and Weber [2019], the model implies that when the home region features a higher R&D or human capital growth, it will also experience lower inflation rates and a real exchange rate depreciation.

Given that D_t, H_t are growing, we solve the model scaling all variables so as to obtain an equilibrium in deviation from a balanced growth path.

6.1 R&D expenditure shocks

To understand the regional transmission of a surprise increase in ERDF funds, we examine the dynamics induced by federal R&D expenditure disturbances in the home region, setting human capital accumulation to zero, and dropping education choices from the optimization problem. Thus, $H_t = \bar{H}_t = 1, u_{H,t} = 1, M_t = 0, \ \forall t$, and specify the production function for wholesale firm to be:

$$Y_t = (u_{K,t}K_t)^{\alpha}(Z_tL_t)^{1-\alpha} \tag{22}$$

where α is the capital share and:

$$Z_t = (\psi^R_t)^{\mu_R}(u_{D,t}D_t)^{\zeta}(\bar{u}_{D,t}\bar{D}_t)^{1-\zeta} \tag{23}$$

where $\psi^R_t = \frac{G^R_t/\bar{D}_t}{G^{HD}_{tR}/\bar{D}_{t-1}}$, μ_R and $1-\zeta$ are parameters.

(22) and (23) imply that firm labor productivity has an endogenous component that depends on the amount of effective R&D services, $u_{D,t}D_t$, and on the aggregate level of effective R&D services, $\bar{u}_{D,t}\bar{D}_t$. The fact that productivity depends on the utilized stock of aggregate R&D captures the idea that accumulated knowledge facilitates the creation of new knowledge via technological spillovers. $1-\zeta \in (0,1)$ governs the externality due to the utilized aggregate stock of R&D on the firms productivity. When μ_{RD}=0, federal government R&D expenditure has no productive use (it is ineffective in enhancing $Z_t(j)$) and is as wasteful as federal consumption expenditure. The specification for Z_t implies that current federal R&D spending positively impacts labor productivity, yet past expenditure deteriorates it. We do so to capture the idea that a sustained government effort in R&D activities is needed to enhance labor productivity.

In the model, federal R&D expenditure affects the home region in three ways: i) directly via Z_t, as determined by μ_R; ii) indirectly, by altering the accumulation of R&D investments, as measured by Ω_t; iii) indirectly, with s_t^D measuring the amount of subsidies per unit of investment.

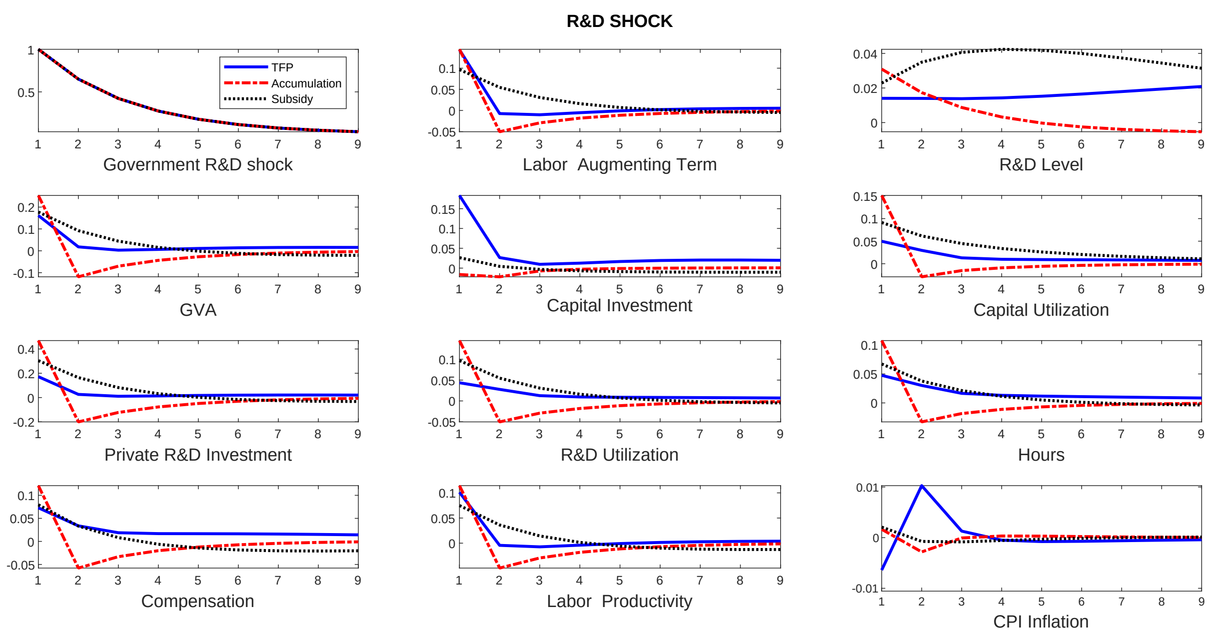
Parameterization. For the baseline scenario, we use standard parameter values. We select $n = 0.1, \eta = 0.35, \beta = 0.992^4; \sigma = 2, \chi = 2, \delta_{k,ss} = 0.08, \delta_{R,ss} = 0.06$ $\tau = 0.25, \epsilon = 10, \alpha = 0.3, \zeta = 0.65$ (which we take from Kung [2015]) $\Psi_p = 10, \vartheta_R = 0.75, \vartheta_\pi = 1.5$ $\psi_{K,2} = 4.2, \psi_{D,2} = 3.7$ (which are slightly smaller than those in Bonciani and Oh [2020] and adjusted to match our annual frequency); steady states subsidies for R&D expenditure are equal to 0.1. We also assume that in the steady state R&D grows at 0.5 percent a year and that in the steady state, utilization and Tobin's Q are all equal to 1, as are the inflation rates in the two regions. The AR(1) coefficient of all shocks is set to 0.65. These choices imply, that the real interest rate is roughly four percent a year, that price stickiness is low, that adjustment costs are moderate, that there is home bias in consumption, and that federal R&D shocks are fairly persistent. We examine three separate scenario. In the first we assume that federal R&D investment only affects Z_t: $\mu_R = 0.1, \omega = 1, \omega_H = 0$; in the second that it only affects the accumulation of R&D, $\mu_R = 0, \omega = 1, \omega_H = 0.1$; in the third that it only subsidizes private R&D investment $\mu_R = 0, \omega = 1, \omega_H = 0$.

Figure 6 plots the responses of selected variables after an impulse in government R&D expenditure. In each box there are three lines, corresponding to the three specifications we consider.The responses we present are obtained using the stationary model.

The outcomes when R&D shocks affect Z_t. In response to the R&D spending shock, private output, hours, investments in physical and R&D capital, and the real wage instantaneously increase as does labor productivity. The increase in government spending is accompanied by an increase in the labor augmenting term and in the utilization of the two types of capital, to take advantage of the labor productivity increase. Although output is demand determined, the supply effects of the shock are important, even with the low value of μ_{RD} we employ: private investments increase and this leads to a higher level of individual and aggregate stock of R&D in the economy; labor demand is boosted and the real wage increases; there is a downward pressure on marginal costs, which counteracts the increase in demand, leading to an instantaneous fall of CPI inflation.

This pattern of instantaneous responses differs from those generated by spending shocks in a standard, closed economy, New Keynesian models. In such a model government consumption expenditure shocks generate a negative wealth effect and a positive demand effect, see e.g. Pappa [2021], or Ramey [2019]. The negative wealth effect, arising because the households are Ricardian, increases the labor supply; the positive demand effect, due to increased public sector absorption, increases labor demand, real wages, and private output, while the effect on private investment depends on the details of the economy. The increase in demand increases current and expected future inflation. Thus, when monetary policy is conducted with a Taylor rule and the interest rate is away from zero, increases in the nominal (and real) rate counteract most of positive demand effects generally producing insignificant or even negative responses of private output and investments, while hours increase. These conclusions may be altered when a portion of the agents consume all of their current income; however, in no case increases in government consumption give rise to the positive instantaneous comovements we observe in the data.

Figure 6: Dynamics in response to federal R&D shocks



The responses we obtain differ for two main reasons. First, the R&D shock has positive effects on labor productivity. Thus, besides demand, it also has supply effects. Second, the supply effects are important because the spending shocks affect the accumulation of both physical and R&D capital.

Together these two effects imply that utilization of productive factors and labor demand increase in response to the shock. They also imply that temporary demand shocks have medium term consequences, as they positively affect the production possibility frontier of the economy. Thus, in our economy, the same shock drives cyclical and long term dynamics, making many standard trend and cycle decompositions inappropriate, see also Canova [2020a].

The instantaneous responses also differ from those generated by a shock in government physical capital investment. In this case, an unexpected increase in government spending has three effects, two similar to the ones induced by government consumption shocks, and an additional positive wealth effect, due to future productivity enhancement see e.g. Leeper et al. [2010] and Ramey [2020a]. Together, they imply that real wages and employment mildly increase on impact, while investments and output increase with a lag, spreading the effect of the shock on a number of years as capital accumulation increases. In our setup, the externality stemming from the aggregate stock of R&D amplifies the effect of the spending shock. Moreover, the enhancement of productivity factors implies that investments and output increase on impact. On the other hand, because labor productivity increases are temporary, the effects will be less persistent than with a government investment shock.

As time unfolds, the initial boost in private output and investments dies out and both responses become zero, because the drag that past government R&D expenditure exercises on the labor augmenting term, compensates for the increase in the stock of the two types of capital. Hours decline at a slower rate as firm take advantage of the increase in stocks of R&D and of physical capital. Labor productivity and wage responses also decline and approach the steady state from above, while utilization of the two types of capital declines more slowly. Because the speed at which output, investments of both types of capital, real wages and productivity decline is faster than the speed government R&D expenditure decline, cumulative multipliers at the three years horizon are smaller than on impact. The employment multiplier is instead roughly unchanged, as employment and government R&D responses decline at approximately the same rate across horizons.

The first panel in Table 6 presents the multipliers obtained in this setting. Multipliers are computed, accumulating at each horizon the discounted growth rate of the variables of interest in response to the shocks, once the balanced growth path is added, and scaling this amount by the accumulated discounted growth rate of federal R&D spending, again once the balanced growth path is added. As anticipated, with the parameter values we employ, the model qualitatively reproduces the two main stylized facts present in the first panel of Table 1: in response to the shock all multipliers are instantaneously positive; the multipliers of all variables but employment decline considerably in the medium term. Quantitatively, our parameterization produces impact output and investments multipliers which are about 3/4 of the average GVA and investment multipliers found in Table 1, while the impact hours multipliers are about 1/3 of what is found in the data.

Table 6 also reports the multipliers obtained with shocks to federal consumption expenditure. As the discussion indicated, disturbances of this type have no growth effects on any of the variables.

Table 6: Cumulative multipliers, Theory

	Consumption Expenditure Shocks								
	Baseline								
Horizon	1 year	3 years							
GVA	0.00	-0.00							
Employment	0.11	0.11							
Compensation	0.08	0.08							
Investment	0.00	-0.00							
Labor productivity	0.08	0.08							
	R&D Shocks								
	Baseline		**Lagged level**			**Lagged growth**		**Large size**	
Horizon	1 year	3 years	1 year	2 years	3 years	1 year	3 years	1 year	3 years
GVA	1.50	0.41	0.55	1.58	0.18	0.47	1.40	1.54	0.40
Employment	0.33	0.23	0.25	0.23	0.47	0.17	0.28	0.41	0.30
Compensation	0.70	0.57	0.41	0.59	0.21	0.50	0.78	0.76	0.59
Investment	3.33	1.12	1.21	3.40	0.39	1.01	2.97	3.36	1.05
Labor productivity	0.95	0.17	0.25	1.13	0.02	0.27	0.91	1.01	0.18
	Human Capital Shocks								
	Baseline		**Higher depreciation**			**Lower adj.costs**		**Lower productivity**	
Horizon	1 year	3 years	1 year		3 years	1 year	3 years	1 year	3 years
GVA	0.12	1.48	-0.37		2.49	-0.88	1.15	-0.46	0.45
Employment	-0.44	1.96	-0.93		2.44	-1.10	1.96	-0.78	0.93
Compensation	0.51	-0.41	1.29		-1.56	1.36	-1.15	1.20	-0.48
Investments	0.01	4.19	-1.38		6.90	-2.56	3.43	-1.71	1.11
Labor productivity	0.73	-0.58	0.83		-0.29	0.58	-0.85	0.60	-0.37

Notes: the first panel reports cumulative multiplierw for unproductive federal expendure; the second panel of the table reports the cumulative multipliers for R&D shocks directly affecting TFP; the third panel cumulative multipliers for HK shocks affecting the human capital accumulation equation. In the baselines specification the shock enters in growth rates; in the ‘’lagged growth” specification, the shock enters in lagged growth rates; in the “lagged level” specification, the shock enters in lagged level; in the “large size” case $n = 0.3$. For human capital shocks, in the “Higher depreciation” case, $\delta_H = 0.10$; in the “Lower adj. costs” case, $\psi_k = 3.76$; in the “lowerproductivity”, $\vartheta = 0.25$.

The outcomes in the other two specifications The qualitative pattern of responses is similar in the other two specification; the only visible difference concerns the dynamics of physical capital investment and of inflation. In the baseline specification, physical capital investment has an exponential declining shape. In the accumulation specification, however, physical capital investment falls since physical and R&D capitals are substitutes in production, and R&D investment increases a lot.

CPI dynamics qualitatively differ: in the baseline case supply effects dominate, making CPI inflation fall on impact and rebound afterwards. In the other two specifications, the demand effect dominates, making CPI inflation increase on impact and fall afterwards. Thus, while the main implications for private output, hours and (total) investment are unchanged, different specifications may give rise to different inflation dynamics in response to R&D shocks.

Multipliers in the alternative specifications are qualitatively very similar. However, in the specification where federal spending alters the accumulation of R&D, the fall in years 2 and 3 are generally larger, consistent with the responses in figure 6.

Heterogeneities. Given the widespread heterogeneities present in the data dynamics, we examine whether alternative setting can account for the different average multiplier patterns presented in Tables 1 and 2 and for the spillovers documented in Table 3.

Recall that the main differences between Tables 1 and 2 is that in some groups of regions the initial boost to economic activity due to ERDF shocks remains in the medium term, that after 2000, the instantaneous effect is muted and the peak response happens after two years. Table 6 shows that these patterns are consistent with two alternative specifications for the government R&D term in Z_t. If labor productivity is affected by the growth of government R&D expenditure with a lag, then the model can qualitatively match the dynamics present in the typical EU region following ERDF shocks after 2000. With this selection the demand effects of the shock occur instantaneously while the supply effects begin with one period delay and this asyncronicity gives rise to humps in the multipliers observed in the data (see third column of Table 6). Given that the two effects are now asyncronous, it is clear that the supply boost on private output is at least as large as the demand boost. If, on the other hand, the Z_t term is specified as:

$$Z_t = (G^R_{t-1}/\bar{D}_t)^{\mu_{RD}}(u_{D,t}D_t)^{\zeta}(\bar{u}_{D,t}\bar{D}_t)^{1-\zeta} \tag{24}$$

the persistence of the multipliers increase (see the second column block of Table 6). Here there is still asyncronicity in the timing of demand and supply effects, but because there is no drag from past government R&D expenditure on labor productivity, the medium term effects are enhanced and the multipliers of private output, investments, real wages and labor productivity are now increasing with the horizon making three years horizon cumulative multipliers are larger than one year multipliers [4].

Finally, cross regional spillovers are difficult to characterize in a two-region economy. However, if we think of a country as a larger region in which the magnitude of the impulse remains the same, then

[4]There is an alternative parameterization which produces a similar time profile for multipliers. It requires that the level of government spending enters contemporaneously in Z_t, but that both price stickiness Ψ_p and the productivity of government R&D investment μ_{RD} are increased. Here the initial effect is smaller, because the supply effects are muted given that output is "more" demand determined. However, the higher productivity of government spending implies larger and more persistent supply effects. Thus, the cumulative medium term multipliers of all five variables are larger than the impact multipliers.

increasing the size of the region n should approximately produce the effect we care about. Indeed, Table 6 suggests that when the region is larger, the multiplier effects of government R&D spending shocks become larger at all horizons, as it is the case in the data. However, magnitude differences with the baseline case are small.

In sum, the model is quite rich. Depending on parameter values and the specification of the production function it can produce different time profiles of multipliers and can, in part, account for the spillovers we observe in the regional EU data. Moreover, the way federal R&D expenditure enters does not matter for the qualitative features of the responses and the multipliers we present.

6.2 Human capital expenditure shocks

To mimic the effects of ESF shocks, we set $u_{D,t} = 1, u_{D,t} = 1, D_t = S_t = 0,\ Z_t = 1,\ \forall t$ and specify the production function of firm to be

$$Y_t = (u_{K,t} K_t)^{\alpha} (u_{H,t} H_t L_t)^{1-a} \tag{25}$$

where $(u_{K,t}K_t)$ are effective capital services and $(u_{H,t}H_tL_t)$ effective labor services. Federal spending in human capital does not directly affect the regional production possibility frontier. Instead, it alters the accumulation of human capital or household education choices via human capital subsidies.

Parameterization. The version of the model with human capital expenditure, features four additional parameters that need to be selected. Evidence from Jones and Manuelli [2005] and Dinerstein et al. [2020] suggests annual depreciation values for human capital of teachers is between 4 and 6 percent. We set $\delta_H = 0.04$. There is not much empirical evidence to select ϑ, the share of individual human capital in the accumulation equation. In the baseline experiment, we set $\vartheta = 0.85$. The persistence of federal human capital spending ρ_{HK}, is set to 0.2, to mimic the fact that EU programs last one or two years. Finally, the steady state value of the human capital subsidy is set to 0.1. All other parameters are maintained to the values mentioned in the previous subsection.

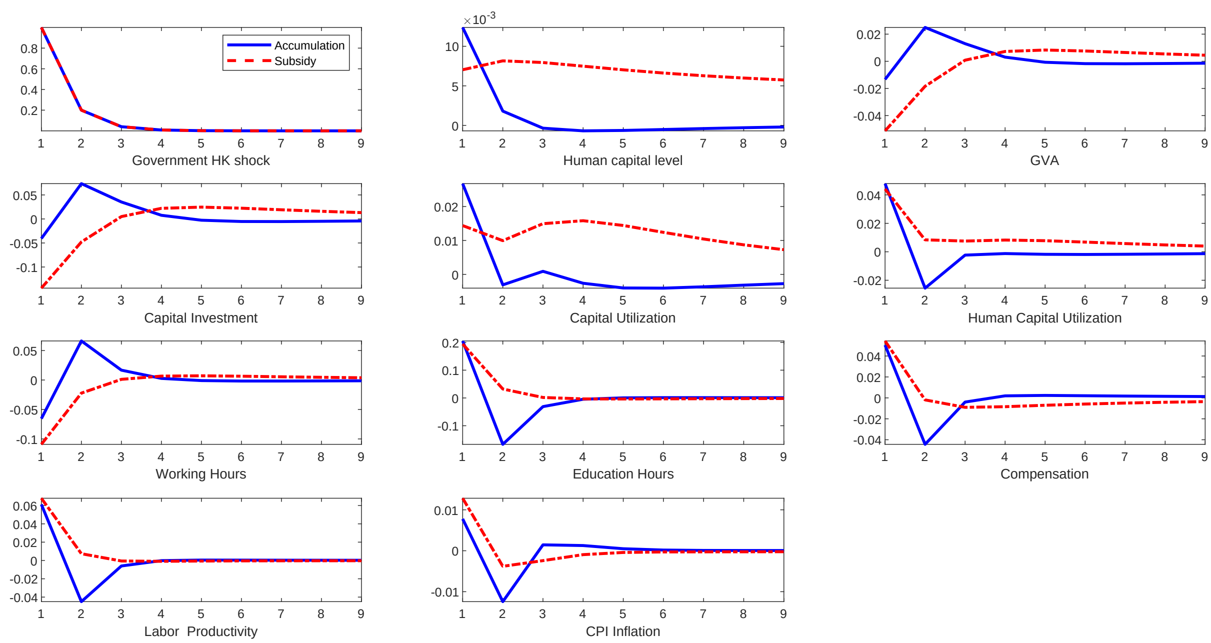
Figure 7 plots the responses to an impulse in federal human capital expenditure. There are two lines in each box, one representing the dynamics produced by expenditure affecting the human capital accumulation equation and the other the dynamics produced by human capital subsidies.

The outcomes. When federal spedning affect human capital accumulation, working hours, investments fall while education hours, the real wage and labor productivity increase on impact. Thus, the shock induces households to shift time away from work towards education and this tightens the labor market. The fall in production produced by this shift is limited because both physical and human capitals are used more intensively, counteracting the fall in working hours. Note that the increase in labor costs pushes CPI inflation upwards.

Since government spending is temporary, the initial boost in education hours is quickly reversed and, because of the higher productivity of labor, working hours, investments and private output responses become positive and converge back to the steady state from above. The opposite occurs for real wages and labor productivity, which converge to the steady state from below. The combined effect of temporary federal spending and of the quick reversal of the increase in training hours makes human capital accumulation small.

The dynamics are slightly different when subsidy shocks are considered. It is still true that a subsidy shock leads households to devoted more time to education and less to work. However, because woking hours drop more in this case, capital investments and private output are more negative. Following the drop in working hours, utilization of physical capital increases more persistently. Finally, because the medium term response of all variables is positive and larger than in the other specification there is a measurable increase in the stock of human capital, even if the shock is temporary.

Figure 7: Dynamics in response to federal human capital shocks



Interestingly, the pattern of responses displayed in Figure 7 is qualitatively similar to the one produced by temporary negative labor supply shocks - here initially agents take more leisure and later work more productively. The twist relative to this situation is that the externality produced by federal education expenditure affects the accumulation of human capital. Hence, it induces persistent effects in all macroeconomic variables, regardless of the persistence of the spending disturbance.

The parameterization we employ accounts for a couple of important stylized facts: (i) the initial effect on private output, investments, and hours is negligible or negative; (ii) the effect at the three years horizon on these three variables is positive. We are also able to generate a persistent, albeit small, medium term increase in compensation, but given the rudimentary specification of the labor market we employ, we are unable to produce a positive medium term labor productivity multiplier.

To generate labor productivity (and wage) responses that look like those in the data, one needs to enrich the model to have at least two types of workers; unskilled workers who do not train, and skilled workers, who spend time improving their skills. When skilled workers return to their working activities, they command a higher wage (making average compensation persistently increase). Furthermore, because they have higher marginal product, average labor productivity should increase in the medium term. As the scope of the current section is to explain the pattern of GVA, investments, and employment multipliers uncovered in data, we leave this extension for future work.

Quantitatively, the model falls short of generating the medium term boom we see in the data. For example, at the three years horizon cumulative multipliers are roughly one third of those in the data (see third panel of Table 6). As in the case of R&D shocks, the model is flexible and has the potential to generate larger medium term multipliers if human capital depreciation in the steady state is larger (see column 2 of Table 6) or if capital adjustment costs are smaller (see column 3 of Table 6). When there is higher human capital depreciation, physical capital accumulation is stronger and this leads to much higher investment multipliers than otherwise. Similarly, when capital adjustment costs are smaller, physical capital accumulation is larger, leading to much higher GVA, hour and investment multipliers. Note that decreasing the productivity parameter of federal human capital expenditure in the accumulation of human capital considerably reduces medium run multipliers.

Discussion. What are the crucial ingredients of the model that deliver the required results in response to human capital shocks? First, there should be a sufficiently high steady state depreciation of human capital. Without it, the impact effects of hours is positive on impact and the medium term effects are muted. As shown in the second column of Table 6, with higher steady state depreciation, hours and GVA multipliers become larger at all horizons in absolute value and investments multipliers grow at all horizons, as the economy builds a larger stock of physical capital to better smooth consumption over time.

As alternative, we need physical capital to be easily adjustable in response to the shocks (see third column of Table 6. Otherwise, the profile of investment multipliers is uniformly reduced and twisted and this makes medium term private output multipliers smaller.

Second, we need a sufficiently high productivity of federal human capital expenditure to quantitatively produce the multipliers we see in the data. If this is not the case, the initial impact on private output, hours and investments becomes more negative and the time profile of multipliers at longer horizons is lower (see fourth column of Table 6)

In sum, the pattern we see in the data is consistent with the idea that federal human capital expenditure has a direct positive effect on human capital accumulation and an indirect effect on physical capital accumulation. To make sure that the physical capital accumulation supports the increase in human capital and thus ignites a virtuous cycle, one needs either a sufficiently high steady state human capital depreciation or sufficiently low adjustment costs of physical capital. The productivity of government spending in the human capital accumulation is also important to shape the profile of multipliers. Differential regional values for these three parameters may thus account for some of the heterogeneous dynamics observed in the data.

A counterfactual One of the features of RRF is that it provides a combination of grants and loans to national governments in almost in equal proportions. However, since the funds we examined in section 4 were just in the form of grants, not much can be said to assess what would be the consequences of using both grants and loans in the recovery process. The issue is relevant since some countries, for example Italy and Greece, have decided to also use loans, which need to be repaid by individual countries and will enter the national stock of debt by 2023, while others, e.g. Spain and Germany, will only use grants.

Table 7: Cumulative multipliers, Grants vs. Grants and loans

	R&D Grants			**R&D Grants and Loans**		
Horizon	1 year	2 years	3 years	1 year	2 years	3 years
GVA	1.50	0.48	0.41	0.62	-0.94	-1.59
Employment	0.33	0.31	0.23	-0.22	-0.38	-0.63
Compensation	0.70	0.58	0.57	0.67	0.28	0.00
Investments	3.33	1.23	1.12	1.46	-1.75	-3.02
Labor productivity	0.95	0.14	0.17	0.91	0.19	-0.46
	HK Grants			**HK Grants and Loans**		
Horizon	1 year	2 years	3 years	1 year	2 years	3 years
GVA	0.12	1.03	1.48	-1.28	-1.12	0.36
Employment	-0.44	2.56	1.96	-1.32	1.19	1.49
Compensation	0.51	-1.52	-0.41	1.43	-1.42	-1.25
Investments	0.01	3.22	4.19	-3.65	-2.45	1.31
Labor productivity	0.73	-1.53	-0.58	0.48	-1.89	-1.00

Notes: the table reports the cumulative multipliers for R&D shocks directly affecting labor productivity and for human capital shocks affecting human capital accumulation. The first three columns report multipliers when the home region does not need to repay federal expenditure; the second three when 50% of federal expenditure is repaid with distorting taxation.

While the data does not allow us to understand the consequences of these two mode of financing, the model can be twisted so that federal support comes in the form of grants or grants and loans and thus can give us some idea of what will happen when the second option is exercised. Given what Italy and Greece have pledged to do, we assume that 50 percent of the federal amount given to the home region is in the form of loans. We also assume that they will be repaid using funds raised with distorting labor taxation.

Table 7 reports the multipliers obtained in the baseline specification presentable in table 6 and in the alternative specification where half of the regional funds are in the form of loans. It is clear that in the mixed grants-loans scenario, the multipliers become uniformly smaller or more negative at all horizons. This occurs because when distorting labor taxation is employed to cover the principal and the interest of the loans the demand effect of the shocks are smaller and the supply effects are either wiped out or considerably reduced. One can twist the time profile of the multipliers by allowing debt in the model and postpone the payments to later dates. However, the conclusions that in the medium run (intended as the period when the debt is paid back), multipliers of both types of shocks are smaller, remains unchanged.

The policy implication of Table 7 are clear. Countries that only employ the grants portion of the RRF are in better position to recover, both because medium term multipliers are larger on average and because the accumulation of government debt may jeopardize the recovery at some future date.

7 Conclusions

This paper provides empirical evidence on the dynamic effects of the two most important structural funds the EU has granted to regions of member states over the last 30 years. Given that NGEU funds have features resembling those of these two regional funds, we use historical evidence to evaluate the likely consequences of the planned fiscal expansion on the regional economies of the EU.

We focus attention on the dynamic adjustments that the European regional development fund (ERDF) and the European Social Fund (ESF) have produced on the production, employment, productivity, investments, and labor market participation. We construct a usable data set for the structural funds and employ a Bayesian IV-LP technique to construct dynamic multipliers for the variables of interest, region by region; we then compute cross sectional averages and cluster the regional distribution of multipliers using economic, geographical, institutional, and national characteristics.

On average, ERDF innovations have statistically significant and economically relevant positive short term effects on all regional macroeconomic variables, making the funds potentially useful for countercyclical purposes. These funds temporarily boost productivity and lead to expansion of employment, real compensation, investments and production. Nevertheless, the positive impact dies out quickly and gains dissipate almost entirely within three years in many regions. ESF innovations, instead, have negative (although often insignificant) consequences on impact but exercise a positive effect on all regional variables after 2-3 years, making them good instruments to achieve medium term transformation objectives. These funds temporarily affect labor markets, by decreasing private employment and increasing compensation. However, in the medium term the increase in labor productivity they generate, induces positive and economically important effects on investments, employment, and production. Quantitatively the two programs produce average regional multipliers with quite different magnitudes. Thus, if employment, production, and investments growth are the yardstick to measure the success of the two programs, ESF dominates EDRF in the medium run.

Both programs produce considerable heterogeneity in regional macroeconomic outcomes. The level of regional development, tenure with the EU, membership to the Euro, regional location, and national borders are all important to explain the asymmetric transmission, in particular, of ERDF innovations. Although the distribution of EU funds is skewed toward poorer, peripheral, and less developed regions, the asymmetric patterns we discovered indicate that these funds have led to increased polarization and regional inequality. If minimization of regional distortions is important, the ESF program is preferable, as it benefits a larger number of regions in a number of countries.

To interpret the dynamics we uncovered and to give a structural interpretation to the mechanism generated by the funds, we extended a standard workhorse New Keynesian model of a monetary union to allow for endogenous growth. We do this through two separate channels: R&D and human capital accumulation. ERDF innovations, which we model as federal R&D shocks, change the productivity of labor and the production possibility frontier. However, their effects are temporary because the average growth rate of the regional federal expenditure is negatively serially correlated. ESF innovations, which we model as federal human capital shocks, alter the labor/leisure/schooling margins, cause a temporary drop of economic activity, but a significant boost in the medium term, because the productivity of effective labor improves.

What did we learn from the exercises that can be useful to predict what the macroeconomic effects of NGEU funds will be? EU grants can have a useful role in counteracting generalized recessions and in boosting job creation and investments that may lead to economic transformation. Thus, the creation of NGEU funds is a good idea and the choice of borrowing to finance them seems correct, because they are likely to produce economic gains that can sustain the cost of borrowing and avoid persistent accumulation of debt. However, because EU funds benefit some regions more than others, and the less fortunate turn out to be poorest, peripheral, and non-Euro regions of recently added countries, the adjustment and transformation process will be unequal.

There are no obvious solutions to avoid increases in regional inequalities. However, there are examples of EU regions, which managed to escape the poverty trap and join the wealthy club. Studying in details what has made a difference would be instructive to avoid repeating mistakes made in the past. In general, administrative and structural reforms, efficiency checks and, perhaps, generational changes may help to spread the gains more uniformly across EU regions.

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Appendix A: EU regional funds

EU regional policy targets all regions of the European Union with the goal of supporting job creation, business competitiveness, economic growth, sustainable development, and to improve the quality of life of EU citizens. To reach these goals and to deal with the heterogeneous stages of development of different EU regions, a portion of the total EU budget is set aside for the so-called Cohesion policy in each budget cycle. For example, for the 2014-2020 cycle, the Cohesion policy program is endowed with over 355 billion Euros, almost a third of total EU budget.

The European Structural and Investment (ESI) funds, the main tools to achieve the Cohesion policy goals, comprises four different programs: the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund (ESF), the European Agricultural Fund for Rural Development (EAFRD). In the most recent budget cycle, the European Maritime and Fisheries Fund (EMFF) has been added. ERDF covers over 40 percent of the total budget, EAFRD over 20 percent, and ESF and CF less than 20 percent each.

The funds should be used to implement the Commission's priorities. Thus, the grants to member states and regions are subject to conditions. The priorities vary with the budget cycle but are growth, employment and social equality have been long lasting themes in the EU agenda. For the 2014-2020 budget cycle the Commission has five targets:

• Employment: at least 75 percent of the population 20-64 year-old should have a job.

• Research & Development: 3 percent of the EU's GDP should be invested in R&D.

• Climate change and energy sustainability: greenhouse gas emissions should be reduced by 20 percent; energy from renewable sources should increase by 20 percent; and energy efficiency should increase by 20 percent.

• Education: the rate of early school leavers should be reduced below 10 percent.

• Fighting poverty and social exclusion: people in or at risk of poverty and social exclusion should be reduced by at least 20 millions.

The bulk of Cohesion Policy funding is concentrated on less developed European countries and regions. The idea is to help them to catch up and to reduce economic, social and territorial disparities that still exist in the EU. For the 2014-2020 budget cycle over 50 percent of the funds are targeted to less developed countries and regions.

ERDF is available since 1989 (and thus available from the first budget cycle), aims at strengthening economic and social cohesion in the area and focuses on several key priority areas (known as 'thematic concentration') which include: innovation and research; the digital agenda; support for small and medium-sized enterprises; and the low-carbon economy.The resources allocated to these priorities depend on the region. In developed regions, at least 80 percent of funds must focus on, at least, two of these priorities; in transition regions, the amount drops to 60 percent; and in less developed regions to 50 percent.

Under the European Territorial Cooperation programs, at least 80 percent of funds must be concentrated on the four priority areas but allowances are made for specific regional characteristics. Furthermore areas that are naturally disadvantaged because remote, mountainous, or sparsely populated benefit from special treatment.

Contrary to ERDF, which is distributed according to regional characteristics, CF target countries whose per-capita Gross National Income is less than a fixed percent of the EU average. In the past, it was 75 percent; in the current budget cycle is was increased to 90 percent. The fund aims at reducing economic and social disparities and at promoting sustainable development. For the 2014-2020 period, the Cohesion Fund is operative for Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. In the past, Ireland also received grants from this fund.

CF was created in 1993 (and thus it is available from the second budget cycle) and allocates funds for two main activities. First, for infrastructures connected with trans-European transport networks. Second, for projects related to energy or transport, as long as they benefit the environment in terms of energy efficiency, use of renewable energy, development of rail transport, strengthening public transportation, etc.

The funds allocated by this program can be suspended by a Council decision (taken by qualified majority) if a member state shows excessive public deficit and if it has not resolved the situation or has not taken the appropriate actions to do so.

ESF was created in 1999 (and thus it is available from the third budget cycle) and invests in people, focusing on improving employment, human capital, and education opportunities across the EU. It also aims to improve the situation of the most vulnerable citizen at risk of poverty. The fund covers all EU regions and there is a special provision to foster youth employment.

For the 2014-2020 budget cycle, ESF focuses on four thematic objectives:

- Promoting employment and supporting labor mobility.
- Promoting social inclusion and decreasing poverty (20 percent of the grants should be committed for this scope).
- Investing in education, skills, and lifelong learning.
- Enhancing institutional capacity and an efficient public administration.

ERDF, CF, and ESF are subject to the same rules as far as programming, management, and monitoring. Given their nature, ERDF should be broadly considered investments in manufacturing and R&D; CF investments in infrastructures; and ESF investments for human capital and education development.

Finally, EAFRD is available since 1992 (and thus available from the second budget cycle) and finances regional rural development. Programs are designed in cooperation between the European

Commission and the member states, taking into account the strategic guidelines for rural development policy adopted by the Council and the priorities laid down by national strategy plans.

While up to the 2007-2013 budget cycle, the fund was treated independently, in the latest programming period, EAFRD is included in the policy framework of the European Structural and Investment funds and subject to the Common Provisions Regulation.

For the 2014-2020 programming period, the fund focuses on three main objectives:

- Fostering the competitiveness of agriculture.
- Ensuring sustainable management of natural resources and climate actions.
- Achieving a balanced territorial development of rural economies and communities, including the creation and maintenance of employment.

The European Maritime and Fisheries Fund (EMFF) is a new fund created for 2014-2020 budget cycle. It is designed to:

- Help fishermen in the transition to sustainable fishing.
- Support coastal communities by diversifying their economies.
- Finance projects that create new jobs and improve the quality of life along European coasts.
- Make it easier to access financing.

For the 2021-2027 budget cycle a number of changes will take place, some funds will be eliminated and the allotted amounts will be available for grants or for loans. According to the July 2020 agreement, the new long term EU budget (now called Multi Annual Financial Framework) will be endowed with 1074 billion Euros, and the Next Generation EU funds is created with an endowment of 750 billion Euros. The Next Generation EU funds are supposed to create jobs, repair the damage caused by the COVID-19 pandemic, and to support the EU's green and digital priorities. They will be financed from international financial markets, and backed by introducing plastic waste, carbon emission, digital levy, and transaction EU taxes. 390 billions will be available for grants and the rest for loans at low interest.

As for other budget cycles, member states must set out their reform and investment plans for the Commission to assess before funds are disbursed. A conditionality mechanism allows a qualified majority in the European Council to hold up the flow of funds to member states that fail to follow through on reforms. Another provision could block disbursements from the funds and the EU budget to countries that fail to uphold the rule of law. Loans will be capped at 6.8% of a recipient's Gross National Income and will only feed through to government debt, once countries borrow in the open market to repay the debt to the EU (supposedly from 2028).

The Recovery and Resilient Facility is the largest of these funds with a budget of 672 billion Euros and should support cohesion, civil protection, health and the recovery from the COVID pandemic. The allocation mechanism for the first two years the RRF takes into account the unemployment rate for 2015-2019, the inverse of GDP per-capita and the population share of each region; for 2023 the unemployment rate is substituted by the drop in GDP for 2020 and 2021 as observed in 2022.

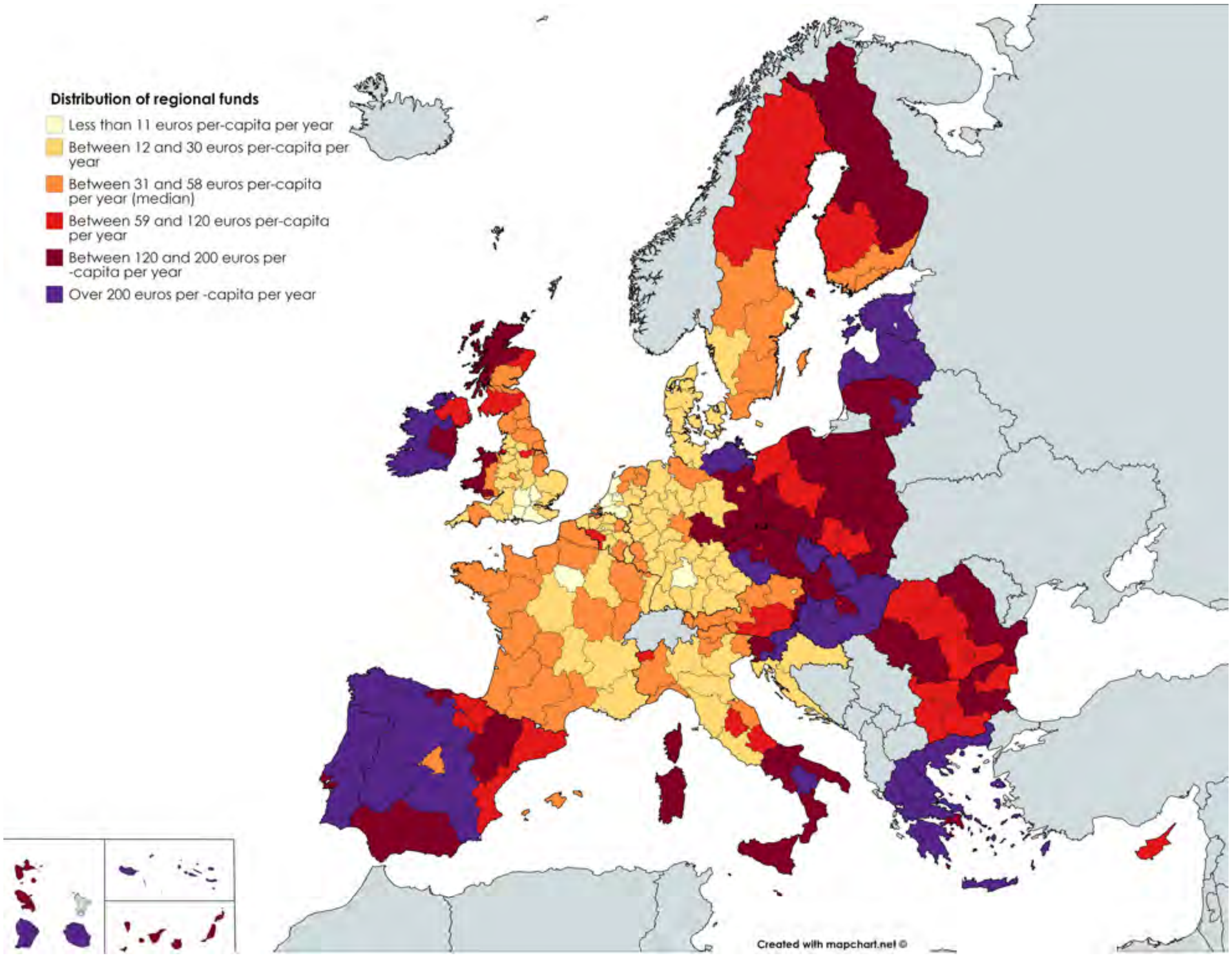
EU transfers are typically made after actual expenditure incurred by the states in a region. Thus the use of EU data payments may distort economic analyses since it creates a lag between the time the expenditure takes place and the time expenditure appears in the EU accounts. To avoid this problem the data we employ use a modified estimate of the real expenditure made by each region, for each fund, in each year.

Table A.1 reports top and bottom recipients of ESI funds on average in per-capita terms and figure A.1 the geographical distribution of average per-capita Eu funds.

Table A.1: Top and Bottom recipients, ESI funds

Region	Acronym	Average yearly per-capita real funds
Azores	PT20	851,29
Ceuta	ES63	714,31
Madeira	PT30	569,69
Melilla	ES64	526,75
Alentejo	PT18	525,11
Anatoliki Makadonia-Traki	EL51	487,45
Dytiki Makadonia	EL53	444,62
Sostines	LT01	429,43
Ipeiros	EL54	428,67
Voreio Aigeio	EL41	426,76
Algarve	PT15	422,86
Hampshire-Isle of Wright	UKJ3	10,68
Outer London 1	UKI7	10,68
Zuid-Holland	NL33	10,48
Noord-Holland	NL32	10,46
Stuttgart	DE11	9,95
Inner London 2	UKJ2	9,72
Bruxelles	Be10	9,34
Inner London 1	UKJ1	9,29
Paris	FR10	8,25
Stockholm	SE11	7,99

Figure A1:Geographical distribution of average real per-capita ESI funds



Appendix B: Estimation of regional funds

Regional funds data are estimated using two types of information: payments made by the EU to a country in a year and an index of specificity, which describe how the region spends the allocated money within the programming period.

Payments follow the cycle of reimbursements to member states. The typical pattern consists of i) advance payments, ii) payments following certification during the period, iii) closure payments at the end of the period, iv) financial corrections after the closure of the period. In a given year, all four types of payments may occur and may refer to projects started at different time and, for the years corresponding to the beginning and the end of the cycle, for projects in different budget cycles. Given that there is no information on the type of payments, the estimation problems amounts to allocate the accounting amounts to different years. According to EU documents (see, Regionalization of ESIF payments 1989-2015, European Commission, 2017) this is done by employing an index of regional specificity of expenditure which accumulates expenditure over budget cycles and compares the cumulative sum to a uniform expenditure pattern. Thus, regions that tend to spend most of the amounts at the end of the budget cycle are treated differently than regions that spend more uniformly or more at the beginning of the budget cycle.

The allocation rule used gives a fraction ϕ_z of the expenditure to the year in which the EU payment appears while $1-\phi_z$ is distributed to the previous years. ϕ_z is set using $\phi_z =$ $phi_{\max} - \mu_z(\phi_{max} - \phi_{min})$ where ϕ_{max} and $\phi_{\min}$ are in the range (0.8,1) and (0.2, 0.4) and μ_z is the index of regional specificity. The remaining amount is allocated using $A_{z,p+q-k} = \frac{1-\phi_z)2^{k-1}}{\sum_{k=1}^{l} 2^{k-1}}$ where $l = int(\mu_z(q-1)) + 1$, p is the first year of the programming period, q is the number of years up to the current. In words, in the remaining years the remaining amount is spread so that each year expenditure is twice as large as in the previous year. The scaling factor depends on l which in turns depends on μ_z. When μ_z is close to zero payments are allocated over a smaller number of years. When μ_z is close to 1, expenditure is distributed over the entire q range of years.

Given that the allocation rules depend on ϕ_{max}, ϕ_{min} the estimated data provided in excel format are constructed as mean value randomizing these two parameters within their range. EU sources mention that the accuracy of the allocation procedure is stronger for data after 2000 and that the information on the index of specificity is more reliable for ERDF than for ESF.

Because of the way the data is constructed, one can not exclude that anticipatory effects could be present. Furthermore, because the index of specificity differs across regions, different gestation lags between the proposal, the approval and the implementation projects across regions can not be excluded. In general, because measurement errors are likely to be large, one should take with a grain of salt the exact timing of the effects we describe in the paper.