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 *

March 1, 2021

Abstract

We examine the dynamic macroeconomic effects of the two largest EU regional structural funds. On average, ERDF funds have significant positive short term consequences on regional macroeconomic variables and gains dissipate almost entirely within three years. ESF funds have negative impact effects on regional variables, but their average cumulative medium term multipliers are positive and economically significant. We detect important regional asymmetries which may induce differential transition paths and outlooks for economic transformation. Location, level of development, EU tenure, Euro area membership and national borders account for part of the asymmetries. We present a two-region equilibrium model with sticky prices and endogenous growth through investment in R&D and human capital that reproduces the facts and explains some of the observed asymmetries. The policy implications for the newly created Recovery fund are discussed.

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

JEL Classification: C32, E27, E32, H30.

*First version: October 2020. We thank Juan Dolado for useful comments. Part of the work was conducted while the first author was Santander Chair of Excellence at Universidad Carlos III, Madrid.

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 created 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 part 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 incentivizing 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?

These questions loom in the back of the mind of policymakers and academic economists. While 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 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 regional macroeconomic effects? Are they uniform? What may account for the differences across regions? 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 local projection approach to measure the dynamic multipliers of the two structural funds, region by region. With the time profile of this distribution, we summarize its characteristics using cross-sectional averages and cluster regional statistics along economic, geographical, institutional, or national dimensions.

We suggest a different way for modelling fiscal policy in an otherwise standard New Keynesian model in order to highlight the growth enhancing nature of the structural funds considered. Relative to the existing literature, the model feautures endogenous growth. Investment in R&D and human capital are allowed to be directly affected by the federal expenditure and both endogenously alter labor productivity and growth. The additional mechanisms are crucial to understand the stylized facts we collect and to generate realistic responses to the specific spending disturbances considered. We highlight the structural parameters that may generate dynamic heterogeneity and differential growth prospects.

The empirical results The two funds have different macroeconomic effects. ERDF funds have statistically significant and economically relevant average positive short term impact on all regional macroeconomic variables, making them 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 funds have a negative, although often insignificant, impact effects but they exercises positive average effects on all regional variables after 2-3 years, suggesting they 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 funds equaling to one percent of regional gross value added (GVA) makes GVA 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 funds leads to 5% cumulative increase in GVA, to a cumulative increase of 1.6% in employment, and to a cumulative increase of 4.3% in investments, on average, over three years. Thus, if employment, production, and investments growth are the yardstick to measure the success of the programs, ESF dominates EDRF in the medium run.

These 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 grants have positive medium term cumulative macroeconomic effects, while these effects are negative in northern regions; and ESF grants have larger and more significant medium term repercussions. Similarly, for regions belonging to older EU member countries, EDRF grants produce less negative and ESF grants more positive medium term effects. We also find that the level of development is important and regions whose per-capita income is in the central portion of the distribution benefit most from the 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 funds are superior also in this dimension, as they benefit a larger number of regions in the medium run in a variety of EU countries.

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

The insights of the model Relative to existing medium scale DSGE models, our model incorporates two important features. First, we consider a two-region monetary union structure, which makes it well suited to simulate the effects of the structural funds in the different regions of a monetary union. Second, our theoretical model has one feature, previously disregarded in the literature, which is crucial to understand the effects of EU funds: labor productivity has an endogenous component that depends on either the local level of R&D or human capital services and federal government spending generates an externality on the aggregate level of these services. In such a setup, temporary government spending shocks produce persistent dynamics, even without agglomeration effects, because they have both demand and supply effects: they boost aggregate demand, because government absorption of goods and services increases; they alter aggregate supply, because the productivity of factors of production increases.

Changes in the timing of these two 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 spending shocks in R&D 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 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 expenditures affects the TFP with a lag, or contemporaneously, but price stickiness and the productivity of government R&D investment are large, persistent medium term multipliers could be created, as a result of larger and more persistent demand effects.

Federal government spending in education enhances the accumulation of private human capital. In the short run, increases in education spending decreases employment and increases real wages, as workers take advantage of the funds to change their allocation of time 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 and its utilization should slow depreciation over the adjustment path. 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. Without these, negative medium term multipliers could be generated also in this case.

Given the small open economy nature of NUTS2 regions, the model considers federal spending in a two-country world, where the home region is relatively small relative to the rest and there is trade in goods and services. We restrict attention to a monetary union, where the central bank set the interest rate as function of the aggregate inflation rate as many EU countries peg their exchange rate to the Euro. 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 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 documented 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 the country level. Thus, the paper brings together two unrelated strands of literature. The first analyses 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 for investment purposes 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 grants; 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] or Deryugina [2017]. We contribute to this literature by employing EU regional data; providing an alternative 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, the technique employed to estimate the average effects is invalid when considering EU regional funds; third, she limits attention to the last two budget cycles (2000-2006 and 2007-2013), while we take a longer perspective; fourth, she uses commitments allocations as instruments in her regressions; but such instruments are likely to be correlated to the regression error, rendering estimation 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 of fund 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 of fund 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, GVA 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, the macroeconomic variables in different countries react differently to the flow 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 sources of 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 appendices have a description of the nature of the EU structural funds; some graphical statistics of the new data set and the equations of the model.

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 gross value added (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://ec.europa.eu/regional_policy/EN/policy/evaluations/data-for-research/. 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 grants target agricultural support, in our exercises we employ data for ERDF, which is concerned with investments in innovation and research, and in 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. There is a time gap between the allocation of funds in EU books and their transfer to the regional government; there are mistakes in the coding of the data; and the numbers come in nominal terms. Details concerning the construction of a usable data set of real structural funds

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

comparable across regions are in Canova et al. [2020].

3 The econometric procedure

To examine the dynamic effects of ERDF and ESF grants on regional macroeconomic variables we employ a Bayesian local projections framework. Given the potential endogeneity of structural funds to EU economic conditions, we use their innovations as instruments in the projection equations. Innovations are constructed as the residuals in 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. [2]. Annual Euro data is available from 1980 to 2017 from the same EU sources mentioned above.

The dependent variable in local projection equations is the cumulative growth rate at horizon h of the macroeconomic variable of interest, i.e, $y_{i,t,h} = \sum_{j=1}^{h} \frac{Y_{i,t+h-1} - hY_{i,t-1}}{Y_{i,t-1}}$. The independent variable is the cumulative change in the relevant fund, scaled by regional GVA, i.e. $x_{i,t,h} = \sum_{j=1}^{h} \frac{G_{i,t+h-1} - hG_{i,t-1}}{GVA_{i,t-1}}$. This way and consistent with the literature, see e.g. Dupour and Guerrero [2017] or Ramey and Zubairy [2018], the estimated coefficients on $x_{i,t,h}$ can be interpreted as the cumulative multipliers of the funds (Euro change in private income per Euro of grants) at each horizon h. We choose to scale the grant variable by regional GVA rather than regional income since the measurement of the regional component of the public sector is problematic. The controls in the projection equation are 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. The instrumental variable regression is

$$x_{i,t,h} = \alpha_{i,h} + \beta_{i,h} w_{t,h} + u_{i,t,h} \tag{2}$$

where $w_{t,h}$ are ERDF or ESF spending innovations, obtained from regressing the EU expenditure variable on aggregate Euro area variables as detailed above. Because of the way $\hat{x}_{i,t,h}$ is constructed, $c_{i,h}$ represents the cumulative multiplier at horizon h of an unexpected increase in a structural fund.

Given the short sample size in the time dimension, we limit attention to h=1,2,3. We estimate equation (1) using 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 equation (2) are non-informative.

[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

Once estimates of $c_{i,h}$ are obtained for each i and different h we compute cross-sectional averages by trimming the top 10 and bottom 10 percent of the estimates [3]. We also characterize the distribution of regional multipliers in a number of ways. In particular, we will 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 multiplier 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 income per-capita distribution. Finally, we cluster multipliers using national borders and, for each horizon, we report the average multipliers within a country.

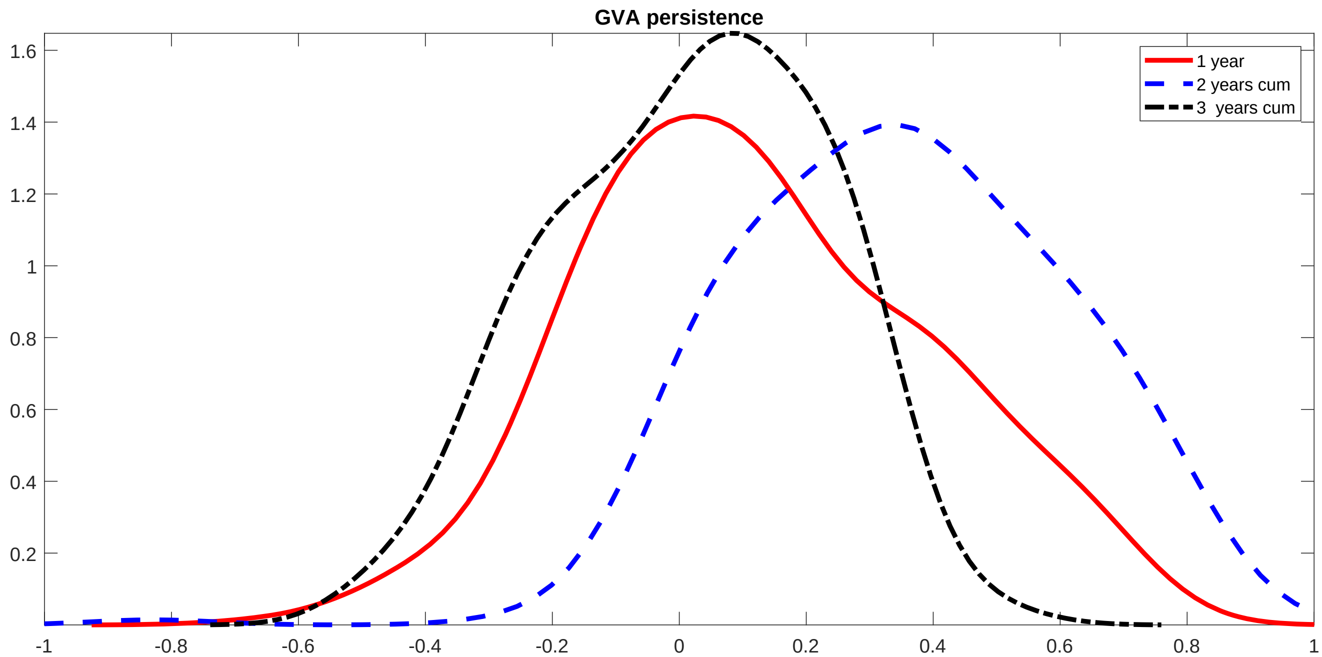
Two important issues deserve some discussion. First, given the long legislative process, the accrual of structural funds to a region may be predictable and their effects on the private sector may occur prior to the actual book-entry in the EU budget. While this is a possibility, accounting for predictability using commitments, rather than actual entries, as it is done in Coelho [2019], does not resolve the issue because commitment data refer to the aggregate in a specific year and not to a specific project. For example 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. One way to take care of anticipation would be to change the timing of the instrumental variable regression, and use $w_{t-j,h}$ in place of $w_{t,h}$, in which case $u_{i,t,h}$ may also include variations, predictable j-years in advance. Such a change produces no differences in the average multipliers we report because the variables used to construct $w_{t,h}$ are highly positively serially correlated.

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) and (2), 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 heterogeneous across regions, such an approach leads to inconsistent estimates of the quantities of interest, see Canova [2020a].

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 collapses at one point or that becomes more concentrated as h increases; hence, an alternative approach needs to be used to compute average multipliers which have some consistency properties. For this reason, we estimate (1) and (2), 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 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

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

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



heterogeneity. Note that, were 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, regardless of whether dynamic homogeneity holds 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 grants, when all 279 EU regions are considered.

Innovations in the grants distributed by the two funds have very different dynamic effects. ERDF funds are, 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 funds equal to one percent of regional GVA, private GVA grows by 1.8%, investments by 5.9% and labor productivity by 2.4%, but the growth rate of employment is only 0.85%. Hence, ERDF funds seem more effective in boosting the production side than the labor market side of the average European region.

The expansionary effects of ERDF grants are, however, temporary and after three years little remains of the initial expansion. For example, 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

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.

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 but, 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 this dynamic pattern 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, increases 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 investments, which comes over and above the level firms would have undertaken without the public support, may generate an indirect positive effect, explaining why output and employment multipliers are 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 the theoretical part of our analysis.

ESF funds 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 investments 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 grants equal 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. ERDF funds have an important countercyclical role, as they expand economic activity in the short run on average; but their macroeconomic effects are temporary and the medium term gains in investments and job creation are quite limited. On the other hand, ESF grants have minor production, employment, or investments effects in the short run, but have economically significant medium term effects. In fact, they boost the average growth rate of private output, investments, and productivity; they exercise a statistically significant influence on the growth rate of employment, and contribute to increase workers' compensation. Interestingly, both type of funds incentivate labor market participation, probably in expectation of higher job creation in sectors targeted by the grants.

Some robustness exercises. The results of Table 1 consider the analysis of 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 funds 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 these grants are 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 funds, the conclusions are similar. Qualitatively, there is no difference and while the impact effects of grants are negligible, their medium term effects are statistically significant and economically important. Quantitatively, the average medium-term effects on production, job creation, and investments are enhanced and an increase of ESF grants equal to one percent of regional GVA, in response to an innovation in ESF funds, produces a cumulative GVA multiplier of 6.4%, employment multiplier of 1.9%, and investments multiplier of 8.4% at the three years horizon.

Second, 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 funds on GVA, employment, and labor productivity change: they become smaller on impact, but turn 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 could drive the differences.

The qualitative features of ESF grants are instead unchanged, but as with ERDF funds, 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 investments 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 with ESF grants more appropriate, as the latter are available only from that date. While the sample is short, and the uncertainty around point

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.

estimates larger, the bottom panel of Table 2 indicates that the medium term reversal noted in the full sample, is altered if only the last three budget cycles are considered. For example, private GVA, employment and investments growth multipliers at the three years horizon are all positive and larger than those at the one year horizon. This turns out to be due to the fact that the peak multiplier is shifted at year two, which seems to indicate that 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:

$$c^Y_{i,h} \approx (Y/E)_i c^E_{i,h} \tag{3}$$

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, (3) 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, (3) is constructed assuming that capital is constant over the adjustment path, while Tables 1 and 2, demonstrate that unexpected changes in EU funds accrued to the average region produce 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 generally 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 education and economic transformation, they are fundamentally different from the types of government expenditure analyzed using 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. As already mentioned, 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 present in the existing US studies.

Spillovers The estimates reported in Tables 1 and 2 are likely to provide only a lower bound to the effects of EU funds, since they disregard spillovers in regional economic activity. For example, firms taking advantage of ERDF funds may employ workers living in neighboring regions, and ESF grants 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 total 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 to simplify the computation. First, because of language barriers and of institutional constraints, labor mobility is typically restricted to national markets. Second, 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 a 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 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

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.

average regional effects. On the other hand, the cumulative three years multipliers of ESF grants 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 multipliers at the three years horizon are 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.

5 A closer look at the heterogeneity of the estimates

Table 2 implicitly suggests that there are important heterogenities in the dynamics induced by EU funds across regions. Standard clustering however, does not necessarily reduce the economic importance of heterogeneities. For example, at the three years horizon, and for ERDF funds in Euro area regions, the interquartile range of cumulative GVA multipliers is [-2,5] and of 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; but non-normal differences exist across regions. The task of this section is to explore in more detail, 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 4 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.

Table 4: 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

Location is important when evaluating the macroeconomic success of ERDF funds. 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 on average. 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 funds. 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 to explain the heterogeneity of macroeconomic effects of the funds. For instance, for ERDF funds, the GVA and employment cumulative 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 grants, 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 funds have similar dynamic effects.

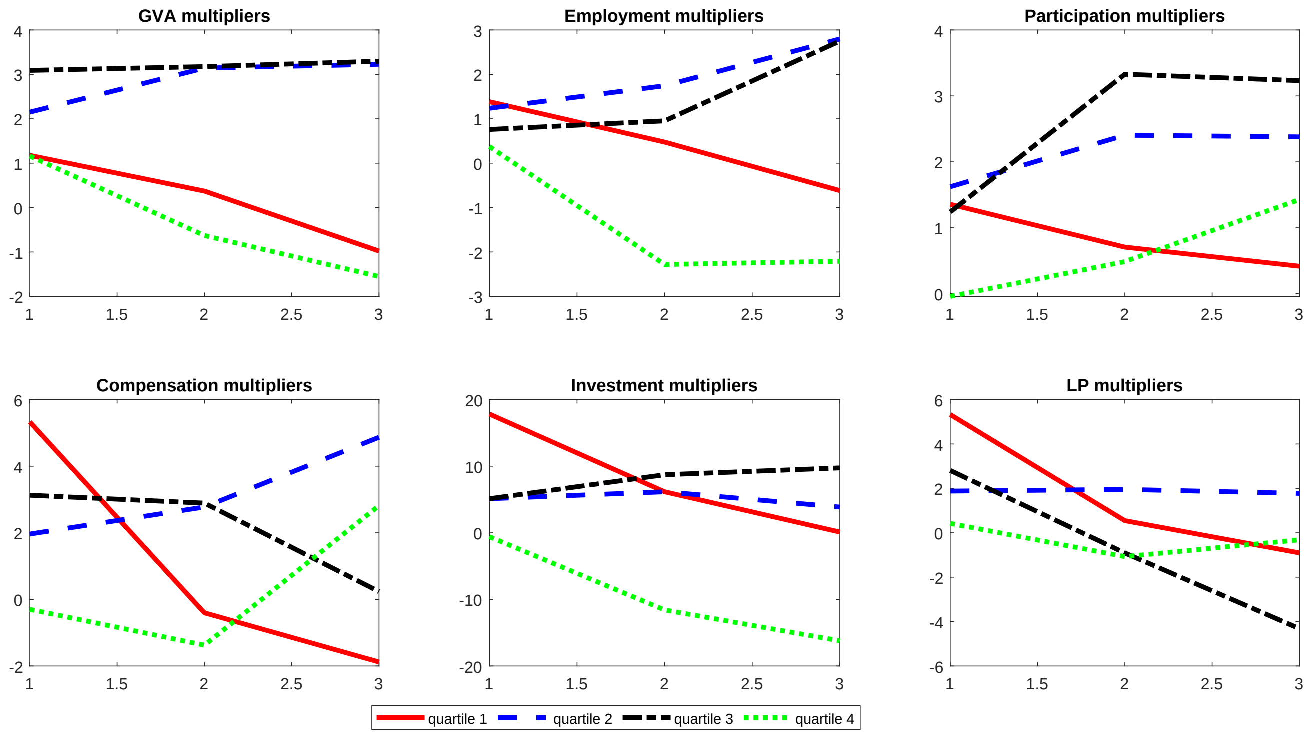
Income quartile groupings. The regional distribution of economic development may also shape multipliers dynamics. Poor regions, for example, may be unable to take full advantage of the funds because they lack local entrepreneurship; they may not have enough local funding; or the effects in terms of private 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 the multipliers estimates, even factoring in the fact that poorer regions receive larger amounts of per-capita funds.

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

Acco4ding to Figure 2, regions in the central portion of the income distribution benefit most from ERDF funds: 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 funds 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.

Hence, over the adjustment path, income and labor market differences among regions in the top

Figure 2: Cumulative multipliers by quartiles, ERDF funds

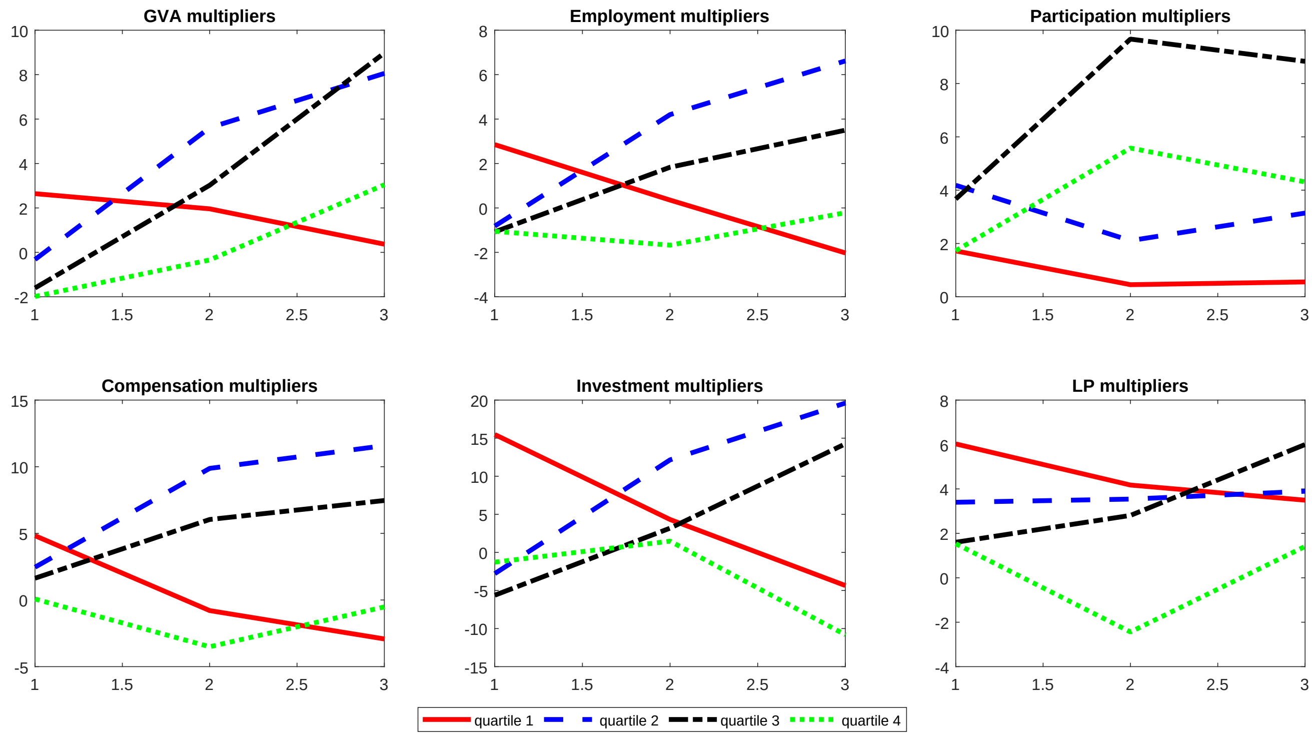


three quartiles of the income distribution tend to narrow, but those between these regions and those in the first quartile tend to increase. These medium term adjustments are consistent with the long run polarization of income per-capita in EU regions estimated in Canova [2004], where the poor remain poor, and the rest of the regions converge toward a high standard of living. They also suggest that ERDF funds may lead to increased long run regional inequalities, unless they are combined with measures that persistently revamp the economy of poorest regions.

For ESF funds, quartile differences are also evident in Figures 3. 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 investments 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 funds. Thus, ESF funds also tend 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

Figure 3: Cumulative multipliers by quartiles, ESF funds

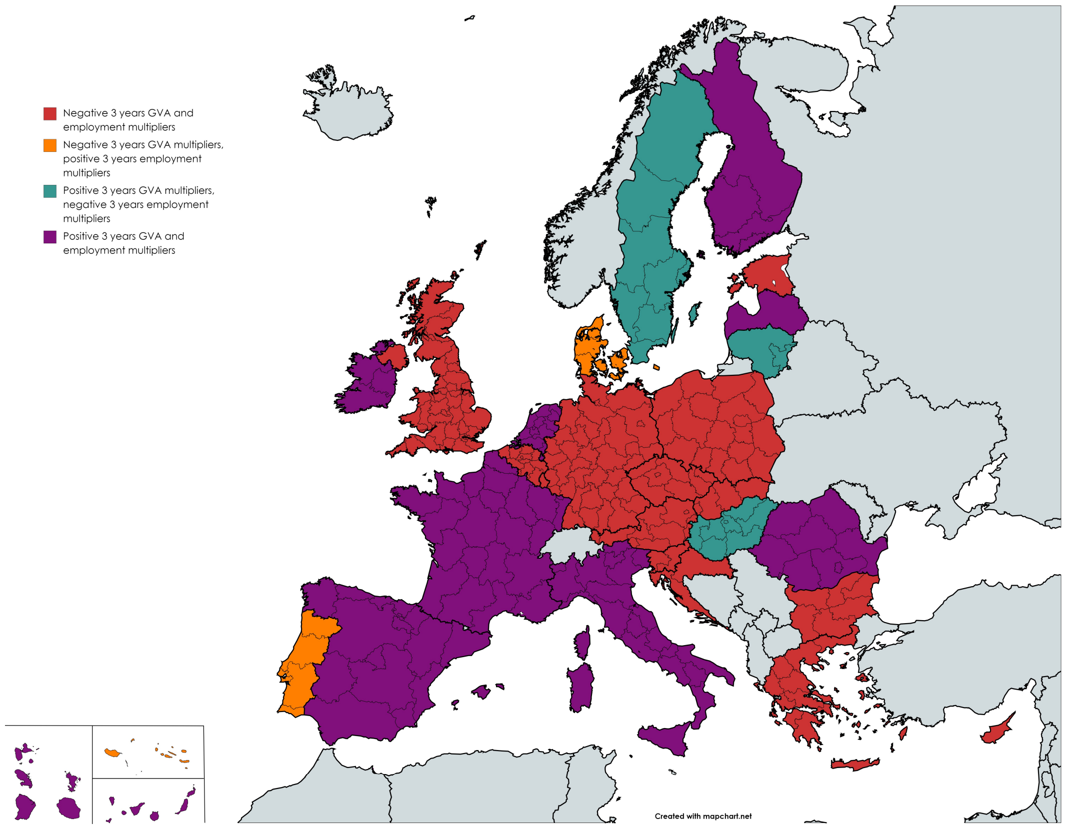


regions this way. If, say, labor markets institutions matter, regions of a country should respond more homogeneously to the fiscal stimulus, as far as GVA and employment multipliers are concerned, and country specific labor market outcomes should explain differences in national dynamics.

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.

For ERDF grants in Figure 4, 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 regions (Greece, Cyprus, Estonia, and Bulgaria), ERDF grants have negative medium term effects primarily in the central regions of the EU.

Figure 4: ERDF funds

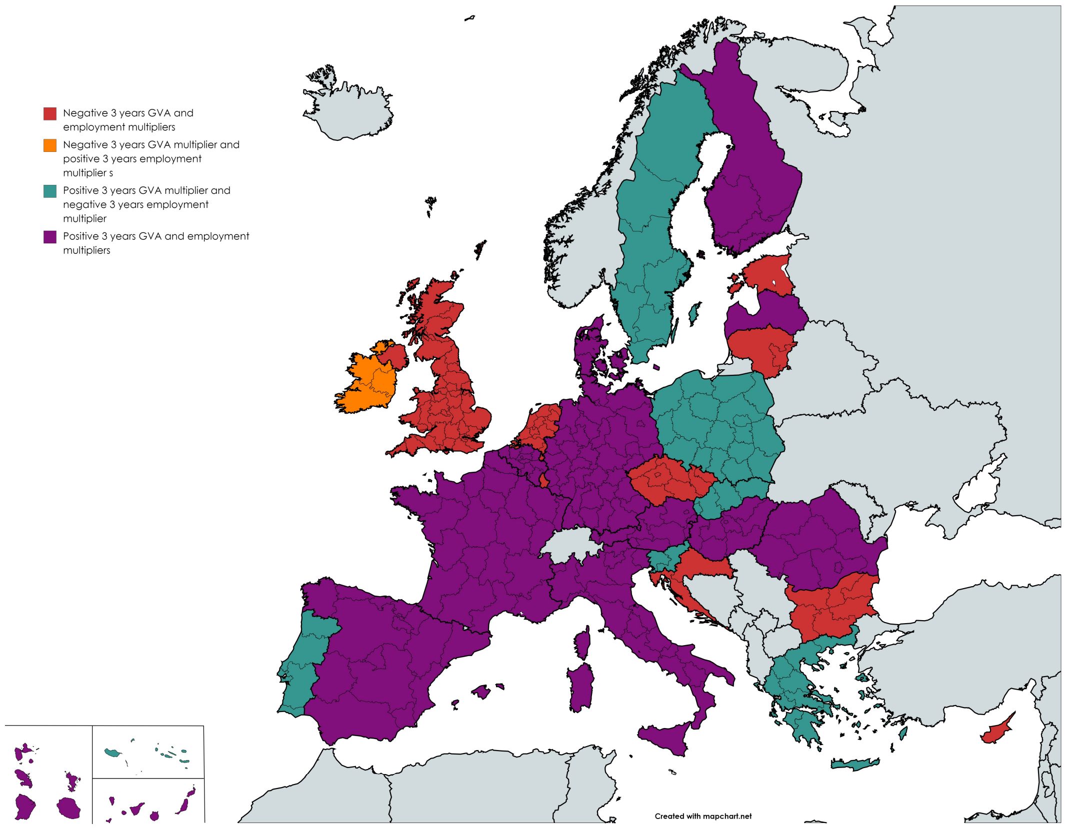


For ESF grants, the number of countries displaying positive and significant average cumulative medium term GVA and employment multipliers increases (Austria, Hungary, Germany and Denmark join the club of winners) and the group of countries where both cumulative three years multipliers are negative is reduced to the UK, Czech Republic, Croatia, Lithuania, Luxembourg, The Netherland, and Bulgaria.

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 funds create jobs, increase private sector 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 provides grants that combine features of ERDF and ESF funds, 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 grants benefit 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

Figure 5: ESF funds



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 the 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 the NGEU grants are moderate, and those in terms of employment are small. In the past, job creation, in particular, in response to ERDF grants, 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 funds. 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 There are four important stylized facts our empirical investigation has uncovered. First, the two types of funds may serve different purposes: while ERDF grants seem useful for short run stabilization purposes, ESF grants are better suited to foster medium term objectives.

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

Third, there is evidence of a considerable heterogeneity in regional dynamic responses 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 advantages of the externalities the funds provide and tend to lag behind the others in terms of recovery and transformation.

Given that NGEU funds combine features of both ERDF and ESF funds, they have a good probability of success on average. Thus, one can be moderately optimistic that they will be effective countercyclical tools in the pandemic and useful medium term instruments to foster economic transformation in the regional economies. The current downturn could be contrasted by an appropriate combination of grants and loans, as long as they 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, our analysis considers the effects of structural funds, which are basically grants from the EU government 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, there is a risk that a portion of the funding will remain unused as the planning time is limited and a careful cost-benefit analysis is needed to decide among alternatives.

6 Interpreting the dynamics

This section uses a dynamic stochastic general equilibrium model to understand the propagation mechanism of unexpected changes in EU funds in the regional economies, and to identify the structural parameters that may account for the heterogeneities 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, as these require a home production sector, and labor market frictions, even though in EU they are probably relevant.

The basic features of the monetary union model are similar to many frameworks in the the New Open Economy Macroeconomics (NOEM) 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 from the literature 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 government spending in R&D and education, rather than federal government consumption, infrastructure investment, or military expenditure. Short run nominal rigidities allow us to capture demand driven effects of increases in the fiscal absorption and endogenous growth through R&D and human capital investments allow government expenditure disturbances to have important supply side effects.

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

Agents have access to a complete financial market, where they can trade state-contingent nominal bonds. Using a single uncontingent union wide bond does not change any of the conclusions we reach. A central bank sets the union wide interest rate as a function of aggregate variables. Tax collection occurs at the local level; for simplicity there is no local government spending and the proceeds of the tax collection are transferred to the federal government, which uses the funds for consumption purposes, R&D, or human capital expenditures. The fiscal setup we employ mimics the fact that countries have historically provided the funds for the EU budget, and these funds are used for productive and non-productive purposes in the regional economies.

Households derive utility according to the function:

$$E_0 \sum \beta^t \frac{(C_t(1 - L_t - M_t)^{\chi})^{1-\sigma}}{1-\sigma} \tag{4}$$

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

Households own physical, R&D, and human capital, and choose how much to invest in each type and their utilization rate. The laws of motion of the three types of capitals are:

$$K_{t+1} = (1 - \delta_{K,t}(u_{K,t}))K_t + \Phi_K\left(\frac{I_t}{K_t}\right)K_t \tag{5}$$

$$D_{t+1} = (1 - \delta_{D,t}(u_{D,t}))D_t + \Phi_D\left(\frac{S_t}{D_t}\right)D_t \tag{6}$$

$$H_{t+1} = (1 - \delta_{H,t}(u_{H,t}))H_t + \Theta(H_t M_t)^{\vartheta}(\bar{H}_t \gamma_t^{HK})^{(1-\vartheta)} \tag{7}$$

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; δ_j is depreciation which is a function of the utilization rate of the capital stock. We specify $\delta_{j,t} = \delta_{j,t} u_{j,t}^{\xi_j}$, $j = K, D, H$, where ξ_j is a parameter controlling the concavity of the depreciation function. $\Phi(\cdot)$ is a non-negative concave function, which we specify as in Jermann [1998].

$$\Phi_K\left(\frac{I_t}{K_t}\right) = \varphi_{K,1} + \frac{\varphi_{K,2}}{1-\frac{1}{\psi_K}}\left(\frac{I_t}{K_t}\right)^{1-\frac{1}{\psi_K}} \tag{8}$$

$$\Phi_D\left(\frac{S_t}{D_t}\right) = \varphi_{D,1} + \frac{\varphi_{D,2}}{1-\frac{1}{\psi_D}}\left(\frac{S_t}{D_t}\right)^{1-\frac{1}{\psi_D}} \tag{9}$$

where $\varphi_{j,l}$, $j = 1, 2$ and and ψ_j, $j = K, D$ 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 the adjustment costs, the shadow prices of physical and R&D capital are time varying.

The second term on the right hand side of (7) is the quantity of "new" human capital produced at t. It consists of four terms: Θ is a productivity parameter; $H_t M_t$ is effective human capital at t; $\bar{H}_t$ is the aggregate stock of human capital and $\gamma_t^{HK} = \tilde{G}_t^{HK}/\tilde{G}_{t-1}^{HK}$ is the gross growth rate of the federal expenditure in human capital where $\tilde{G}_t^{HK}$ is measured in per-human 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 government expenditure in human capital, γ_t^{HK}, for human capital production.

Households purchase consumption and investment goods, and state contingent bonds. The expenditure is financed with after-tax labor income, capital and R&D income, profits and bond income. The household maximization problem is subject to the constraint:

$$C_t + I_t + T_t + S_t + E_t \pi_{t+1} \Lambda_{t,t+1} B_{t+1} = (1-\tau_t) w_t H_t L_t + r_{K,t} u_{K,t} K_t + r_{D,t} u_{D,t} D_t + B_t + \Xi_t \qquad (10)$$

where B_{t+1} are the holdings of the state contingent nominal bonds paying one unit of currency in period $t+1$ if a specified state is realized, $\Lambda_{t;t+1}$ is the period$-t$ real price of these bonds, and π_t the inflation rate, w_t is the real wage rate, $r_{K,t}$, $r_{D,t}$ are the rental rates of effective capital and R&D services, τ_t is a labor income tax and T_t is a lump-sum tax/transfer; finally Ξ_t is profit income from the monopolistic competitive domestic firms.

The consumption basket C_t consists of domestically produced and imported goods. Let C_{ht} be the composite of domestically produced goods, and C_{ft} the composite of imported goods. Then:

$$C_t = \left[\varphi_h^{\frac{1}{\eta}} C_{ht}^{\frac{\eta-1}{\eta}} + \varphi_f^{\frac{1}{\eta}} C_{ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad (11)$$

where $\eta > 0$ is the intraregional elasticity of substitution; $0 < \varphi_h, \varphi_f < 1$ with $\varphi_H + \varphi_f = 1$, capture preferences for domestic versus foreign goods. When $\varphi_h > n$, preferences display home bias. We assume that I_t, S_t are also composite goods and aggregate the physical and R&D investment goods produced in the union with a function analogous to (11).

Letting P_{ht} be the price index of domestically produced goods, and P_{ft} the price index of imported goods, the home price level P_t is:

$$P_t = \left[\varphi_h P_{ht}^{1-\eta} + \varphi_f P_{ft}^{1-\eta} \right]^{\frac{1}{1-\eta}} \qquad (12)$$

We assume that firms set prices in the sellers' local currency and the law-of-one-price holds. Thus, the cost of imported goods in the home consumption basket is the price charged by foreign exporting firms, given that the exchange rate is fixed.

Firms The final home good Y_t is produced from intermediate inputs $Y_t(j)$ using the technology:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad (13)$$

where ε is the elasticity of substitution of intermediate goods. The zero-profit condition implies:

$$P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}} \tag{14}$$

There is a continuum of intermediate firms producing differentiated goods on the $[0,1]$ interval. Firm j production function is $Y_t(j) = f(u_{k,t}, K_t(j), Z_t(j), u_{H,t}, H_t(j), L_t(j))$ where $(u_{H,t}H_t(j)L_t(j))$ is effective labor input,$(u_{K,t}K_t(j))$ effective capital input and $Z_t(j)$ is technological progress, which depends on individual firm's j and aggregate R&D and on human capital expenditure decisions.

Intermediate firms are price takers in the input market and monopolistic competitors in the product markets. They set their price $P_t(j)$ facing quadratic adjustment costs as in Rotemberg [1982]. The optimization problem for domestic firms is:

$$max E_t \sum_{l=0}^{\infty} \Lambda_{t,t+l} \Xi_{t+l}(j), \tag{15}$$

with

$$\Xi_t(j) = \left(\frac{P_{ht}(j)}{P_{ht}} - \frac{MC_{jt}}{P_t} \frac{P_t}{P_{ht}} \right) Y_t(j) - \frac{\Psi_P}{2} \left(\frac{P_{ht}(j)}{\pi_H P_{ht-1}(j)} - 1 \right)^2 Y_t \tag{16}$$

subject to

$$Y_t(j) = \left(\frac{P_{ht}(j)}{P_{ht}} \right)^{-\varepsilon} Y_t \tag{17}$$

where $P_{ht}(j)$ is the price of the intermediate input, and MC_{jt} are nominal marginal costs. Since firms are owned by the households, they discount future profits $\Xi_{t+l}(j)$ using the discount factor $\Lambda_{t,t+l}$ of the households that own the firms.

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 its expenditure. A part of federal spending is for (unproductive) consumption purposes and another for R&D and human capital. Thus, $G_{mt} = (G_t^C) + G_t^{RD}(1 + \epsilon_{RD,t}) + G_t^{HK}(1 + \epsilon_{HK,t}))$ where $\epsilon_{it},\ i = RD, HK$ are zero mean AR(1) processes. G_{mt} is per-capita spending in region $m = h, f$, and total spending in the home region is nG_{ht}. Federal spending for government consumption, (G_t^C) is half of total spending and is treated as a waste. We assume that the government demands differentiated products produced in each region and the demand takes the same CES form as private demand.

Our assumption of perfect financial markets implies that any risk associated with variation in lump-sum taxes across regions is undone through risk sharing. Ricardian equivalence holds in our model. The federal budget is balanced by varying local lump sum taxes.

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

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\vartheta_R} \left(\frac{\pi_t^u}{\pi}\right)^{\vartheta_\pi} \tag{18}$$

where $\pi_t^u = n\pi_{ht} + (1-n)\pi_{ft}$, is the aggregate CPI inflation rate at time t; π_{mt} are domestic and foreign CPI inflation rates, $m = h, f$ R and π are, respectively, the steady state nominal rate and the steady state inflation rate, while $\vartheta_R, \vartheta_\pi$ are parameters.

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

$$\frac{u_c(C_t^*, L_t^*, M_T^*)}{u_c(C_t, L_t, M_t)} = \left(\frac{C_t^*(1-L_t^*-M_t^*)^\chi}{C_t(1-L_t-M_t)^\chi}\right)^{-\sigma} \left(\frac{(1-L_t^*-M_t^*)}{(1-L_t-M_t)}\right)^{\chi} = \varpi_0 \varsigma_t \tag{19}$$

where ϖ_0=1, so that, initially, the representative households in the two regions have equal amounts of wealth; $\varsigma_t = \frac{P_t^*}{P_t}$ is the real exchange rate; and variables with 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 Optimal pricing implies a symmetric equilibrium, such that for all j, and all variables $X_t(j)$, $X_t(j) = X_t$. We assume that contingent bonds are in net zero supply, so that $B_t = 0$. Finally, the resource constraint for the home economy is

$$Y_{ht} = nC_{ht} + (1-n)C_{ht}^* + nI_{ht} + (1-n)I_{ht}^* + nS_{ht} + (1-n)S_{ht}^* + nG_{ht} + n\frac{\Psi_P}{2}\left(\frac{\pi_{ht}}{\pi_h} - 1\right)^2 nY_t, \tag{20}$$

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

6.1 R&D expenditure shocks

To mimic the effects of unexpected increases in ERDF funds, we examine the dynamics induced by federal R&D expenditure disturbances, setting human capital accumulation to zero and dropping human capital and education choices from the optimization problem. Thus, $H_t = \bar{H}_t = 1, u_{H,t} = 1, M_t = 0,\ \forall t$ and we specify the production function for intermediate firm j to be:

$$Y_t(j) = (u_{K,t}(j)K_t(j))^\alpha \left(Z_t(j)L_t(j)\right)^{1-\alpha} \tag{21}$$

where α is the capital share and:

$$Z_t(j) = (\gamma_t^{HD})^{\mu_{RD}}(u_{D,t}(j)D_t(j))^\zeta(\bar{u}_{D,t}\bar{D}_t)^{1-\zeta} \tag{22}$$

where $\gamma_t^{HD} = \frac{\tilde{G}_t^{HD}}{\tilde{G}_{t-1}^{HD}}$, μ_{RD} is a productivity parameter and ζ is an externality parameter.

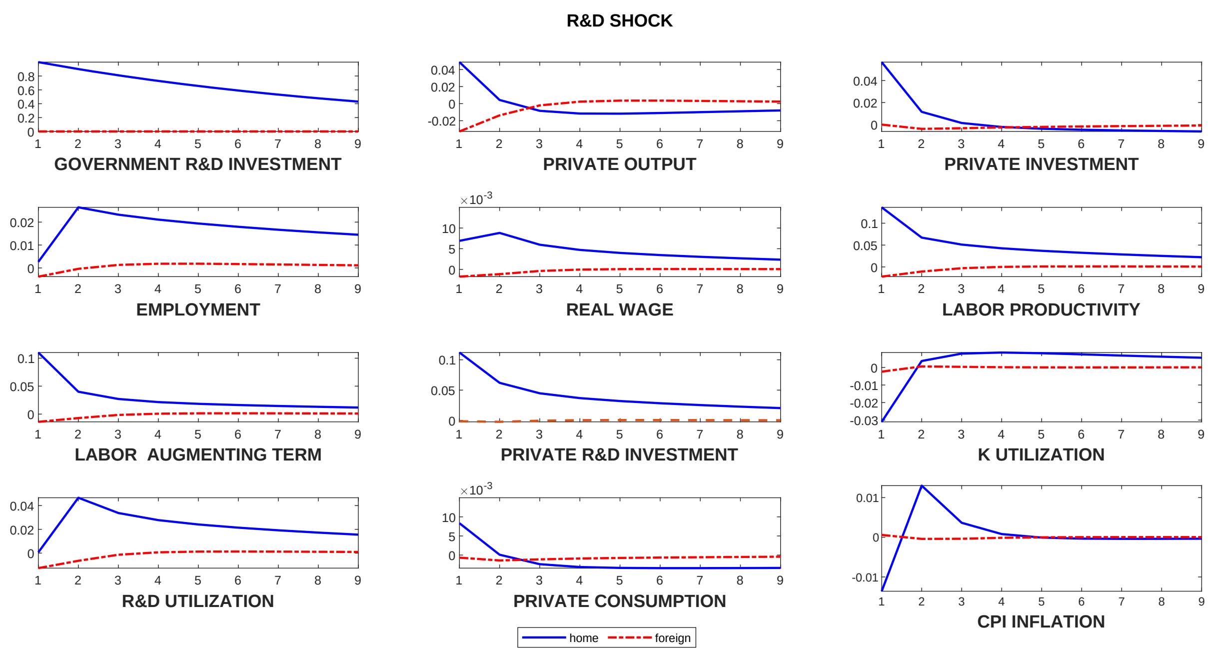
Firm j labor productivity has an endogenous component that depends on the amount of effective R&D services rented by the individual firm, $u_{D,t}(j)D_t(j)$, and on the aggregate level of effective R&D services, $\bar{u}_{D,t}\bar{D}_t$. The fact that productivity depends on the utilized aggregate stock of 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 firm j productivity. The exogenous component of labor productivity depends on the growth rate of federal R&D expenditure. $\tilde{G}_t^{RD}$ is exogenous to firm j decisions. When μ_{RD}=0, federal government R&D activities are ineffective in enhancing $Z_t(j)$. In this case, government R&D expenditure has no productive use and its effects are similar to those of wasteful government consumption expenditure. The specification for $Z_t(j)$ 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 is needed to enhance labor productivity.

Parameterization. For the baseline scenario, we use standard values for the parameters. We select $\beta = 0.992^4; \sigma = 2, \chi = 4, \tau = 0.25, \phi_{k,2} = 1.65, \phi_{d,2} = 1.58$ (the last two are taken from Bonciani and Oh [2020] and adjusted to our annual calibration), $\delta_{k,ss} = 0.08, \delta_{RD,ss} = 0.08, \psi_h = 0.5, \eta = 6, n = 0.2, \epsilon = 10, \Psi_p = 10, \vartheta_R = 0.9, \vartheta_\pi = 1.5, \alpha = 0.3, \zeta = 0.65$ (which we take from Kung [2015]), $\mu_{RD} = 0.1$ and $\rho_{RD} = 0.65$. 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. These choices imply, that the real interest rate is about four percent a year, the government R&D investment is mildly productive, that price stickiness is low, that the substitution between domestic and foreign goods or between intermediate goods is sufficiently high, that there is some home bias, and that R&D shocks are fairly persistent. Because the model features growth, we solve it scaling trending variables (private output, consumption, investment and government expenditure) by the stock of R&D in the economy.

The outcomes. Figure 6 plots the responses of selected variables after an impulse in government R&D expenditure. In response to the R&D spending shock, private output, employment, investments in physical and R&D capital, and the real wage instantaneously increase as does labor productivity. The increase in government spending is also accompanied by an increase in the labor augmenting term Z_t and in the utilization of physical and R&D capital, to take advantage of the labor productivity increase. Although output is demand determined, the supply side effects of the expenditure shock is 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 this increases the real wage; there is a downward pressures on marginal costs, which counteracts the increase in demand, and leads to an instantaneous fall of CPI inflation.

The pattern of instantaneous responses in Figure 6 differs from those generated by spending shocks in a standard, closed economy, New Keynesian model. 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 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 unproductive government consumption give rise to the positive instantaneous comovements we observe in the data.

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



There are a couple of reasons that make the responses here different. First, the shock we consider has positive effects on labor productivity. Thus, besides demand, it also has supply effects. Second, the supply effects are non-negligible because government spending shocks affect the accumulation of both physical and R&D capital. 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 and long term consequences, as they positively affect the production possibility frontier of the economy. Thus, in our economy, the same shock drives cyclical and medium term dynamics; and standard trend and cycle decompositions are inappropriate, see also Canova [2020b].

The instantaneous responses are also different from those generated by government investment in physical capital, when no externalities occur. Here, increases in government spending have 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]. These three forces generally increase real wages and employment (although much less so) on impact, while investments and output increase with a lag. Morevover, the effect of the shock is spread out on a number of years as capital accumulation increases.

In our setup the externality from the aggregate shock of R&D tends to amplify the effect of the government spending shock. Moreover, the enhancement of productivity factors implies that investments and output will increase on impact. On the other hand, the drag that the growth rate of government R&D spending exercises on labor productivity implies much less persistent effects than otherwise.

As the consequences of the shock unfold over time, 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 Z_t compensates for the increase in the stock of two types of capital. Employment declines 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 is humped shaped with a maximum two years after the shock. 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 (see Table 5).

Table 5 presents the multpliers obtained in our theoretical exercise. 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 baseline parameterization produces impact output and investments multipliers which are about 3/4 of the average GVA multipliers found in the data, while the impact hours multipliers are roughly matched.

Heterogeneities. Given the widespread data heterogeneities, we examine whether different parameterizations of the model can account for the different multiplier patterns presented in Table 2 and for the spillovers documented in Table 3.

The main differences between Tables 1 and 2 is that in some groups of regions the initial boost to

Table 5: Cumulative multipliers, Theory

	R&D Shocks								
	Baseline		**Lagged spending**			**Alternative**		**Large size**	
Horizon	1 year	3 years	1 years	2 years	3 year	1 years	3 years	1 year	3 years
GVA	1.59	0.82	0.57	1.21	0.96	0.28	0.90	3.12	1.66
Employment	0.91	0.91	0.86	0.91	0.92	0.73	0.73	1.57	1.27
Compensation	0.50	0.34	0.36	0.45	0.39	0.43	0.59	0.75	0.47
Investments	3.56	1.93	1.45	2.75	2.20	0.94	2.40	4.29	2.34
Labor productivity	1.35	0.74	0.60	1.06	0.84	0.52	0.99	1.92	1.0.5
	Human Capital Shocks								
	Baseline		**Higher depreciation**			**Higher adj.costs**		**Lower G productivity**	
Horizon	1 year	3 years	1 year	2 years	3 year2	1 years	3 years	1 year	3 years
GVA	-0.15	0.59	-0.23		0.78	-0.16	0.44	-0.53	0.54
Employment	-0.10	2.33	-0.47		2.92	-0.07	2.33	-0.94	2.14
Compensation	0.12	-1.81	0.24		-2.42	0.08	-1.88	0.64	-1.74
Investments	-0.16	0.95	-0.08		1.21	0.20	-1.64	-1.93	0.78
Labor productivity	0.98	-0.81	1.28		-1.30	0.94	-0.97	1.51	-0.70

For R&D shocks, in the "lagged spending" case, the growth rate of government R&D enters the production function with a lag; in the "alternative case" the lagged level of government R&D spending enters the production function; in the "large size" case $n = 0.3$. For human capital shocks, in the "higher depreciation" case, $\delta_H = 0.10$; in the "higher adjustment costs" case, $\psi_k = 7.5$; in the "lower G productivity", $\vartheta = 0.25$.

economic activity remains in the medium term and that, after 2000, the instantaneous effect is muted and the peak response happens after two years. Table 5 shows that these patterns are consistent with two alternative parameterization of the government R&D term in $Z_t(j)$. 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 average EU region following ERDF shocks after 2000. With this parameterization the demand effects of the shock occur instantaneously while the supply effects begin one period after and this asyncronicity gives rise to the hump in the multipliers. Note, as we have already mentioned, that the supply effect on private output is at least as large as the demand effect.

To generate more persistent effects of government R&D shocks, one has at least two options. The first is to assume that the labor productivity term is

$$Z_t(j) = (G_{t-1}^{RD})^{\mu_{RD}} (u_{D,t}(j) D_t(j))^{\zeta} (\bar{u}_{D,t} \bar{D}_t)^{1-\zeta} \tag{23}$$

which is what we report in the third column block of Table 5. Here there is asyncronicity in the timing of demand and supply effects, as in the previous case. However, 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 at the three years horizon are larger than those at the one year horizon. There is however an alternative parameterization that produces a similar pattern of multipliers. Here the level of government spending enter contemporaneously $Z_t(j)$. However, both price stickiness Ψ_p and the productivity of government R&D investment μ_{RD} are increased. With these selections, the initial effect becomes smaller, because the supply effects are muted as output is "more" demand determined. However, the higher productivity of government spending implies larger and more persistent medium term supply effects. Thus, also in this case, the cumulative medium term multipliers of all five variables are larger than the impact multipliers.

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 increasing the size of the region n should approximately produce the effect we care about. Indeed, Table 5 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.

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 account for the spillovers we observe in the regional EU data.

6.2 Human capital expenditure shocks

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

$$Y_t(j) = \left(u_{K,t}(j)K_t(j)\right)^{\alpha} \left(u_{H,t}H_t(j)L_t(j)\right)^{1-a} \tag{24}$$

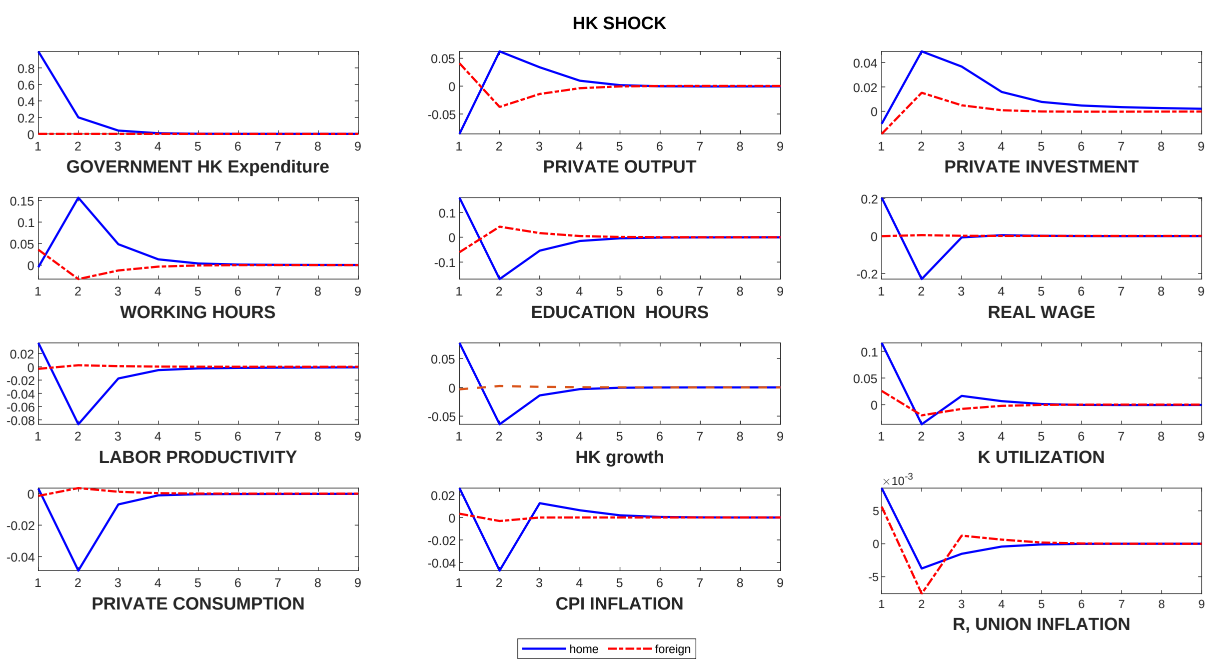
where $(u_{K,t}(j)K_t(j))$ are effective capital services and $(u_{H,t}H_t(j)L_t(j))$ effective labor services. Thus, government spending in human capital does not directly effect the production possibility frontier of the regional economy. Instead, it alters the accumulation of individual human capital. As a result, while government R&D expenditure shocks resemble TFP improvements, government human capital expenditure shocks alters the law of motion of a state variable as would an investment shock in a standard capital accumulation equation.

Parameterization. The version of the model with human capital expenditure, features three new free parameters that need to be selected. Evidence from Jones et al. [2005] and Dinerstein et al. [2020] suggests annual depreciation values for human capital of teachers is between 4 and 6 percent. We set $\delta_H = 0.08$, to capture the idea that the type of human capital that was produced a decade ago is of little use today because of technological changes. 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 $\vartheta = 0.15$. Finally, the persistence of government spending on human capital ρ_{HK}, is set to 0.2, to mimic the fact that EU reeducation programs last one or two years at most. All other parameters are set to the values mentioned in the previous subsection.

The outcomes Figure 7 plots the responses of the variables of the model to an impulse to government human capital expenditure. On impact, working hours, investments and private output fall and education hours increase, as does the real wage and labor productivity. Thus, the increase in government human capital spending induces households to shift time away from work towards education; this tightens the labor market and decreases production. The fall in production is attenuated because both physical and human capitals are used more intensively and this counteracts the fall in working hours. The increase in labor costs pushes inflation upwards.

Since the government spending is temporary, the initial boost in education hours is reversed and, because of the higher productivity of labor, working hours, investments and private output 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 government spending together with the quick reversal of the training hours increases makes human capital growth negative from the second period on. Note also that capital and human capital utilization are above their steady state values for a number of years.

Figure 7: Dynamics following HK Shocks



The pattern of responses displayed in Figure 7 is qualitatively similar to the one produced by temporary negative labor supply shocks, where initially agents take more leisure and later work more productively. The twist here is that the externality of public expenditure in education affects the accumulation of human capital and, hence, induces a persistent effect in macroeconomic variables, regardless of the persistence of government spending.

The parameterization we employ accounts for a couple of important qualitative stylized facts present in the data: (i) the initial effect on private output, investments, and hours is negative; (ii) the effect at the three years horizon on these three variables is positive. Given the rudimentary specification for the labor market we use, we are unable to generate a persistent increases in compensation or a positive medium term effect on labor productivity.

To generate qualitative responses for these two variables that look like those in the data, we need 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 skill and receive a wage premium in exchange. When skilled workers leave the labor market for training, the average wage in the economy increases. When they return to their working activities, they command a higher wage (making compensations persistently increase) and have higher marginal product and this should generate an increase in labor productivity in the medium term. We do not pursue such an extension as the scope of the current section is to explain the pattern of GVA, investments, and employment multipliers uncovered in data.

Quantitatively, the model falls short of generating the medium term boom we see in the data. For example, at the three years horizon the model cumulative multipliers are at most one third than those in the data (see second panel of Table 7). While the current model can generate larger medium term multipliers if human capital depreciation in the steady state is faster than what we have assumed (see column 2 of Table 7) and the demand effect of the shock is larger (see column 3 of Table 7), higher and more persistent medium term multipliers can occur only if there is a secondary boost to investment that spreads the positive hump for a number of periods. We conjecture that to produce such a secondary effect physical and effective human capital must be complement (as suggested by Krusell et al. [2000]) or that government expenditure beside affecting human capital accumulation directly triggers TFP changes, much in the same spirit as R&D expenditure.

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 high steady state depreciation of human capital. Without it, the impact effects of hours and private output become positive and the medium term effects are muted. On the other hand, as shown in column 2of Table 7, with higher steady state depreciation rate, hours and GVA multipliers become larger at all horizons in absolute value and investments multipliers grow at all horizons, as the economy builds up a larger stock of physical capital to smooth consumption over time. Second, variable human capital utilization must be procyclical and this can happen only if human capital depreciates slower the more it is utilized. The intuition is simple: when human capital is not sufficiently used, it depreciates faster as people tend to forget the skills they acquired. On the opposite, the more extensively human capital is used, the smaller will be its depreciation along the adjustment path. Without this feature, it is impossible to get a reversal in investments and private output after the initial negative impact, as the economy does not take advantage of the boost to human capital accumulation government expenditure produces to build up physical capital. Third, we need a sufficiently high productivity of government expenditure in human capital to produce the results we see in the data. If this is not the case, the initial negative impact on private output, hours and investments becomes larger and the whole term structure of multipliers at longer horizons is muted (see fourth column of Table 7) Fourth, we need physical capital to be easily adjustable in response to the shocks. Otherwise, as shown in column 3 of Table 7, the profile of investment multipliers changes shape and this makes medium term private output multipliers smaller.

In sum, the pattern we see in the data is consistent with the idea that federal government expenditure for human capital has both a direct 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 to have, on one hand, variable human capital utilization and high steady state human capital depreciation and, on the other, low adjustment costs of physical capital. The productivity of government spending in the human capital accumulation is also important and differential regional values may account for some of the heterogeneities found in the data.

7 Conclusions

This paper provides empirical evidence on the dynamic effects of two 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 the historical evidence we uncovered to evaluate the likely consequences of the planned fiscal expansion on the regional economies of the EU.

We focus attention on 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.

ERDF innovations have statistically significant and economically relevant average 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, in many regions, almost entirely within three years. ESF innovations, instead, have negative consequences on impact but exercise a positive average 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 speaking the two programs produce average cumulative regional multipliers with quite different magnitudes. Thus, if employment, production, and investments growth are the yardstick to measure the success of the 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 in the past have led to increased polarization and regional inequality. If minimization of the distortions to regional inequality is important to policymakers, the ESF program is preferable, as it benefits a larger number of regions in a number of EU countries.

To interpret the dynamics we uncovered and to give a structural explanation to the mechanism generated by the funds, we extended a standard workhorse New Keynesian DSGE model of a monetary union to allow for endogenous growth. We do this through two separate channels: R&D and human capital accumulation. ERDF grants, which we model as shocks affecting private R&D, 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 grants, which we model as shocks affecting human capital accumulation, by altering the labor/leisure/schooling margin, cause a temporary drop of economic activity but a significant boost in the medium term, because they improve the productivity of effective labor.

What did we learn from the exercise that can be useful to predict the macroeconomic effects of NGEU funds? 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 seems 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 the effects of EU funds is far from uniform, benefiting some regions much 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 detail what has made a difference would be instructive to avoid repeating errors made in the past.

In general, administrative and structural reforms, efficiency checks and, perhaps, generational changes may help to make the gains more uniform across EU regions.

References

Alan Auerbach, Yuriy Gorodnichenko, and Daniel Murphy. Local fiscal multipliers and fiscal spillovers in the united states. *IMF Economic Review*, 68:195–229, 2020. 1, 4

Sascha O. Becker, Peter H. Egger, and Maximilian von Ehrlich. Absorptive capacity and the growth and investment effects of regional transfers: A regression discontinuity design with heterogeneous treatment effects. *American economic Journal: Economic Policy*, 5(4):29–77, 2013. 1

Gianluca Benigno and Pierpaolo Benigno. Price stability in open economies. *Review of Economic Studies*, 70(4):221–251, 2003. 6

Michele Boldrin and Fabio Canova. Inequality and convergence in europe's regions: Reconsidering european regional policies. *Economic Policy*, 13:207–253, 2001. 1

Dario Bonciani and Joonseok Oh. Uncertainty, innovation, and slow recoveries. Technical Report 802, Bank of England, 2020. 6.1

Timo Boppart and Per Krussel. Labor supply in the past, present, and future: A balanced-growth perspective. *Journal of Political Economy*, 128(1):118–157, 2020. 6

Amaranta Canova, Fabio Canova, and Evi Pappa. A dataset of european regional real per-capita structural funds. Technical report, LFM, Norwegian Business School, Universidad Carlos III., 2020. 2

Fabio Canova. Testing for converge clubs in income per-capita: a predictive density approch. *International Economic Review*, 45:49–77, 2004. 1, 1, 5

Fabio Canova. Should we trust cross sectional multiplier estimates? Technical report, CEPR, working paper 15330., 2020a. 3

Fabio Canova. Faq:how do i extract the output gap? *manuscript*, 2020b. 6.1

Fabio Canova and Evivi Pappa. Price differentials in monetary unions: the role of fiscal shocks. *Economic Journal*, 117:717–739, 2007. 1, 4

Gabriel Chodorow-Reich. Geographic cross-sectional fiscal spending multipliers: What have we learned? *American Economic Journal: Economic Policy*, 11(2):1–34, 2019. 1, 3, 4

Maria Coelho. Fiscal stimulus in a monetary union: Evidence from eurozone regions. *IMF Economic Review*, 67:573–617, 2019. 1, 3

Giancarlo Corsetti, Keith Kuester, and Gernot Muller. Fixed on flexible: Rethinking exchange rate regimes after the great recession. *IMF Economic Review*, 65(3):586–632, 2017. 6

Tatyana Deryugina. The fiscal costs of hurricanes: disaster aid versus social insurance. *American Economic Journal: Economic policy*, 9(3):168–198, 2017. 1, 4

M. Dinerstein, R. Magalokonomou, and C. Yannelis. Human capital depreciation. *CESifo Working Paper*, (8614), 2020. 6.2

Bill Dupour and Rodrigo Guerrero. Local and aggregate fiscal policy multipliers. *Journal of Monetary Economics*, 92:16–30, 2017. 1, 3, 4

Jordi Gali and Tommaso Monacelli. Optimal monetary and fiscal policy in a currency union. *Journal of International Economics*, 76(1):116–132, 2008. 6

Urban J. Jermann. Asset pricing in production economies. *Journal of Monetary Economics*, 41(2): 257–275, 1998. 6

L. Jones, R. Manuelli, and H. Siu. Fluctuations in convex models of endogenous growth, ii: Business cycle properties. *Review of Economic Dynamics*, 8:805–828, 2005. 6.2

Per Krusell, Ohanian Lee E., José-Víctor Ríos-Rull, and Gianluca. Violante. Capital- skill complementarity and inequality: A macroeconomics analysis. *Econometrica*, 68(5):1029–1053, 2000. 6.2

Howard Kung. Macroeconomic linkages between monetary policy and the term structure of interest rates. *Journal of Financial Economics*, 115:42–57, 2015. 6.1

E. M. Leeper, T. B. Walker, and S. Yang. Government investment and fiscal stimulus. *Journal of Monetary Economics*, 57(8):1000–1012, 2010. 6.1

Philip Mohl and Tobias Hagen. Do eu structural funds promote regional growth? evidence form various panel data approaches. Technical report, ZEW, Manheim, http://www.ub.edu/sea2009.com/Papers/117.pdf., 2009. 1

Emi Nakamura and Jon Steinnson. Fiscal stimulus in a monetary union: Evidence from us regions. *American Economic Review*, 103(4):753–792, 2014. 1, 3, 4, 6

Evi Pappa. Fiscal rules, policy and macroeconomic stabilization in the euro area. *ECB Sintra Forum, Paper and Proceedings*, 2021. 6.1

Paraskevi Pappa and Vanghelis Vassilatos. The unbearable tightness of being in a monetary union: Fiscal restrictions and regional stability. *European Economic Review*, 51(6):1492–1513, 2007. 6

Hashem Pesaran and Sarah Smith. Estimating long run relationships from dynamic heterogenous panels. *Journal of Econometrics*, 126:79–113, 1995. 3

Valerie Ramey. Ten years after the financial crisis: What have we learned from the renaissance in fiscal research. *Journal of Economic Perspectives*, 33:89–114, 2019. 6.1

Valerie Ramey. The macroeconomic consequences of infrastructure investments. Technical report, NBER, working paper 27625, 2020a. 6.1

Valerie Ramey. Discussion of 'what do we learn from cross-sectional empirical estimates in macroeconomics' by adam guren, alisdair mckay, emi nakamura, jon steinsson. Technical report, University of California San Diego, 2020b. 4

Valerie Ramey and Sarah Zubairy. Goverment spending multipliers in good times and in bad: Evidence from us historical data. *Journal of Political Economy*, 126:850–901, 2018. 3

Julio Rotemberg. Sticky prices in the united states. *Journal of Political Economy*, 90(6):1187–1211, 1982. 6

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 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. The ERDF fund covers over 40 percent of the total budget, the EAFRD funds over 20 percent, and ESF and CF funds 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.

The 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 the ERDF fund which is distributed according to regional characteristics, the Cohesion Fund 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.

The Cohesion Fund 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.

The 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, the 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 funds should be broadly considered investments in manufacturing and R&D; CF funds investments in infrastructures; and ESF funds 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, the 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