Evaluating Welfare Effects of Place-Based Policy Using Regional Variation in Eastern and Western Germany

Nardeen Abdulkareem *

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Abstract

This paper conducts a positive analysis of the welfare effects generated by the European Regional Development Fund (ERDF), a vital instrument for delivering place based policy in Germany. The policy implementation in Germany's 400 districts comes in the form of investments in projects which support initiatives such as small to medium sized enterprises (SMEs), research & innovation, and climate change adaptation. We find that structurally weaker districts, especially those concentrated in former Eastern Germany, exhibit stronger welfare outcomes relative to the economically stronger Western counterparts, suggesting that the fund is generally achieving its intended purpose. To extract these results, we extend existing empirical work to our German setting by implementing bleeding edge machine learning models, such as causal forests and de-biased machine learning, to estimate heterogeneous treatment effects and capture fine regional variation in outcomes. The resulting measurement of heterogeneous outcomes provides an empirical foundation for future normative analysis which work to design models which provide equitable and welfare maximizing allocation of place-based policy across space, thereby helping solve the social planner's allocation problem under a fixed budget.

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1 Executive Summary

This report investigates the role of the European Regional Development Fund (ERDF) in creating measurable improvements in economic welfare across Germany's 400 districts. The ERDF is one of the European Union's key tools for reducing regional inequality. After more than 30 years of reunification, there continue to be significant differences between former East and West Germany. These are evident in productivity, innovation, and overall economic performance. Assessing the efficacy of ERDF funding in supporting lagging regions is crucial for policymakers, due to persistent disparities. To address this, this study uses detailed ERDF project-level data (over 45,000 projects from 2014-2020) with relevant economic metrics, including but not restricted to productivity, industry structure, innovation, and population. Traditional econometrics methods are combined with novel machine-learning techniques to estimate both the mean impact of ERDF spending and its heterogeneity.

Key Findings:

- **Average effects of ERDF spending are positive but modest.** While ERDF spending yields positive average effects, the impact is modest. The effect on short-run productivity growth (GVA per capita) is consistently small, and sometimes statistically insignificant. This outcome is partially attributed to the minor scale of ERDF investment relative to the scale of the economies they target.

- **Effects become clearer when looking three years ahead.** The effects of ERDF funding become clearer with a longer time horizon. When the analysis entails three-year forward growth, the impact is larger and statistically significant. Doubling the per capita ERDF funding is estimated to boost GVA growth by approximately 0.07 percentage points. This is meaningful despite its small numerical value considering the substantial scale of regional economies.

- **The biggest gains occur in former East Germany.** Implementing machine-learning methods allows for the estimation of heterogeneous effects at the district level. This study concludes that Eastern regions accrue larger benefits from the ERDF. This finding highlights that the fund is successful in supporting places most in need as Eastern regions have historically been less developed.

- **Some strong Western regions show small or even negative gains.** Some districts in Bavaria do not exhibit positive returns from additional ERDF investment. These regions have established strong industrial and technological bases, which implies that diminishing marginal benefits may be in play.

- **Structural factors matter more than funding alone.** Pre-existing conditions, particularly manufacturing strength and innovation capacity, are the variables most strongly associated with economic growth. While the ERDF provides support, it is not able to replace the importance of strong regional foundations.

Implications for Policy: ERDF spending is found to be directionally effective, particularly in weaker regions. Its impact is limited without complementary structural policies. Closing Germany's deep economic divide requires more than just funding. A more effective approach would require policymakers to consider allocating ERDF funds based on regional absorption capacity and pairing financial assistance with policies to boost industry, innovation, and local institutions. This study's use of machine-learning techniques demonstrates a significant potential for guiding precise future allocation of resources.

2 Introduction

Despite the dispersion of hundreds of billions of euros through the European Regional Development Fund (ERDF). Persistent and substantial variation in economic outcomes exists across Europe, particularly in regions which were part of the former Soviet Union. To put things more saliently, over 35 years after Germany's reunification, districts within former Eastern Germany continue to lag behind Western districts in many measurable metrics such as productivity growth, innovation intensity, and firm density. Ostensibly, there is a vast literature documenting spacial imbalances within Germany, but, there remains limited empirical analysis that seeks to measure if ERDF investments materialize into welfare gains for their targeted regions. An analysis of the effectiveness of one of the EU's main driver for addressing regional heterogeneity provides critical information for policy makers, and researchers who seek to build powerful normative models to more efficiently, effectively, and equitably disperse ERDF funding throughout Europe. Therefore, this paper means to address the limited empirical analysis through a positive study on how welfare outcomes are realized within Germany's 400 districts as a result of place based policy delivered by virtue of the ERDF.

Uncovering heterogeneous effects of ERDF investments in projects such as support for small to medium sized enterprises (SMEs), research & innovation, and climate change adaptation allows us to examine whether the structurally weaker Eastern German districts exhibit larger benefits in terms of welfare outcomes compared to Western districts due to the funding. The challenges with a positive analysis of this sort include, endogeneity caused by the non random selection of regions which receive funding due to pre-determined economic conditions or political forces, and spillover effects (externalities) the funding may exhibit from and to neighbouring districts. In order to address these challenges, we employ machine learning models in order to capture accurate specification through the flexibility provided by non-parametric models, using de-biased or orthogonalized models which are cross fitted to avoid regularization and over-fitting bias, and exploiting flexible interaction through ensemble tree methods such as generalized causal forests. This framework yields conditional average treatment effects (CATE) which aid us in the measurement of which characteristics are deterministic for providing the largest gains from our policy instrument. In order to proceed with the study, our data contains information on 45,000 projects, at a programming period that spans from 2014 to 2020, data past 2020 is not used in order to avoid any externalities caused by the COVID-19 pandemic.

As for context, this paper will build upon the work I undertook during the second year of my undergraduate program as a research assistant for Dr. Rowan Shi at Toronto Metropolitan University. My extension to the literature and previous work is threefold, inference in high dimensional settings through double machine learning, an analysis of heterogeneous regional responses through generalized causal forests, and a brief positive analysis of the results with policy design in mind. The remainder of the paper will then proceed as follows; section 3 provides a literature review of the recent analysis of place-based policy in Germany and around the world. Section 4 provides some qualitative information and background on the data we have collected. Section 5 outlines the reduced form, and machine learning models used to make the proceeding positive welfare analysis. Section 6 provides the empirical results and implications to the resulting heterogeneous treatment effects. Section 7 gives a conclusion to the work provided. There is also an appendix bellow which contains some graphs that may be to the readers interest.

3 Literature Review

Contemporary literature on place-based policy evaluates interventions which target specific geographical locations in order to materially raise the economic performance of a given local economy. The goal of place-based policy has been aligned with uplifting lagging regions by stimulating job creation, and persistent welfare gains through the formation of special economic zones (SEZ) and support for small to medium sized enterprise (SMEs). Neumark and Simpson (2015) outline early research in this line of work by emphasizing agglomeration economies, spacial mismatch, and equitable distribution for regional policy. This overview highlight the empirical challenges caused by the selection of regions to distribute funding to, spillover effects, and displacement effects. Notably, they underscores the need for credible identification strategies for the purpose of estimating gains from place-based policy at the intensive and extensive margins.

Ehrlich and Seidel (2018) provide a causal analysis of Germany's Zonenrandgebiet (ZRG) transfers in 1971. The West German program targeted markets on the Western side of the "Iron Curtain" along the Soviet border, to incentive the population along the border to stay. Following Germany's reunification in 1990, these transfers were redirected to Eastern Germany. The study explores the positive welfare effects 16 years after the program ended, and finds substantial increases in income, capital stock, and employment through a regression discontinuity (RD). However, the study also discovers high relocation of economic activity through labour mobility and land lords rent seeking behaviour. Brachert, Dettmann, and Titze (2019) similarly study Germany's GRW discretionary investment grants using a RD design based on the threshold of eligibility for the program. The authors find a notable increase in valued added productivity at the district level, but little impact on employment and wages. Hence, the policy is stated to be insufficient for addressing long-run regional disparities in labour market outcomes between Eastern and Western Germany. A notable piece of literature is Lu, Wang, and Zhu (2019) which examines China's Special Economic Zones (SEZs) following Deng Xiaoping famous southern tour. This paper uses detailed firm level data to illustrate the remarkable increases in capital investment, employment, output, productivity, and wages in China's SEZ. They highlight the central role that the number of new firms entering the market had on the formation of a highly competitive business environment which brought large net benefits to China. The authors examine heterogeneous effect across industries, and discover that capital intensive sectors benefited the most due to the influx of new entrants. Finally, Faggio (2019) examines the UK's Lyons Review relocation policy which distributed 25,000 jobs from London to other regions. Faggio finds that relocation increased private sector employment in the services for treated regions. This study find heterogeneity in outcomes at an extreme granular level, agglomerated forces were observed only at a 3 kilometre radius to the treated zone.

Previous studies illustrate the effectiveness of place-based policy at addressing regional inequality. They observe how these policies persistently raise local economic activity and highlight the heterogeneity across regions and industries, and critically how specific targeted intervention determines effectiveness. In the German setting, studies expose the susceptibility of the weaker Eastern districts to positive outcomes. Notably, the literature addresses that previous policy was not effective at tackling long run structural divergence in welfare outcomes. Thus, this literature seeks to provide the empirical foundation for evaluating welfare effects of ERDF funding and whether the cohesion policy tackle inequality adequately.

4 Data and Summary Statistics

The empirical analysis that follows combines several datasets covering information across all levels of the Nomenclature of Territorial Units for Statistics. NUTS-1 level corresponds to the 16 states within Germany, the NUTS-2 level corresponds with 38 more granular government administrations, and the NUTS-3 level gives us fine data on Germany's 400 districts. A kreisfreien Städte refers to urban districts, and Landkreise refers to rural districts within Germany. The data we have collected captures economic performance, information of firms structure, sectoral compositions, and the support provided by the European Union (EU) by way of a placed-based policy, namely the European Regional Development Fund (ERDF).

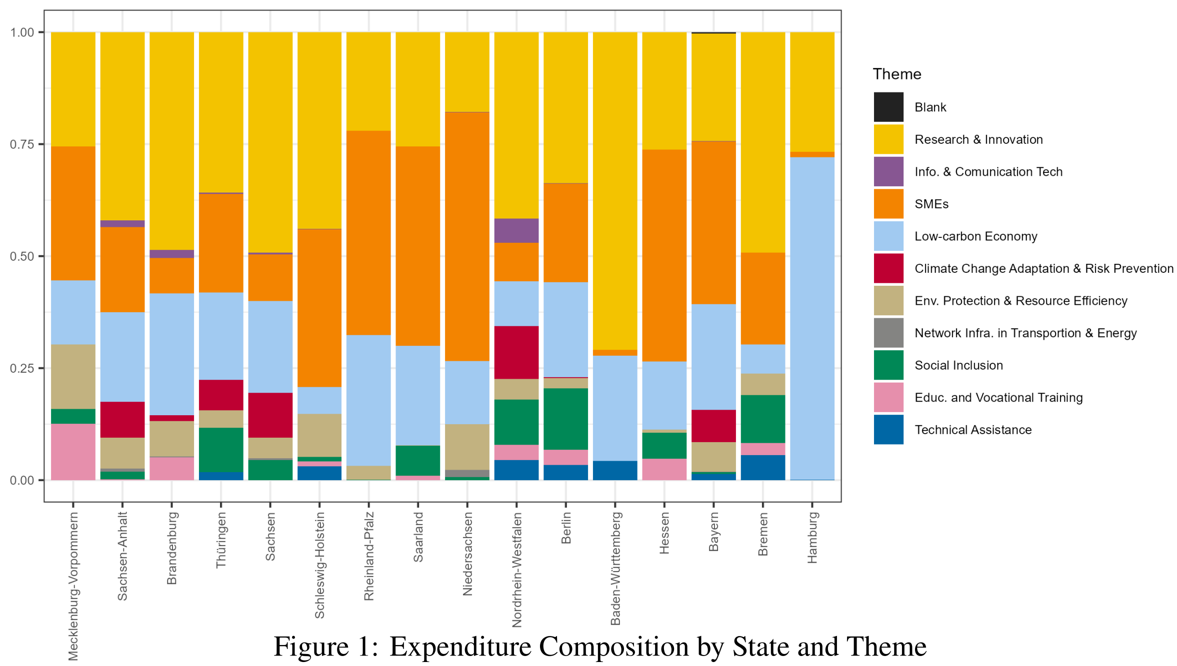
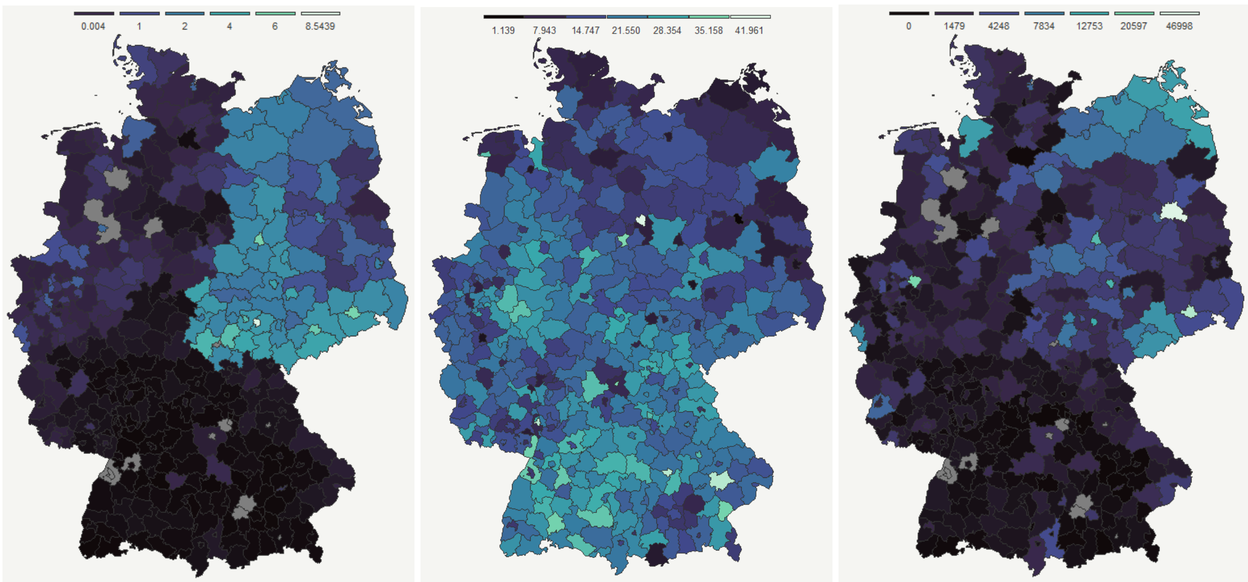


Figure 1: Expenditure Composition by State and Theme

The data on the funding provided by the (ERDF) is retrieved from Kohesio; the European Commissions open database on projects which aim to push cohesion across Europe by systematically targeting imbalances between countries and regions. The data provides information on categories of intervention, thematic objectives, policy objectives, and funding for over 45,000 individual projects across 382 German districts which received funding. The ERDF programming period of interest is 2014 to 2020 since the dataset contains sparse observations before 2015 and we would like to avoid any externalities post 2020 caused by the pandemic. I aggregate ERDF spending at the NUTS-3 level and attain measures of total ERDF spending per district, ERDF spending per capita, and ERDF spending per capita as a share of GDP per capita, to attain information that will be used in the subsequent analysis.

Using Eurostat's regional accounts data, I obtained measures for gross value added (GVA) at the NUTS-3 level. The data aligns with the aforementioned programming period and provides us with the means to evaluate productivity differences between Germany's Eastern and Western districts. It follows that, a measurement of the GVA is used as the primary outcome variable for the assessment of how well ERDF funding improved welfare across Germany. The data on gross value added also provides some information on the industry composition across districts, which yields shares of the value added to regional economies that comes from the manufacturing sectors. Eurostat also provides data on the number of high-technology patent applications filed within Germany at the NUTS-3 level. This information acts as a proxy for measuring the intensity of innovation within districts. Which will be essential to measuring heterogeneous treatment effects as a result of ERDF funding.



(a) Projects per Capita (1000's)

(b) Manufacturing Shares

(c) Funding / GDP per Capita

Figure 2: Regional Variation in ERDF Funding and Economic Structure

The OECD provides data through the Regional Demographics Database on productivities and populations within Germany by district. This data is used to obtain GDP per capita figures at the NUTS-3 level. This is used to the create figures and plots since it is more accessible for a general reader than GVA. Finally, I have attained input output tables on Germany at the NUTS-2 level. This data provides information on sectoral productivity shares, manufacturing shares, and labour inputs across regions within a larger geographical encoding in Germany. Notably, we are able to derive the share of high-technology manufacturing, production, and labour shares in each of the NUTS-2 regions with this data. However, I am not sure where this data comes from; I attained this data from my professor who I worked for during my research assistantship, and she mentioned that it was compiled in the Netherlands.

Figure 2 provides cardinal information regarding the general make up of the German economy, and how the ERDF was distributed. Figure 2 (a) shows that the distribution of projects through the ERDF taken per 1000 person is concentrated towards the Eastern districts of Germany. This can be attributed to the funds mission of bridging the gap in regional variation between the Eastern and Western districts. Figure 2 (b) gives us the share of GVA accounted for by manufacturing industries across Germany's 400 districts. The presence of well established automotive, machinery, and chemical manufacturing clusters can explain the inequality between the Eastern and Western segment of Germany, and particularly in Bavaria. Figure 2 (c) plots the intensity of investment through the ERDF relative to a districts economic output. We see that districts within the former East German bloc exhibit higher funding to GDP ratios, indicating that Eastern districts are more dependant on the funding compared to the Western districts.

5 Model

We begin this section by outlining the structure of the data used to make the following empirical analysis. We square our data from 2014-2020, so that every region in a given year that did not receive funding has a 0 value assigned to it. Then, to attain the desired variables for our model, we derive manufacturing shares and gross value added (GVA) from Eurostat data. The GVA and ERDF funding is taken on a per capita bases using population data from the OECD, we then take the natural log of these variables for scaling purposes which yield clearer outcomes in our models. GVA is then taken at a three year forward growth rate; this captures the fact that projects which have been funded typically takes a few years to fully be implemented. Formally, the outcome is defined as the average annual change in log GVA per capita from 2015 to 2017. We then find the shares of the funding given to a region in a given year by thematic objective and policy objective in order to determine heterogeneity based on the goal of the distributed funding. Finally, we include the natural log of the number of patent application within a region in 2010 and a binary variable for weather the district is rural or urban.

Table 1: Fixed Effects & Dynamic Model

	Dependent variable:		
	3-Year Forward GVA		ln(GVA)_PC
	Fixed Effects - 1	Fixed Effects - 2	FD GMM
manufacturing_shares	-0.5317^{***} (0.0239)	-0.5317^{***} (0.0239)	1.3937^{***} (0.5156)
ln(funding)_PC	0.0006^{**} (0.0002)	0.0005^{*} (0.0003)	
Year: 2015		0.000170 (0.0008)	
Year: 2016		0.006032^{***} (0.0009)	
Year: 2017		-0.013301^{***} (0.0009)	
ln(funding)_PC:urban		0.000120 (0.0004)	
lag(ln(GVA_PC)): 1			0.6140^{**} (0.2584)
lag(ln(funding)_PC): 0			0.0002 (0.0008)
lag(ln(funding)_PC): 1			0.0003 (0.0009)
lag(ln(funding)_PC): 2			0.0017^{*} (0.0010)
lag(ln(funding)_PC): 3			0.0016 (0.0010)
lag(ln(funding)_PC): 4			0.0024^{*} (0.0014)
Observations	1,540	1,540	385
R^2	0.301555	0.494137	
Adjusted R^2	0.065299	0.322435	
F Statistic	248.257500^{***} (df = 2; 1150)	187.061300^{***} (df = 6; 1149)	
Sargan Test			19.45 (p-value = 0.15)
AR(1)			-2.25 (p-value = 0.03)
Note:			*p<0.1; **p<0.05; ***p<0.01

Before we implement machine learning models, we begin by fitting out data onto increasingly rigorous econometrics models. We begin with pooled ordinary least squares (OLS), fixed-effects (FE), and dynamic first differences models. All together, these models provide a simple framework to compare our machine learning models too. OLS offers the simplest relationship between how ERDF funding influences overall growth in GVA. Fixed effects models remove time-invariant differences across regions while also controlling for macroeconomics shocks that may effect regions in a given year. And, dynamic models account for persistent regional economic performance and uses our lagged outcome variable as a internal instrument to reduce serial correlation. This information yields stable estimates for the average treatment effect (though likely not causal) for ERDF funding on average across all regions and years.

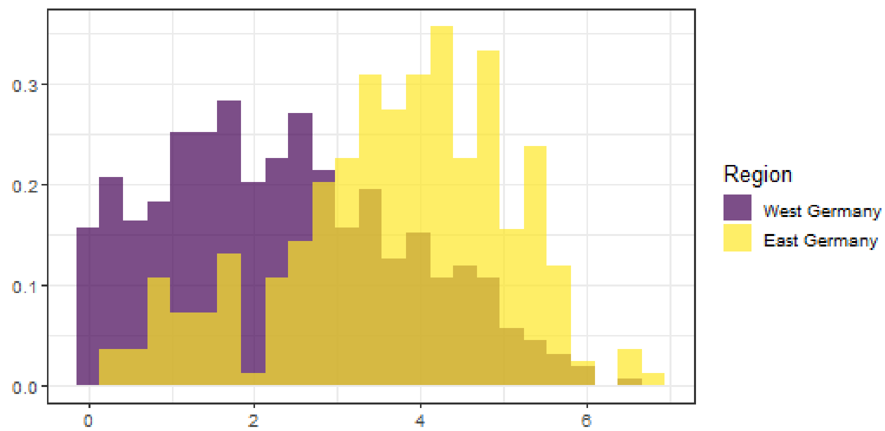
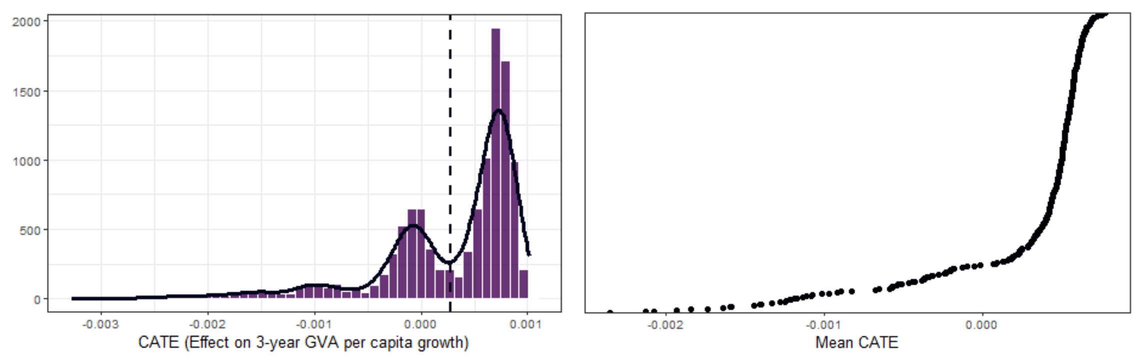


Figure 3: Distribution of ln(Funding per Capita)

The fixed effects models force us to remove any time invariant covariates, meaning we run the natural log of funding per capita and manufacturing shares on the three year forward GVA growth rate while controlling for regional and time invariant effects. The estimated effects of the fixed effects model suggests that higher per capita ERDF funding to a region is associated with small and borderline significant growth rates in the forward looking GVA. The inclusion of an interaction term for urban suggests that there is no statistically significant difference between how urban and rural districts respond to ERDF funding. Nonetheless, the dynamic models specification is peculiar, we estimate the effects of the logged-lagged GVA per capita, lagged ERDF funding, and manufacturing shares on the current log of GVA per Capita using a first differenced GMM transformation. Notably, the remaining GVA lags, lagged ERDF funding, and manufacturing shares are used as internal instruments. In this case, are able to use lagged ERDF funding, and manufacturing shares as internal instruments since they are correlated with themselves and assumed to be exogenous to changes in GVA. The estimates for ERDF funding from this dynamic model are small and exhibit borderline statistical significance. But the model captures valuable insight on how ERDF funding exhibit positive effects approximately 2 or 3 years in the future. Manufacturing share, do exhibit large and statistically significant positive coefficient, this highlight the role of industrialization in shaping regional economic performance. Notably, the Sargan test does not reject instrument validity, and diagnostic tests show significant AR(1) correlation, however, AR(2) is not calculated since there are not enough time period to do so. Although, the dynamic model is not ideal for estimating the effect of ERDF funding on welfare, we are still able to conclude that the short-run effects of ERDF funding on GVA per capita are difficult to observe.

6 Empirical Results

The Double Machine Learning (DML) partial linear regression (PRL) model yields orthogonalized estimate that represent a causal partial effect when controlling for whether the region is urban, amount of patent applications, industrial structure, regions, time, and thematic funding shares. The first model we estimate uses the log of GVA per capita as the outcome and ERDF funding as treatment. The average treatment effect (ATE) comes out to be 0.0005156. This indicates that a one percent increase in the log of ERDF funding per capita is associated with approximately a 0.0005156 percent increase in GVA per capita. The ATE has a p-value of 0.856 which indicates that the result is statistically insignificant. However, when we use an identical model but with the three year forward growth rate of log GVA per capita as the outcome variable, we attain a modest ATE value of 0.0007111. This ATE is relatively large in magnitude and statistically significant at the 5 percent level. We can observe that on average, a 100 percent increase in ERDF funding per capita (double) will raise the gross value added per capita growth rate three years in the future by 0.07 percent. Overall, from a policy perspective this indicates that a larger amount of spending through the ERDF contributes to higher levels of domestic output. The reason the ATE value is so small is because funding from the ERDF is very small compared to how large Germany's output is per region. This effect may also seem small since the ERDF's effects may take many year to materialize. The value may also be skewed since funding overall targets lagging regions which experience systematically lower GVA growth. All in all, this reinforces the importance of exploring heterogeneous treatment effects between regions in Germany.



(a) CATE Distribution

(b) CATE distribution by Region

Figure 4: CATE Distributions

In order to derive measurements for heterogeneous economic impact of ERDF funding across districts within Germany, we employ a generalized random forest (GRF). The GRF estimates of the average treatment effect (ATE) of receiving any funding on the three-year forward GVA per capita growth rate is approximately 0.0003, which is statistically insignificant and indistinguishable from zero. These findings suggests that ERDF investments do no increase Germany's growth rate in the short term at the district level. The distribution of the conditional average treatment effects (CATEs) further illustrates the limitations of the ERDF in providing beneficial welfare outcomes on a district by district bases. Although the distribution of CATEs is asymmetric and narrowly distributed within 0.1 percentage points, the majority of the regions receive positive benefits to funding, while a few district along long left tail are harmed by the ERDF.

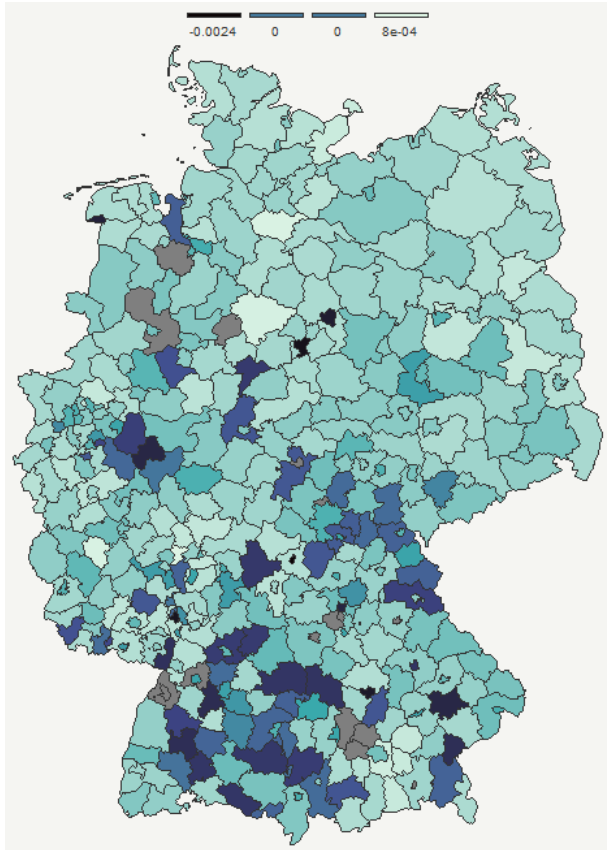


Figure 5: CATE Map

Notably, we observe that the thematic and policy-objective funding categories contribute minimally to the predictive power of the model. However, we observe that the regions in which we measure strong positive heterogeneous effects tend to be the ones in the Eastern German bloc. This indicates that the regions which are being targeted through the Cohesion plan are also the ones who are benefiting, regardless of how small the estimated effect of the benefit is. What is particularly apparent is that the regions which exhibit negative CATEs tend to be in those in Bavaria, which we have historically and analytically shown to exhibit strong innovative ability and a large manufacturing base. This is doubly interesting since the variable importance, a measure of the prediction power of our covariates, informs us that strong technological capability and a high share of manufacturing production tends to predicted a large portion of the growth in productivity. Taken together, the results imply that ERDF funding does not translate into measurable short-run output gains but that existing regional, structural, innovation capacity, and industrial compositions directly predict welfare outcomes more accurately than ERDF funding. This is likely because the small size of the fund cannot measurably close the gap and divergence in economic output of the districts across Eastern and Western Germany. Additionally, how effectively regions can absorb and translate funding into economic performance is not captured by the generalized random forest due to the limitations of estimating welfare growth via GVA. A large portion of the welfare benefits from the ERDF may be captured by other variables and externalities such as labour mobility and house rents which the data is not readily available for.

7 Conclusion

This paper conducts a positive empirical analysis which aims to measure how the European Regional Development Fund (ERDF) increases welfare outcomes across 400 districts in Germany. The effect of the ERDF funding remains mostly undocumented, and this papers purpose is to bridge that gap. Regardless, through the collection of project level funding data and the incorporation of district level structural and economic indicators we were able to employ both reduced form regressions and modern machine learning methods to make our inferences.

We began with a pooled OLS, fixed effects, and a dynamic GMM first differences models to estimate modest effects of the short-run average impact of ERDF investments on gross value added (GVA) per capita growth. The findings provided in this section also reflect the fact that projects often take years to materialize into measurable improvements in productivity. The machine learning models later provided similar information regarding the estimated average treatment effect for three-year forward changes in log GVA per capita on ERDF funding. More notably, generalized causal forest uncovers substantial heterogeneity in district-level responsiveness to ERDF funding. While the observed distribution of the conditional average treatment effects (CATEs) remains narrow and concentrated around 0. The districts which experiences positive effects are exactly the districts targeting by the ERDF. We even show that a modest set of high-capacity regions, primarily in Bavaria, exhibit mild negative effects to receiving funding from the ERDF. However, this is likely attributed directly to the selection bias inherent in place-based policy programs which aim to reduce the spacial mismatch between regions in a country. At the same time, variable-importance metrics show that the strongest predictors of GVA growth are not ERDF spending itself, but pre-existing structural characteristics particularly manufacturing intensity and technological capability. These findings highlight a critical limitation: the ERDF alone does not meaningfully alter the underlying industrial fabric of regional economies. Instead, it modestly reinforces performance where conditions are already conducive to growth. This points to an inherent tension in place-based policy: funding may be well-targeted toward lagging regions, but the capacity of those regions to absorb and convert investment into productivity gains remains uneven.

Overall, the analysis suggests three main conclusions. First, the ERDF provides small but measurable positive effects on short-run welfare when evaluated with forward-looking outcomes. Second, benefits are not evenly distributed: structurally weaker Eastern districts gain more from marginal increases in funding. Third, the long-run success of Cohesion Policy depends not only on the volume or direction of ERDF allocations but on complementary structural reforms that enhance innovation, industrial capacity, and absorptive capability. These insights offer a foundation for future research on optimal spatial allocation and provide policy-makers with a clearer understanding of how the ERDF interacts with the complex regional dynamics underlying Germany's persistent economic heterogeneity.

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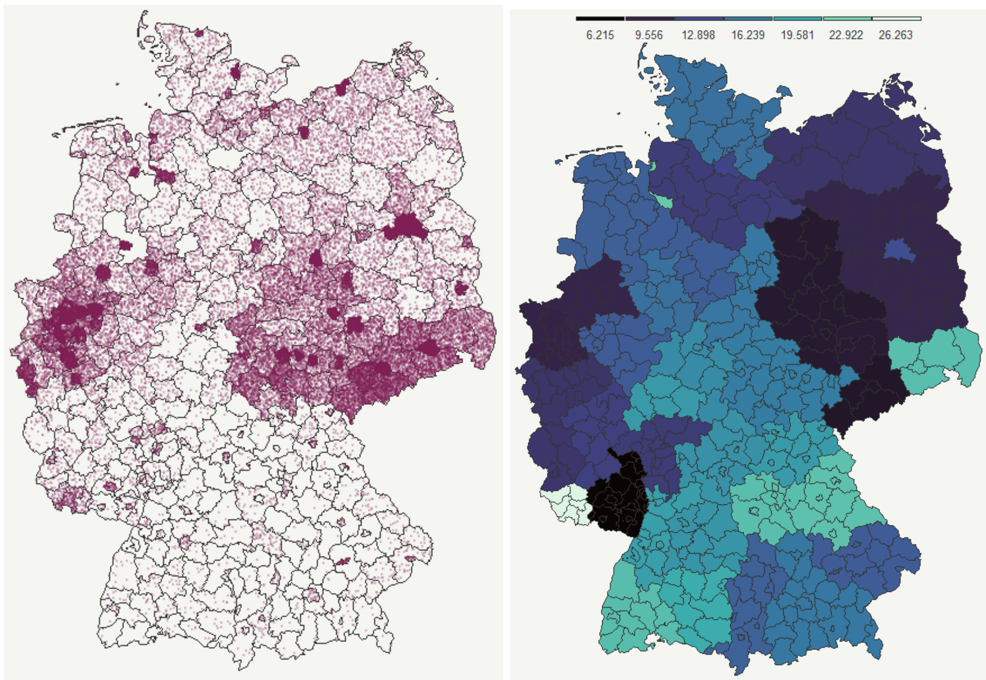
8 Appendix

Figure (a) is a dot map of the exact locations of ERDF projects in Germany. Figure (b) illustrates the divide between Eastern and Western Germany with input output table data to measure share of labour allocated to high-tech industries within the NUTS-2 regions.



(a) Dot Map of ERDF Projects (b) Share of Labour in High-Tech Industries

Figure 6: More Regional Variation in ERDF Funding and Economic Structure

The following figure is derived from the input output tables at the NUTS-2 level. They Provide the composition of productions shares within Germany by Industry.

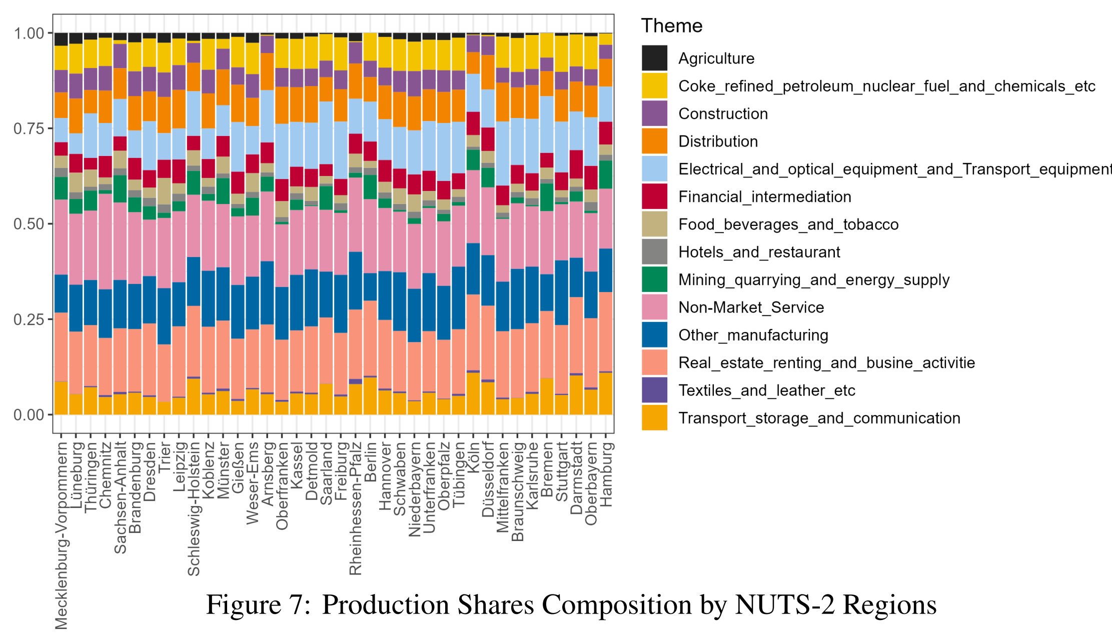


Figure 7: Production Shares Composition by NUTS-2 Regions

Table 2: OLS

	Dependent variable:
	3-Year Forward GVA Pooled OLS
ln(funding)_PC	0.000555** (0.000239)
Manufacturing Shares	−0.531703*** (0.023887)
ln(patent apps)	−0.250545*** (0.025014)
Urban	−0.192608*** (0.025603)
Year: 2015	0.000165 (0.000767)
Year: 2016	0.006027*** (0.000848)
Year: 2017	−0.013311*** (0.000865)
Constant	0.426485*** (0.029618)
Region Controls	Yes
Observations	1,540
R^2	0.695859
Adjusted R^2	0.592980
F Statistic	6.763861*** (df = 389; 1150)
Note:	*p<0.1; **p<0.05; ***p<0.01