Multifaceted effects of public regional policy measures on regional living conditions. Evidence from German redistribution policies and European Cohesion Policy.

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Preface

This cumulative doctoral dissertation aims to measure multidimensional outcomes of redistributive regional policies such as structural investment funds and fiscal equalization policies. The thesis at hand consists of four stand-alone research papers that are jointly authored (sections 2 to 5). An overview on this papers and my own contribution is given in table V1. In addition, in section 1, I discuss the motivation, the research settings, as well as research questions and objectives, and give a short methodological introduction. Section 7 summarizes the main findings of the research conducted, draws policy implications and discusses limitations and future research perspectives.

Table V1: Overview of papers in the cumulative dissertation

	Title	**Journal**	**Co-Author**	**Own contribution**
1	*How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany*	Journal of Regional science (2020), 60, 1047 - 1073	Thomas Brenner (15%)	Main author (85%)
2	*Measuring the regional, multifaceted, direct and indirect Effects of European Cohesion Policies*	*Submitted to:* Journal of Regional Science	Thomas Brenner (5%)	Main author (95%)
3	*Who benefits from structural investment policy? An empirical analysis of the German structural fund GRW on regional wage structures*	*Submitted to:* Regional Science and Urban Economics	Thomas Brenner (10%)	Main author (90%)
4	*Analyzing the spatio-temporal diffusion of economic change –Advanced statistical approach and exemplary application* [1]	*Submitted to:* Spatial Economic Analysis	Thomas Brenner (10%)	Main author (90%)

[1] published as working paper on Innovation and Space 01.21

Abstract

The place a person lives in significantly affects the living standards and life chances of this person. Peripheral and economically weak regions within highly developed countries appear to offer their residents fewer opportunities, due to economic constraints, such as unemployment and lower wages, weaker regional amenities (e.g. such as weaker infrastructure and educational opportunities) or social challenge, such as increased risks for social marginalization, poverty and premature mortality. These constraints affect the daily lives of people living in these regions. Thus, peripheral and structurally lagging regions tend to appear less attractive and economic and social disparities to primarily dynamic metropolitan areas foster social polarization. Socioeconomic trends such as structural change, the new geography of jobs or ageing tend to reinforce within-country inequalities. The theoretical considerations in this thesis illustrate that reducing regional disparities and promoting spatially equivalent living conditions is an important topic in regional science because of its economic, social and political implications.

Regional redistributive policy such as structural investment funds and fiscal equalization schemes aim to make less developed regions more attractive and to increase economic and non-economic life-chances. But how effective are those policies? While there is a long tradition of examining economic growth effects of regional policies, there is a lack of scientific research and knowledge on effects that are not directly related to the economic output growth, such as the regional quality of life. This thesis aims to contribute to the literature on the efficacy of regional policy interventions dedicated to less developed regions by presenting novel empirical findings that focus on regional outcomes measures beyond regional economic output growth. To this end, four research questions are posed:

1. *How can individual well-being and the dynamic development of multidimensional regional inequalities be measured in a suitable way beyond economic parameters?*

2. *Which policy measures are proving particularly effective to reduce dimensions of regional inequalities?*
3. *Are there differences in the regional effects between those policy measures that directly affect public institutions and the municipal budget (e.g. formula-allocations in fiscal equalizations) and those that directly support private actors (e.g. structural funds)?*
4. *Are there regional differences in the effectiveness of funds, for example between rural and urban areas? Can regional factors be identified that have a particular (positive or negative) influence on the impact of policy measures in the selected areas of life (e.g. population density, demographics or economic strength)?*

Spatial vectorautoregressive panel models (SpVARs) are used to empirically assess the effects of regional policy measures. These models have the advantage of being flexible, accounting for indirect effects between variables, time lags between subsidies payments and regional effects and allowing for the evaluation of multidimensional policy outcomes within the same model. Another goal of this thesis is to further develop the SpVAR approach into an explicitly spatial design that adequately accounts for spatial spillovers and spatial interdependencies between variables and allows to estimate additional impulse response functions that estimate effects occurring in neighboring regions.

This cumulative dissertation contains four stand-alone research papers in addition to an overarching introduction and a concluding chapter. The first paper analyzes the effects of the German Fiscal equalization scheme and the structural fund GRW at the level of German labor market regions. The paper shows, that fiscal equalization scheme grants have a significant positive effect on regional net migration rates for persons under 50 years of age. This particularly applies for regions with low endogenous fiscal capacities, which can be described as structurally lagging behind. It is argued that the dynamic development of net migration rates can be used as an indicator of the development of the individually perceived quality of life in the regions. By preventing out-migration from structurally lagging regions, it is found that equalization grants contribute to the goal of spatial equity, although no evidence for promoting regional economic growth is found. This is not found for the GRW policy.

The second paper analyzes the multifaceted effects of European Structural and Investment Funds (ESIF's) in European NUTS-2 regions. The paper finds that the European Regional Development Fund (ERDF) can support regional productivity and employment growth as well as household income growth, which should have a positive impact on the people's material living standards. The effects of ERDF subsidies are particularly present in less developed regions, while no robust regional responses to subsidies are found for the European Social Fund (ESF) and the Cohesion Fund. In contrast to the first paper, no effects on net migration rates are found.

The third article focuses on GRW effects at the regional level of German counties and independent cities. It emphasizes wage developments at different quantiles of the wage distribution as possible effects from GRW subsidies in order to investigate the extent to which possible productivity and income effects of GRW subsidies are transmitted to employees. Industry subsidies are found to have partially positive effects at different levels of the wage distribution in East Germany, while effects in the West are limited to the upper end of the wage distribution. Infrastructure subsidies appear to have higher efficacy on wages than firm subsidies in the industrial scheme, but are also limited to East Germany and to the service sector.

The empirical findings suggest that the policies under investigation in this thesis have different transmission channels. The occurrence and strength of effects is heterogeneous and differs across policies. All three empirical findings suggest that effects are higher in less developed regions. Thus, they seem to depend on regional preconditions as well as on the policy frameworks.

The final paper presents a novel spatio-temporal panel vector autoregressive approach as an extended spatial econometric method to correctly analyze spatial spillover effects in the SpVAR systems used in this thesis. The paper does not primarily aim to provide new empirical insights, but to extend the spatial dimension of SpVAR models by capturing the full cross-regional interdependencies and spatial spillover between variables over time, which allows to estimate policy effects in neighboring and economically connected regions. It is shown, that positive responses of variable shocks in regions can induce negative effects in neighboring regions through substitution effects.

The findings presented should be of particular interest to policy makers, as relevant policy implications can be drawn. Based on the empirical findings, spatially redistributive policies can support the regional development of less developed regions and thus the quality of life and material living standards in these regions under certain circumstances. First, unconditional policy grants from fiscal equalization appear to be more effective than structural investment funds in increasing regional net migration rates and promoting non-material living conditions. Second, the high conditionality of effects in favor of regions with low economic strength indicates that policies should be even more tailored to these regions to be most effective. Finally, policymakers and researchers need to consider spatially indirect effects, since positive effects in subsidized regions may entail negative effects in neighboring regions.

Zusammenfassung

Der Ort, an dem eine Person lebt, beeinflusst maßgeblich den Lebensstandard und die Lebenschancen dieser Person. Periphere und wirtschaftlich schwache Regionen innerhalb hochentwickelter Länder bieten geringere Möglichkeiten, denn wirtschaftliche Voraussetzungen wie Arbeitslosigkeit und ein geringeres Lohnniveau, sozioökonomische Bedingungen und schwächere sozioökonomische Infrastrukturen beeinflussen die Lebensqualität in diesen Regionen negativ und wirken sich auf das tägliche Leben und die Perspektiven der in diesen Regionen lebenden Menschen aus. Dies betrifft beispielsweise Bildungsmöglichkeiten, Infrastrukturen der Daseinsvorsorge oder soziale Herausforderungen wie erhöhte Risiken für soziale Marginalisierung, Armut und vorzeitige Sterblichkeit in diesen Regionen. So erscheinen periphere und strukturschwache Regionen tendenziell weniger attraktiv und die wirtschaftlichen und sozialen Gegensätze zu sich dynamisch entwickelnden Metropolregionen fördern die ökonomische und soziale Polarisierung. Die theoretischen Überlegungen in dieser Arbeit verdeutlichen, dass der Abbau regionaler Disparitäten und die Förderung räumlich gleichwertiger Lebensverhältnisse aufgrund ihrer vielfältigen Implikationen ein wichtiges Thema innerhalb der Wirtschaftsgeographie ist.

Regionale Umverteilungspolitiken wie Strukturfonds und regionale Finanzausgleichssysteme zielen darauf ab, weniger entwickelte Regionen attraktiver zu machen und die wirtschaftlichen und sozialen Lebensbedingungen zu verbessern. Die Grundlage dafür ist das Streben nach gleichwertigen Lebensverhältnissen, die in Deutschland im Grundgesetz und in der Raumordnung verankert sind. Aber wie effektiv sind diese Politiken? Während es eine lange Tradition gibt, die Auswirkungen dieser Politikmaßnahmen auf das Wirtschaftswachstum zu untersuchen, fehlt es an wissenschaftlicher Forschung über Effekte, die nicht unmittelbar mit der regionalen Wirtschaftsleistung zusammenhängen, so wie die empfundene Lebensqualität in der Region. Diese Arbeit zielt darauf ab, einen empirischen Beitrag zur Literatur zu leisten, die

sich mit der Wirksamkeit regionalpolitischer Maßnahmen beschäftigt. Es sollen neue empirische Erkenntnisse präsentiert werden, die sich auf Effekte jenseits regionalen Wirtschaftswachstums konzentrieren. Zu diesem Zweck werden vier übergreifende Forschungsfragen gestellt:

1. *Wie kann die Entwicklung regionaler Ungleichheit jenseits ökonomischer Parameter, insbesondere die Entwicklung der empfundenen Lebensqualität in geeigneter Weise auf regionaler Ebene gemessen werden?*
2. *Welche der untersuchten politischen Maßnahmen erweisen sich als besonders geeignet, um die regionale Ungleichheit zu reduzieren?*
3. *Gibt es Unterschiede in den regionalen Effekten zwischen solchen Politikmaßnahmen, die direkt öffentliche Institutionen und den kommunalen Haushalt begünstigen (z.B. Schlüsselzuweisungen im Rahmen des kommunalen Finanzausgleichs) und solchen, die in erster Linie private Akteure fördern (z.B. Subventionen im Rahmen der GRW)?*
4. *Gibt es regionale Unterschiede in der Wirksamkeit der Förderung, z.B. zwischen ländlichen und städtischen Räumen? Lassen sich regionale Faktoren identifizieren, die einen besonderen (positiven oder negativen) Einfluss auf die Effekte politischer Maßnahmen in den ausgewählten Lebensbereichen haben (z.B. Bevölkerungsdichte, Demographie oder Wirtschaftskraft)?*

Zur empirischen ökonometrischen Analyse der Effekte regionalpolitischer Maßnahmen werden räumliche vektorautoregressive Panelmodelle (SpVARs) geschätzt. Diese Modelle haben den Vorteil, dass sie flexibel sind, indirekte Effekte zwischen Variablen sowie Zeitverzögerungen zwischen Subventionszahlungen und regionalen Effekten berücksichtigen. Zudem ermöglichen sie die Bewertung mehrerer Ergebnisvariablen innerhalb desselben Modells.

Ein weiteres Ziel dieser Arbeit ist es, den SpVAR-Ansatz so weiterzuentwickeln, dass räumliche Spillover und räumlich indirekte Effekte zwischen Variablen adäquat berücksichtigt werden und es dadurch ermöglicht wird, zusätzliche Impuls-Antwort-Funktionen zu schätzen, die Effekte in benachbarten Regionen schätzen können.

Diese kumulative Dissertation enthält neben einer übergreifenden Einleitung und einem abschließenden Kapitel vier eigenständige Forschungspapiere. Der erste Artikel analysiert die Auswirkungen des kommunalen Finanzausgleichs und des Strukturfonds GRW auf der Ebene der deutschen Arbeitsmarktregionen. Das Papier zeigt, dass die Zuwendungen aus dem Finanzausgleich einen signifikant positiven Effekt auf die regionalen Nettowanderungsraten von Personen unter 50 Jahren haben. Dies gilt insbesondere für Regionen mit geringen regionalen Steuereinnahmen, die auf Strukturschwäche und einen begrenzten regionalen Handlungsspielraum hindeuten. Zudem wird herausgearbeitet, dass die dynamische Entwicklung der Nettowanderungsraten als geeigneter Indikator für die Entwicklung der individuell wahrgenommenen Lebensqualität in den Regionen herangezogen werden kann. Daraus kann geschlossen werden, dass der kommunale Finanzausgleich durch die Verhinderung von Abwanderungen aus strukturschwachen Regionen zum Ziel der räumlichen Gerechtigkeit beitragen kann, obwohl keine Anzeichen für eine Förderung des regionalen Wirtschaftswachstums durch den Finanzausgleich gefunden werden können. Für die GRW können keine Effekte auf regionale Wanderungsraten gefunden werden.

Der zweite Artikel analysiert die Auswirkungen der Europäischen Struktur- und Investitionsfonds (ESIFs) auf der Ebene der NUTS-2 Regionen. Der Artikel kommt zu dem Ergebnis, dass der Europäische Fonds für regionale Entwicklung (EFRE) das regionale Produktivitäts- und Beschäftigungswachstum sowie das Wachstum des verfügbaren Haushaltseinkommens privater Haushalte unterstützen kann, was sich positiv auf den materiellen Lebensstandard der Menschen auswirken sollte. Die Effekte von EFRE-Subventionen sind besonders in weniger entwickelten Regionen sichtbar, während für den Europäischen Sozialfonds (ESF) und den Kohäsionsfonds keine robusten regionalen

Reaktionen auf Subventionen gefunden werden. Im Gegensatz zum ersten Artikel werden keine Auswirkungen auf regionale Wanderungsraten gefunden.

Der dritte Artikel konzentriert sich auf Effekte der GRW Förderung in deutschen Kreisen und kreisfreien Städten. Es werden dabei die Effekte auf die Lohnentwicklung auf verschiedenen Stufen innerhalb der regionalen Lohnverteilung untersucht, um herauszufinden, inwieweit Beschäftigte von möglichen Produktivitäts- und Einkommenseffekten durch GRW-Subventionen profitieren können. Es zeigt sich, dass Industriesubventionen in Ostdeutschland teilweise positive Effekte auf verschiedenen Ebenen der Lohnverteilung haben, während die Effekte im Westen auf das obere Ende der Lohnverteilung beschränkt sind. Infrastruktursubventionen scheinen eine höhere Wirkung auf Löhne zu haben als Unternehmenssubventionen, sind aber ebenfalls auf Ostdeutschland und dazu vor allem auf den Dienstleistungssektor beschränkt.

Die empirischen Ergebnisse legen nahe, dass die in dieser Arbeit untersuchten Politikmaßnahmen unterschiedliche Übertragungswege besitzen. Ob Effekte auftreten und wie stark diese sind, unterscheidet sich zwischen den Politikmaßnahmen. Alle drei empirischen Befunde legen nahe, dass die Effekte in strukturschwachen Regionen höher sind. Regional messbare Effekte scheinen also sowohl von regionalen Voraussetzungen als auch von den politischen Rahmenbedingungen abzuhängen.

Im letzten Forschungsartikel wird eine Erweiterung des in dieser Arbeit SpVAR eingesetzten Ansatzes präsentiert, der die Möglichkeit bietet, räumliche Spillover-Effekte korrekt zu analysieren. Der Artikel zielt nicht primär darauf ab, neue empirische Erkenntnisse zu liefern, sondern die räumliche Dimension von SpVAR-Modellen zu erweitern, in dem die vollständigen räumlichen Spillover im Zeitverlauf der geschätzten Impuls-Antwort-Funktionen erfasst werden. Dies ermöglicht die Schätzung von Effekten, die lokale Politikmaßnahmen in benachbarten oder ökonomisch stark verbundenen Regionen auslösen. Die Analysen zeigen, dass ökonomische Schocks positive Reaktionen in der Ursprungsregion und gleichzeitig negative Substitutionseffekte in benachbarten Regionen auslösen können.

Die vorgestellten Ergebnisse können insbesondere für politische Entscheidungsträger von Interesse sein, da relevante politische Implikationen abgeleitet werden können. Basierend auf den empirischen Erkenntnissen können räumliche Umverteilungspolitiken die regionale Entwicklung strukturschwacher Regionen, insbesondere die Lebensqualität und den materiellen Lebensstandard in diesen Regionen unter bestimmten Voraussetzungen unterstützen. Erstens scheinen die nicht zweckgebundenen Mittel aus dem Finanzausgleich eine effektivere Maßnahme als strukturelle Investitionsfonds zu sein, um die regionalen Wanderungsraten zu verbessern und damit einhergehend scheinbar die nicht-materiellen Lebensbedingungen zu fördern. Zweitens deutet die hohe Abhängigkeit der Effekte von der geringeren Wirtschaftskraft der Regionen darauf hin, dass die politischen Maßnahmen noch stärker auf eben diese Regionen zugeschnitten sein sollten, damit eine möglichst hohe Effektivität erreicht wird. Schließlich müssen politische Entscheidungsträger und Forscher auch mögliche räumlich indirekte Effekte berücksichtigen, da positive Effekte in geförderten Regionen negative Effekte in benachbarten Regionen nach sich ziehen können.

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1. General Introduction: Regional inequalities and the need for a more differentiated analysis of regional policy effects

“Our goal is to achieve equivalent living conditions in urban and rural areas throughout Germany. (...) A new all German support system for structurally weak regions, cities, municipalities and counties addresses growing inequality between cities and regions and serves the goal of creating equal living conditions in Germany." (CDU, CSU & SPD, 2018, p109; p116).

With these words, the German coalition agreement from 2018 between the governing parties CDU/CSU and SPD dedicated political measures in the following years to the goal of equivalent living conditions, which is in fact synonymous with the objective of reducing disparities between German regions that affect the people’s everyday lives. It proves that the discussion about regional inequalities within and between highly developed countries has not only become an important topic in the field of economic geography and regional science, but is also taking place in the political debate. The findings and proposals of an expert commission under the direction of the German ministry of the interior were presented in “Our Plan for Germany” in July 2019 (Federal ministry of the Interior, Building and Community, 2019). A key finding of the report is the recognition that existing structural policy measures need adjustments to support structurally lagging regions more efficiently.

Those policy measures have in common that they directly support underdeveloped regions, aiming to reduce interregional disparities at different regional levels. Germany’s current structural and regional redistribution policies were primarily designed to support the reunification process between East and West Germany that started in 1990 and is still ongoing, as it can be seen in Figure 1.1. This historical dimension, as well as the political topicality and the low economic centralization compared to other European countries, make Germany an

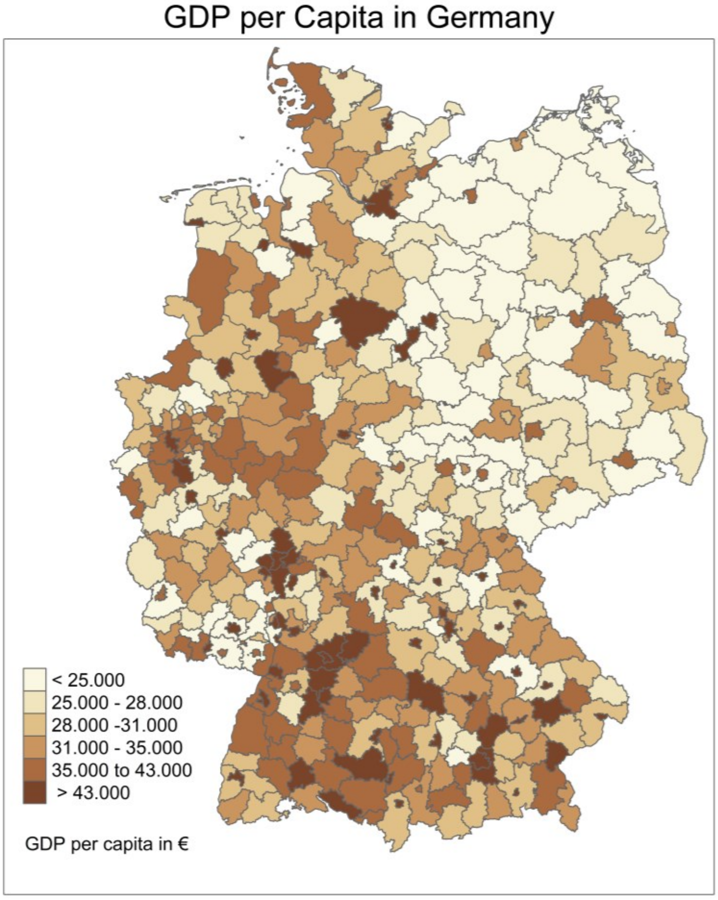

Figure 1.1: GDP per capita in German Cities and County districts 2016. Data source: Working Group "National Accounts of the Federal States"

interesting case study in the scientific discussion around tackling regional inequalities with regional policy measures.

However, economic and social developments tend to increase dissimilar living conditions within countries in Europe and the world and pose new challenges to regional and structural policy measures that are not limited to Germany, such as the European Cohesion Policy. The first challenge arises from long-term structural change. The ongoing economic development towards a globalized and digitalized information- and knowledge-based high-tech economy causes a concentration of innovation and jobs in metropolitan areas, especially high-wage jobs in knowledge intensive business services, that is discussed as the "new geography of jobs" (Moretti, 2012). Hence, attractive cities that are integrated into dynamic global networks, such as London, Paris or Berlin, are growing fast, accumulating human capital and knowledge and becoming increasingly expensive. Conversely, the number of jobs created in rural and peripheral areas is declining with lower average payment and selective out-migration of high-potentials (Stockdale, 2006). This economic divide becomes apparent in Figure 1.1. In addition, traditional industrial and manufacturing areas are still struggling with long-term decline due to structural change and the accompanying local problems such as high unemployment rates, low competitiveness and municipal tax revenues. This development causes a divide between dynamic metropolitan areas and their suburbs on the one hand and rural and old industrial areas on the other hand which is expected to widen in the future (Iammarino, Rodriguez-Pose & Storper, 2019).

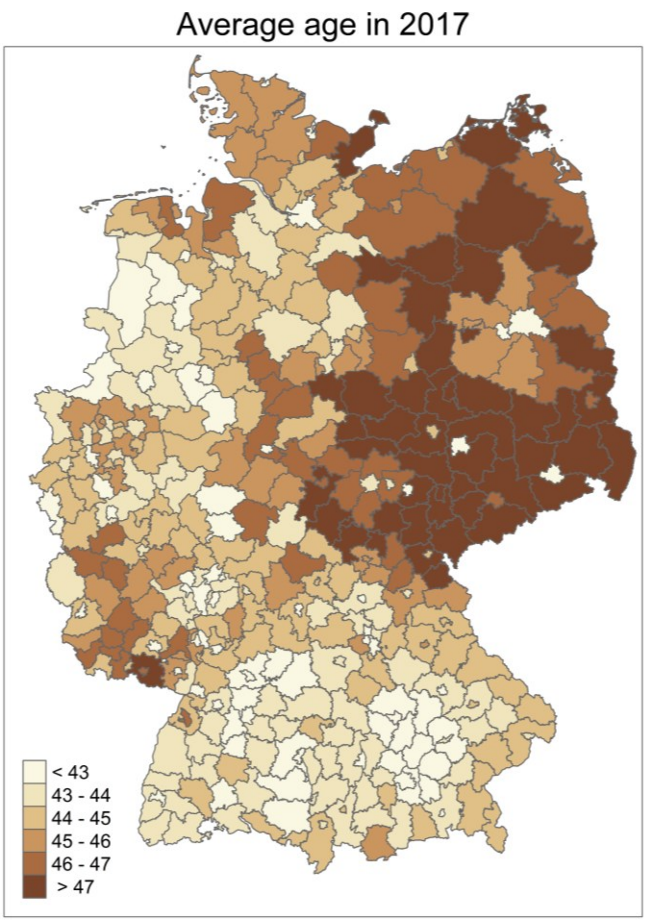

Figure 1.2: Average age of population in German cities and county districts 2017. Data Source: Official Federal and state intercensal population updates based on the Census 2011

The second major challenge for regional development is the demographic change. The ageing of society mainly affects rural regions, since young people leave to take advantages of the broader opportunities offered by cities (Stockdale, 2006). In consequence, the populations of these areas are ageing faster than those that are attractive to young people and the population density of the regions that experience out-migration declines. As illustrated in Figure 1.2, especially the rural parts of East Germany that experienced substantial out-migration since 1990 are ageing fast, while cities, even those in the East, have the youngest population. As shown by the federal population forecast, future migration and natural population trends will even increase the differences between regions with shrinking and growing population (Schlömer et al., 2015).

A constantly shrinking population has manifold socio-spatial consequences that overlap each other. Mitze et al. (2017) find negative effects of ageing populations to regional labor markets that result in long-term labor-market marginalization of regions. Moreover, shrinking populations put supply structures and local infrastructure under pressure. The capacity utilization of necessary physical and social infrastructures such as grocery stores, public transport or health-care, educational and community life institutions decreases and makes them less profitable at simultaneously declining municipal tax revenues that limit public budgets (Steinführer et al., 2014). Beyond that, lower returns on housing due to declining demands compared to other regions may inhibit private capital investments in residential construction, modernization projects and related infrastructure. This underinvestment deteriorates the quality of housing supply in the long term (Couch & Cocks, 2013). Those factors have direct impact on the quality of life of the remaining residents in less attractive regions and will probably lead to further population losses, as the regions become more and more unattractive to live in and manifest interregional disparities. Hence, the dynamics of regional economic, demographic and social inequalities are strongly interwoven.

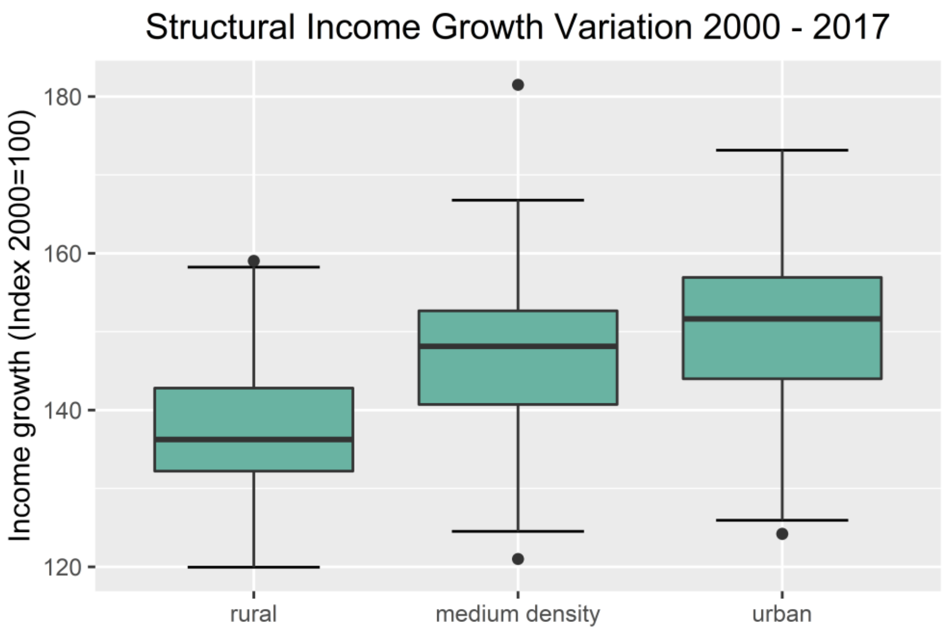

Figure 1.3: Development of average disposable household income in German cities and counties by region type. Own calculation on the basis of data by the German Federal Statistical Office. Regional Classification: Federal Institute for Research on Building, Urban Affairs and Spatial Development

The development of growing regional inequalities is a global phenomenon. For example, Ghanong and Shoag (2015) find that the inequality in average personal income between US metropolitan areas has increased by 30% between 1980 and 2016. Furthermore, Eurostat data reveals, that the total GDP at current market prices in London increased by more than 50% between 2002 and 2018, while the increase amounted to only 16% in North-West England that includes cities with a strong industrial tradition like Manchester and Liverpool as well as rural areas (NUTS-1) (Eurostat, 2021). A similar trend applies to Germany (Figure 1.3). Average disposable household incomes grew considerably faster in urban areas than in rural areas between 2000 and 2017. In addition, as it is shown in more detail in section four, average gross wages on the top of the regional wage distribution grew significantly in German regions between 2000 and 2010, while wages below the median did not grow at all in this period (see Figure 4.1). Thus, disparities do not only rise between regions, but also within regions, which increases overall economic inequalities.

However, inequalities experienced on a daily basis are much more extensive and not limited to the economic dimension. They strongly affect the everyday quality of life of the residents by determining for example the material living standards, access to social and educational infrastructure, local supply of goods, the accessibility of traffic infrastructure and public services, availability of high-speed internet, health care infrastructure or other regional amenities that affect the resident's utilities. Figure 1.4 illustrates the regional characteristics of some interesting indicators on the level of cities and county districts in Germany and reveal notable disparities. It becomes obvious that people in economically weak regions face a higher risk to die at a young age, maybe as a result of weaker health and emergency infrastructure. In addition, rural regions, especially in the east have a low share of households for which a broadband internet connection is available. Moreover, availability of supermarkets and primary schools among other indicators is unequally distributed. Thus, the region a person lives in determines the individual living standards, opportunities and restrictions in the everyday life.

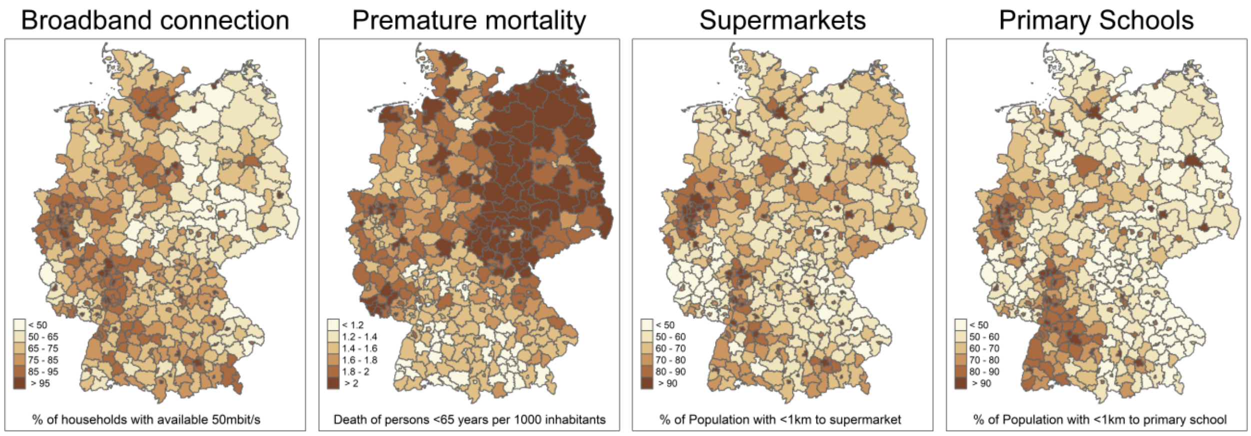

Figure 1.4: Regional inequalities among German cities and county districts in 2017. Data sources: a) Broadband Atlas of the Federal Ministry of Transport and Digital Infrastructure; b) Federal and State deaths statistic; c) and d): Local supply model of the Federal Institute for Research on Building, Urban Affairs and Spatial Development

Does this knowledge about interregional disparities result in the need for political interventions? Common theories of regional growth, such as the New Economic Geography, endogenous growth theory or evolutionary economic geography, suggest that geographical concentration and agglomeration of economic activities bring positive externalities like increasing returns, so that the total output of a region or country should be larger in the presence of regional inequalities (Krugman, 1991; Baldwin et al., 2003; Boschma & Frenken, 2011; Vazquez-Barquero, 2002). High-productive and high-income regions such as agglomerations and regional clusters increase the total efficiency by concentrating physical and human capital and promoting the capabilities to build networks, increase knowledge and innovation and therefore increase the economic standard of the whole country, while those who live in low-income and low-opportunity regions opportunities are free to move to high-income areas and spatial spillovers ensure the spatial dispersion of wealth to a certain point. Thus, investing in agglomerations and front-runner cities should be the best way to enhance total growth and material living standards (Glaeser, 2011). In consequence, policy interventions that tackle economic inequalities may harm total economic growth (Champornowne & Cowell, 1998; Baldwin et al., 2005).

However, this is only half the story. First, the capabilities to migrate and participate on growth are not given automatically. Personal income and movement costs limit the individual possibility to move. Second, individual circumstances such as families and partnerships, immobile properties and obligations, social relationships or job securities work as migration frictions that explain the maintenance of regional inequalities against spatial equilibrium assumptions (Heise & Porzio, 2019). Migration frictions are treated in more detail in chapter 2. In general, people or families with higher incomes and educational levels have higher capabilities to move into regions that promise higher personal incomes and opportunities (Faggian et al., 2012). These selective migration patterns would increase social inequalities and would have negative impact on the living standards of those left in peripheral areas. Third, empirical studies question the basic assumption of a positive relationship between regional inequalities and economic growth for high-developed regions (Brueckner & Lederman, 2015).

In addition, empirical studies investigated the long-term economic, social and political consequences of rising inequalities and economic decline. Economic implications are of rather direct nature. Lower incomes and high unemployment rates limit wealth and material living standards below the level of other regions. Moreover, low incomes alleviate educational standards within the population through persistent outmigration of well-educated persons and missing scopes for individual potentials result in social marginalization of people due to their place of residence. Reduced educational supply due to limited public budgets will even increase this problem. Further social inequalities are rather indirect outcomes. US regions in economic decline are found to have higher premature mortality (in line with Figure 1.4) and lower fertility and marriage levels and more children raised in poverty (Autor et al., 2019). As shown by Chetty et al. (2014) the place of birth also impacts intergenerational income mobility and restricts social advancement opportunities in the US. Thus, regional inequalities cause a lack of perspectives, economic and social life opportunities and life expectancies at birth in structurally lagging regions. Hence, regional inequalities have enormous consequences to the society and lead to a polarization of individual opportunities (Storper, 2018). Regional policies are therefore a way to increase equity in life chances across regions.

Another thread of studies highlights the political outcome of regional inequalities and rising political discontent in disadvantaged regions that are named by Rodriguez-Pose (2018) as "places that don`t matter". These regions are those peripheral or old industrial regions that once were rather prosperous but suffer from economic decline and now concentrate rising protests and populist and anti-establishment votes in many developed countries (see also McCann, 2016 and Dijkstra et al., 2019). This leads to a divide between winners and losers of the described regional socio-economic trends and reflects the divide between dynamic regions and declining and lagging behind regions that offer rising lack of perspectives. For example, Frey (2021) shows that in the US presidential elections 2020, Donald Trump could win 2588 of 3319 counties (82.4%). However, these are home to only 39.7% of the population, as Trump voters mainly came from more rural and economically weak regions in the US' geographic center, while large cities voted in favor of Joe Biden. Similar trends and urban/rural divides could be seen for example in the Brexit votes in 2015 and in national votes all over the world, including France, Germany, Austria or Thailand (Rodriguez-Pose, 2018; Essletzbichler et al., 2018). Hence, regional decline may threaten long-term social cohesion and political stability leading to votes for populist parties and "regional inequality is becoming too dangerous to ignore" (The Economist, 2016, 17th December, pp 70 – 71).

It therefore appears as a new task in regional studies and economic geography to develop strategies for regional development in the obvious conflict of objectives in regional policy-making that can be summarized as promoting efficiency versus tackling inequalities and ensuring socio-economic stability. Hence, Iammarino et al. (2019) argue that place specific policies tackling regional inequalities are social policies before economic policies, although their instruments are mainly of economic nature. Thus, policy can be effective even if the total visible economic outcome is limited. Ferrara and Nisticò (2019) highlight that measuring the effects of redistribution policies should not be evaluated solely on the basis of effects on the regional GDP, but jointly consider effects on material as well as on non-material living standards and regional well-being. This is even more the fact as most regional policy goals are not limited to economic growth. So has the European Commission highlighted the importance of social progress as a key objective of European Cohesion Policies by launching a new EU "Social Progress Index" in December 2020 that aims to measure regional development "beyond GDP" (Annoni & Bolsi, 2020).

This thesis aims to make substantial contributions to the topic of regional inequalities, the ongoing political debate and the widespread scientific literature on the efficacy of policy interventions that are dedicated to less developed regions, by presenting novel empirical findings of regional policy effects on socio-economic indicators that are more aligned with individual quality of life and well-being and go beyond measuring GDP effects. While there are a lot of studies dealing with effects on economic growth, these indicators have hardly been considered in the scientific debate so far. Moreover, the thesis aims to present cutting-edge empirical spatial econometric methods in quantitative policy evaluation and to contribute to this research by extending the recently more often used SpVAR approach to an explicitly spatial research design that includes effects in economically linked regions and accounts for spatial spillovers in the estimated effects over time (see Section 1.3 & section 5). This thesis consists of an overall introductory framework that gives a brief introduction into research questions, research settings and regional policy designs (Sections 1.1 to 1.3) and four individual research papers that are published or currently under review in international journals in the field of regional science (Section 2 - 5). Section 1.4 gives a brief introduction and overview on the conducted research papers. The thesis closes with a general conclusion that connects the most important findings of the conducted empirical research (Section 6).

1.1 Research questions and contribution

A large amount of money is spent in place-based policy measures that can be described as spatial redistribution policies and aim at a more even spatial development. For instance, almost a third of the total EU budget 2014 – 2020 has been spent for Cohesion Policy measures (European Commission, 2014). In the new deal in December 2020 the member states agreed on a policy budget of more than 330 billion euros in seven years, despite the financial challenges due to the Covid-19 crisis (Sapała, 2019). Large sums are also paid out in the context of intra-country redistributions, such as the German GRW policy and interregional financial equalization (see Section 1.2).

However, while there is a long tradition of dealing with economic growth effects of regional policy, there is a lack of scientific research and knowledge about effects that are not directly related to economic growth. A main reason why this is more or less ignored is the lack of objective, accurate and available indicators as well as data quality to measure non-economic living-standards (Ferarra et al., 2020). Well-being and quality of life are, in contrast to GDP, not an exactly definable and objectively measurable indicator, but have many dimensions and are highly subjective. Every citizen can emphasize and weight its individual values to determine its individual perceived well-being and quality of life (see Section 2). Moreover, constructing a reliable composite index is very challenging and vulnerable to personal views of the researchers (Dialga & Thi Hang Gang, 2017). Furthermore, Bond and Lang (2019) and Odermatt and Stutzer (2019) highlight problems with the consistency of self-reported well-being indices especially in a multi-region setting.

However, the question of measuring socio-economic progress is of growing political interest. Recently, several national or regional strategies have been developed to foster social progress and well-being, which becomes for example apparent in the mentioned European Social-Progress-Indicator. Moreover, Scotland's first minister Nicola Sturgeon dedicated well-being as an objective as important as economic growth to Scotland's development (Sturgeon, 2019). Scotland, Iceland and New Zealand joined the "Wellbeing Economy Governments" that have set themselves the goal to focus on well-being instead of GDP measures. It shows that economic growth, especially the value of GDP, as all-in-one indicator for economic and social progress and the dimension of regional inequalities is declining.

This evolves to the first key question of this dissertation:

1. *How can individual well-being and the dynamic development of multidimensional regional inequalities be measured in a suitable way beyond economic parameters?*

This is necessary to estimate the impact of regional and structural policies on these attributes. Many studies have discussed the multidimensional expression and possible operationalization of individual well-being and proposed a variety of new indicators (e.g. Stiglitz et al., 2009; Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung & Conseil d'Analyse Économique, 2010; Held et al., 2018; Ferarra & Nisticò, 2019; Ferarra et al., 2020). These indicators include multiple dimensions that determine and ensure social integration and social participation opportunities for every individual, including material living standards, employment, health care, education, child care, personal activities, work, political voice and governance, social connections and relationships, physical environment, culture, housing, public services, free time, political & physical insecurities, personal relations, environment and ecology and more.

However, in the context of dynamic model building and estimating the multiple regional effects of regional policies, the indicators need to fulfill additional criteria that influence the selection of appropriate indicators. These need to be quantifiable on a regional level, available with high and reliable data quality and dynamic, to see effects of regional policy interventions within the quantitative data analysis. Moreover, substantial local developments (such as increasing local infrastructure quality) have to be reflected in aggregated indicators on a regional level. This is also discussed in the Chapters 2 and 3. As a result, it is concluded in this sections that regional dynamics in the net migration rates are a convenient indicator to estimate the economic and non-economic quality of life and regional amenities. Chapter 4 treats the case of individual living-standards and social fairness of structural policies in estimating the effects on average regional wages. It first investigates the transmission of subsidies to workers and second addresses potential failures of policy measures, as more wealthy people benefit more from subsidies when poor people in rich regions contribute to support rich people in poor regions, (Oates, 1972). To the best of my knowledge these potential outcomes have not been assessed in this context before.

The second key question evolving from this research setting is:

2. *Which policy measures are proving particularly effective to reduce dimensions of regional inequalities?*

Regional policy measures are very different. Structural Policies in Germany such as the GRW fund subsidize particularly individual firms and economic infrastructure. Moreover, there are funds concentrating on research and development, urban or rural development or equalization schemes that redistribute a part of regional tax revenues across regions to secure interregional fairness. European regional and development funds (ESIFs) work on a similar basis also fostering regional development and aiming at regional cohesion with subsidizing regional projects in very different fields of regional development. Due to their different settings, regional policies are expected to have conditional effects, depending on the strength of the regional economy or other regional determinants that impact possible transmission channels (Iammarino et al., 2019). This prompts two additional research questions:

3. *Are there differences in the regional effects between those policy measures that directly affect public institutions and the municipal budget (e.g. formula-allocations in fiscal equalizations) and those that directly support private actors (e.g. structural funds)?*
4. *Are there regional differences in the effectiveness of funds, for example between rural and urban areas? Can regional factors be identified that have a particular (positive or negative) influence on the impact of policy measures in the selected areas of life (e.g. population density, demographics or economic strength)?*

These questions are individually discussed in every chapter. The mode of action of regional policies is generally discussed in chapter 1.2 und is presented according to the respective research setting.

As stated above, a second objective of this dissertation is to apply cutting-edge econometrical research settings to answer the developed research questions. The existing literature on the statistical evaluation of regional policy measure uses manifold statistical and econometric methods. However, as shown by Hagen and Mohl (2009) in the context of European Cohesion policies, these approaches face manifold advantages but also notable drawbacks, that result for example from the type of incorporation of the policies in the model, the use of territorial units, within-region heterogeneity, spatial spillover effects or biases of the used statistical model. Another problem is that a model should also measure indirect effects. For example, if a policy fosters economic growth, which then affects other regional indicators of interest, this should be detected in the model. Thus, this dissertation additionally aims to apply and develop spatial econometric models that fit best to the research question and contribute to the development of econometric methods in this field. The general methodological approach is discussed in chapter 1.3. An advanced spatial econometric method that contributes methodologically to the field of spatial econometric is presented in chapter 5.

1.2 Regional policy settings

The thesis at hand focusses on three regional policies, the German structural fund GRW, the German municipal equalization scheme and the European Cohesion Policy framework. They have been selected, because they all have the overall objective to contribute to the reduction of regional disparities due to spatial redistribution of financial means, have a substantial financial volume that should make a measurable contribution to the regional development, but differ substantially in their strategies, objectives, modes of action, funded institutions and expected regional effects and transmission channels. Due to their individual funding designs, it is expected that policies contribute to the individual quality of life through different transmission channels. Each research paper in this thesis deals with the effects of one or more of these policies.

In general, all three policies redistribute financial means from economically wealthier to economically or geographically disadvantaged regions and aim to foster regional developments and counterbalance constraints that persons, firms and institutions in these regions face in terms of economic strength and personal perspectives such as income levels or work opportunities. Thus, all policies should promote economic or social catching-up processes that contribute to the quality of life in these regions and increase individual perspectives and opportunities.

First GRW, a German structural investment fund with strong economic focus that directly subsidizes private investment projects and firm settlements in economically lagging regions and public infrastructure projects of economic importance, especially in East-Germany. Since its introduction in 1969 GRW has become the most important regional policy instrument to support economic growth and reduce spatial economic inequalities in Germany (Deutscher Bundestag, 2014). The key objectives are to foster economic growth, competitiveness and job creation. Subsidies are earmarked to specific projects and due to its co-funding approach the policy additionally aims to spur private investments in those regions. Sections 2 and 4 investigate GRW effects and deal with the policy settings in more detail.

The European Cohesion policy has similar mechanisms and is closely related to GRW policy, especially the European Regional Development Fund (ERDF). The European Structural Investment Funds consists of five distinct funds (ERDF, European Social Fund (ESF), Cohesion Fund (CF), European Agricultural Fund for Rural Development (EAFRD) and European Maritime and Fisheries Fund (EMFF)), from which the first three belong to the strand of Cohesion policy that mainly aim at the objective of regional convergence in the European Union. Just as GRW, these policies are project-based investment policies. However, they include more social investments and societal objectives such as sustainability and social progress. Section 3 delivers more insights on the mode of action of European Cohesion policies.

The last policy under investigation is the financial equalization scheme on municipality level in Germany. In regional financial equalization schemes, public financial means such as tax revenues are spatially reallocated to municipalities in structurally weaker regions in order to provide additional financial resources and ensure financial flexibility, capacities to act and provision of public goods (Lenk et al., 2013). Despite its large financial volume, effects of financial equalization are not investigated very often compared to the other policies (Wardenburg & Brenner, 2020; Lehmann & Wrede, 2019). Equalization grants are not project-bound, but directly enhance the public budget of disadvantaged regions, which makes them the largest source of income for regions with low revenues (Buettner & Holm-Hadulla, 2008). While availability of GRW und Cohesion policy subsidies depend on the regional eligibility status, the distribution of equalization means is formula based. The objectives of financial equalization policies are not of economic nature in the first place, which leads to the hypothesis that policy outcomes and transmission channels substantially differ from the other two policies. Section two compares regional outcomes of the financial equalization scheme to GRW structural funds.

1.3 Empirical methods and econometric approach

In order to gain new empirical insights to the subject of regional policy analysis, it is important to focus on the best available research methods to empirically estimate the multifaceted effects of regional policies. As stated before, the discussion and the use of empirical methods in studies with similar research questions is widespread from case studies to spatial econometric analysis that results in a variety of methodological approaches. This thesis focusses on spatial vector-autoregressive multi-equation panel model approaches (SpVARs). These are hardly used in this research setting before (Rickmann, 2010), but gained more attention in regional policy evaluation in recent years (e.g. Eberle et al., 2019; Mitze et al., 2018; Marquez et al., 2014; Ramajo et al., 2014)

SpVAR models offer a number of advantages that make them very appropriate for empirical analysis in this context. The first important point is that the method allows to focus on more than one outcome variable within the same model, which allows to reflect in the models that the outcome of a complex and heterogeneous policy such as Cohesion policy is not limited to one variable or transmission channel and is able to measure economic and quality-of-life-indicators effects at the same time (Mitze et al., 2018). Moreover, while single equation approaches focus only on direct relationships between dependent and independent variables, SpVARs are able to capture mutual indirect effects and interdependencies between variables. This is important, since the relationship between subsidies and outcome variables is not necessarily direct, especially in the case of non-economic outcome to structural policy interventions. For example, if the policy leads to economic growth that rises wages or causes in-migration at a later point in time, this is not reflected in a single equation approach, but in the SpVAR model.

Furthermore, the flexibility of estimators allows to integrate flexible time-lags of dependent and independent variables that reflect the dynamic regional development within the econometric models and allows for the inclusion of space-time lagged variables that control for spatial spillovers across regions, as well as statistical components such as fixed-effects. These spatial spillovers are an important additional indirect outcome of policies. However, current models underestimate those spillovers. Therefore, section 5 deals with the further advancements to empirical integration of spillover into the SpVAR approach.

The exact empirical strategy, use of variables and data is explained separately in every research paper. Each model in this thesis is developed on the basis of individual theory in the specific field and therefore has its own theoretical derivation.

1.4 Thesis outlook

The empirical part of the thesis starts with a focus on regional policy effects on quality of life in Germany (Section 2). The theoretical approach argues that migration is a reasonable indicator to measure the quality of life. The paper focusses on two policies, GRW and the municipal equalization scheme. The second paper (Section 3) sheds light on the European Cohesion policy and investigates the combination of economic effects and effects in migration dynamics in European NUTS-2 regions. The third paper deals with the aspect of material living standards. GDP growth and wages are not necessarily linked on the regional or national level (Schwellnus et al., 2017). Therefore, the paper concentrates on the transmission of economic growth to employee wages. Moreover, by investigating effects on the wage distribution it focuses on regional policy effects on intraregional economic inequalities and asks "Who profits from structural policy interventions?". The last research paper deals with the stated drawbacks of SpVAR models in the inclusion of spatial spillover effects and proposes an advanced econometric method to include spillover effects into the estimated policy effects. Section 6 combines the findings from these individual parts and concludes.

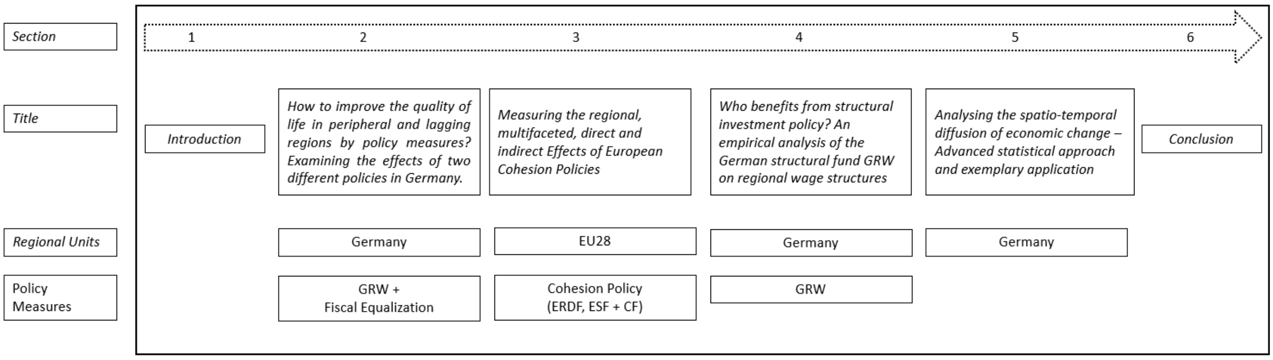

Figure 1.5: Thesis outlook. Research papers, regional units and policies under investigation. Own illustration

1.5 References

Annoni, P. & Bolsi, P. (2020). The Regional Dimension of Social Progress in Europe – Presenting the new EU Social Progress Index. *European Commission Working Paper 06/2020*. Luxemburg: Publications Office of the European Union.

Autor, D., Dorn, D. & Hanson, G. (2019). When Work Disappears: Manufacturing Decline and the Falling Marriage Market Value of Young Men. *American Economic Review: Insights*, 1, 161-178.

Baldwin, R., Forslid, R., Martin, P., Ottaviano, G. & Robert-Nicoud, F. (2005). *Economic Geography and Public Policy*, Princeton: Princeton University Press.

Bond, T. & Lang, K. (2019). The Sad Truth about Happiness Scales. *Journal of Political Economy* 127, 1629-1640.

Boschma, R. & Frenken, K. (2011). The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, 11, 295-307.

Brueckner, M. & Lederman, D. (2015). Effects of Income Inequality on Aggregate Output. *World Bank Policy Research Working Paper 7317,* World Bank, Washington, DC.

Buettner, T. & Holm-Hadulla, F. (2008). Fiscal Equalization: The Case of German Municipalities. *CESifo DICE Report 1/2008*, 16-20.

Champernowne D. & Cowell, F. (1998). *Economic inequality and income distribution*. Cambridge University Press, Cambridge.

CDU, CSU, SPD (2018). *Ein neuer Aufbruch für Europa. Eine neue Dynamik für Deutschland. Ein neuer Zusammenhalt für unser Land.* Koalitionsvertrag zwischen CDU, CSU und SPD. Koalitionsvertrag der 19. Legislaturperiode vom 12. März 2018, Berlin.

Chetty, R., Hendren, N., Kline, P. & Saez, E. (2014). Where is the land of Opportunity? The Geography of Intergenerational Mobility in the United States. *The Quarterly Journal of Economics*, 129, 1553-1623.

Couch, C. & Matthew Cocks (2013). Housing Vacancy and the Shrinking City: Trends and Policies in the UK and the City of Liverpool. *Housing Studies*, 28, 499-519.

Dialga, I. & Thi Hang Giang, L. (2017). Highlighting Methodological Limitations in the Steps of Composite Indicators Construction. *Social Indicator Research,* 131, 441-465.

Deutscher Bundestag (2014). *Koordinierungsrahme der Gemeinschaftsaufgabe „Verbesserung der regionalen Wirtschaftsstruktur" ab 1. Juli 2014*. Deutscher Bundestag, 18. Wahlperiode, Drucksache 18/2200.

Dijkstra, L., Poelman, H. & Rodríguez-Pose, A. (2020). The geography of EU discontent, *Regional Studies*, 54, 737-753. DOI: 10.1080/00343404.2019.1654603.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98, 701-735, DOI: 10.1111/pirs.12373.

Essletzbichler, J., Disslbacher, F. & Moser, M. (2018). The victims of neoliberal globalisation and the rise of the populist vote: a comparative analysis of three recent electoral decisions. *Cambridge Journal of Regions, Economy and Society*, 11, 73-94.

European Commission (2014). Investment for jobs and growth. In Promoting development and good governance in EU regions and cities, sixth report on economic, social and territorial cohesion. *Publications Office of the European Union,* Luxemburg.

Eurostat (2021). Gross domestic product (GDP) at current market prices by NUTS 2 regions (nama_10r_2gdp), retrieved from:
https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10r_2gdp&lang=en

Faggian, A., Olfert, M. & Partridge, M. (2012). Inferring regional well-being from individual revealed preferences: the voting with your feet approach. *Cambridge Journal of Regions, Economy and Society*, 5, 163-180. DOI: 10.1093/cjres/rsr016.

Federal Ministry of the Interior, Building and Community (2019). *Unser Plan für Deutschland – Gleichwertige Lebensverhältnisse überall – Schlussfolgerungen von Bundesminister Horst Seehofer als Vorsitzendem sowie Bundesministerin Julia Klöckner und Bundesministerin Dr. Franziska Giffey als Co-Vorsitzenden zur Arbeit der Kommission „Gleichwertige Lebensverhältnisse"*. Publication of the Federal Ministry of the Interior, Building and Community, Berlin.

Ferrara A., Dijkstra L., McCann P. & Nisticò, R. (2020). The Response of Regional Well-Being to EU Cohesion Policy Interventions. *SSRN Working Paper*. DOI: http://dx.doi.org/10.2139/ssrn.

Ferrara, A. & Nisticò, R. (2019). Does Institutional Quality Matter for Multidimensional Well-Being Inequalities? Insights from Italy. *Social Indicators Research,* 145, 1063-1105.

Frey, W. (2021). Biden-won counties are home to 67 million more Americans than Trump-won counties. In: *The Avenue – Rethinking Metroplitan Policy Program Brookings*, 21.01.2021. https://www.brookings.edu/blog/the-avenue/2021/01/21/a-demographic-contrast-biden-won-551-counties-home-to-67-million-more-americans-than-trumps-2588-counties/

Glaeser, E. L. (2011). *Triumph of the city: How our greatest invention makes us richer, smarter, greener, healthier, and happier.* New York: Penguin Press.

Ganong, P. & Shoag, D. (2015). Why has regional income convergence in the US declined? *Harvard Kennedy School Working Paper*, Cambridge.

Hagen T. & Mohl P. (2009). Econometric evaluation of EU Cohesion Policy: A survey. *ZEW Discussion Paper 09-052*, Mannheim.

Held, B., Rodenhäuser, D., Diefenbacher, H. & Zieschank, R. (2018): The National and Regional Welfare Index (NWI/RWI): Redefining Progress in Germany. *Ecological Economics*, 145, 391-400.

Heise, S. & Porzio, T. (2019). Spatial Wage Gaps and Frictional Labor Markets. Staff Report No. 898. New York: Federal Reserve Bank of New York.

Iammarino, S.; Rodrguez-Pose, A. & Storper, M. (2019). Regional Inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*, 19, 273-298.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99, 183-199.

Lehmann, I. & Wrede, M. (2019). The Bavarian Municipal Fiscal Equalization Scheme: Emphasis on Equity Rather than Efficiency. *FinanzArchiv*, 75, 127-151.

Lenk, T., Hesse, M. & Lück, O. (2013). Synoptische Darstellung der kommunalen Finanzausaugleichssysteme der Länder aus finanzwissenschaftlicher Perspektive*. Studie im Auftrag des Landesrechnungshofs Mecklenburg-Vorpommern*, Leipzig.

McCann, P. (2016*) The UK Regional–National Economic Problem. Geography, Globalisation and Governance*, Routledge, London.

Mitze, T., Schmidt, T. D., Rauhut, D. & Kangasharju, A. (2018). Ageing shocks and short-run regional labour market dynamic in a spatial panel VAR approach. *Applied Economics*, 50, 870-890. https://doi.org/10.1080/00036846.2017.1346360.

Moretti, E. (2012). *The New Geography of Jobs.* Houghton Miffling Harcourt, Boston.

Oates, W. (1972). An Essay on Fiscal Federalism. *Journal of Economic Literature,* 37, 1120-1149.

Odermatt, R. & Stutzer, A. (2019). (Mis-)Predicted Subjective Well-Being Following Life Events. *Journal of the European Economic Association,* 17, 245-283.

Ramajo, J., Marquez, M. & Hewings, G. (2017). Spatiotemporal Analysis of Regional Systems: A Multiregional Spatial Vector Autoregressive Model for Spain. *International Regional Science Review*, 40, 75-96.

Rickman, D. S. (2010). Modern macroeconomics and regional economic modeling*. Journal of Regional Science*, 50, 23-41.

Rodriguez-Pose, A. (2018). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society*, 11, 189-209, DOI: 10.1093/cjres/rsx024.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung; Conseil d'Analyse Économique (2010*): Wirtschaftsleistung, Lebensqualität und Nachhaltigkeit: Ein umfassendes Indikatorensystem.* Expertise im Auftrag des Deutsch-Französischen Ministerrates, Expertisen, Sachverständigenrat zur Begutachtung der Gesamtwirtschaftlichen Entwicklung, Wiesbaden.

Sapała, M. (2019). How much for Cohesion Policy in the 2021-2027 Multiannual Financial Framework? *Regions e-Zine*, 4. DOI: 10.1080/13673882.2018.00001042.

Schlömer, C., Bucher, H. & Hoymann, J. (2015). Die Raumordnungsprognose 2015 nach dem Zensus. In: Bundesinstitut für Bau Stadt- und Raumforschung (BBSR): *BBSR Analysen Kompakt 5/2015*, Bonn.

Schwellnus, C., Kappeler, A. & Pionnier, P. (2017). The Decoupling of Median Wages from Productivity in OECD Countries. *International Productivity Monitor*, 32, 44-60.

Steinführer, A., Küpper, P. & Tautz, A. (2014). Adapt and Cope: Strategies for Safeguarding the Quality of Life in a Shrinking Ageing Region. *Comparative Population Studies* 39, 345-370.

Stiglitz, J., Sen, A. & Fitoussi, J.-P. (2009). The measurement of economic performance and social progress revisited: Reflections and Overview. *Sciences Po publications 2009*, 33, Sciences Po, Paris.

Stockdale, A. (2006). Migration: Pre-requisite for rural economic regeneration? *Journal of Rural Studies,* 22, 354-366.

Storper, M. (2018). Separate Worlds? Explaining the current wave of regional economic polarization. *Journal of Economic Geography,* 18, 247-270.

Sturgeon, N. (2019). Why governments should prioritize well-being. *TED summit 2019*, Edinburgh, 24.07.2019.

The Economist (2016). Place-based economic policies as a response to populism. The Economist, London (17.12.2016).

Vázquez-Barquero, A. (2002). Endogenous Development: Networking, Innovation, Institutions, and Cities, Routledge, London.

Wardenburg, S. & Brenner, T. (2020) How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany. *Journal of Regional Science,* 60, 1047-1073. DOI: 10.1111/jors.12500.

2. How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany.

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Abstract: Peripheral regions commonly appear to be less attractive to live in and policy makers all over the world are applying various measures to make them more attractive. The paper analyzes the effects of two very different measures: The German municipal fiscal equalization scheme and the German funds for structurally weak areas (GRW). It focusses on the impact on perceived quality of life, measured through interregional migration between German labor market regions. Using a spatial vector-autoregressive panel model (SpVar), we find evidence that equalization transfers have a significant positive impact on regional net migration and contribute to the aim of regional equity. These effects are especially found for regions with low endogenous fiscal capacities. GRW funding reveals no significant effects on net migration rates in total, but short-term effects in rural regions.

Keywords: amenities, impulse response functions, migration, quality of life, regional policy

JEL-Classification: C33; O38; R23; R58

2.1 Introduction

Population and economic development in the world are highly polarized, with strong differences between countries as well as within countries. In most countries we find prosperous cities and peripheral regions falling short of this development. Especially rural and more peripheral regions have to deal with manifold challenges that affect regional quality of life, such as structural weakness, unemployment, smaller private incomes, demographic change and insufficient public infrastructure, whereas most metropolitan areas experience population growth and appear highly attractive as a place to live. As a result, we observe rising inequalities between those well-performing regions and declining, mostly peripheral regions. Governmental policy instruments therefore aim at reducing regional disparities by redistribution of financial funds or fiscal equalization transfers to underperforming or structural disadvantaged regions and firms, such as the European Cohesion Policies and manifold national policies. These kinds of policies can be denoted as place-based policies (Iammarino et al., 2019). Germany is an adequate case to study the effects of place-based policies, as it is facing significant disparities, especially between the former separated West and East. Politics is tackling regional inequalities with two very different policies that redistribute high amounts of money.

The economic efficiency of regional development policies has been frequently examined in the German case (Alecke, et al., 2013; Brachert, et al.; 2019; Eberle et al., 2019 and others), as well as in the case of European Cohesion Policy. Pieńkowski and Berkowitz (2016) provide an extensive summary on this issue. However, referring to the insight that regional inequalities have manifold social and political implications for society instead of being solely economic, the evaluation of regional policies should not only consider economic efficiency, but also social and regional justice (Storper, 2011). Various recent studies find that the global phenomenon of rising populist votes is an outcome of regional inequalities and structurally weak regions getting more and more suspended from economic and social development (Rodriguez-Pose, 2018; Dijkstra et al., 2020).

This paper can make a substantial contribution to the discussion on regional inequalities within high developed countries by investigating the effects of two regional equalization policies within Germany, the fiscal equalization scheme on the municipality level and the “Joint Task for the Improvement of the Regional Economic Structures” (“Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur”, henceforth GRW). The central aim of this paper is to investigate whether both policies contribute to the reduction of regional inequalities and the perceived development of the regional quality of life. In order to reach this aim, we use a flexible spatial vector-autoregressive (SpVAR) approach that is an emerging method in spatial policy evaluation (Eberle et al., 2019; Mitze et al., 2018). We use regional migration balances to measure the region's appeal and utilities to inhabitants and migrants, which gives a good impression on the development of regional quality of life in a region. This will be explained in section 2.3.

To the best of our knowledge, our study is the first enhancing an econometric spatial vector-autoregressive process to investigate the complex interactions of economic and socioeconomic variables in a spatial context. This allows us to gain new knowledge about the mechanisms behind regional policies and the complex mutual dynamics of economic and spatial socioeconomic variables. Our results suggest that fiscal equalizations on municipality level have a positive impact on regional net migration rates especially in regions with low endogenous tax income, while GRW funding reveals no significant effects on net migration rates in total, but significant short-term effects in rural regions. We conclude that the former is able to reduce regional inequalities.

The remainder of the paper succeeds as follows. We start with a presentation of the examined policies and existing literature on their effects. In section 2.3 we discuss the advantages and disadvantages of our measurement approach. In section 2.4 hypothetical effects of all policies based on theoretical consideration are developed. Our data and econometric model are presented in sections 2.5 and 2.6. Section 2.7 provides the empirical results and their discussion. Section 2.8 concludes.

2.2 Policy Setup and Literature Evaluation

This paper investigates the impact of two German regional redistribution policies aiming at regional development and cohesion. They are of particular interest as both policies provide financial support for structurally lagging regions, but differ strongly in their funding strategy, thematic focus and amount of payment. This might provide new knowledge on the instruments efficacy regarding socioeconomic regional development.

2.2.1 Fiscal equalization scheme

Financial equalization schemes are used by many countries, redistributing tax revenues from regions and municipalities with high tax incomes to those with low fiscal capacities in order to reduce spatial disparities (see Blöchliger & Charbit (2008) for an overview on OECD countries).

We focus on the German equalization scheme implemented on the municipality level including vertical fiscal transfers from federal states to local jurisdictions and de facto horizontal transfers across municipalities within federal states. These grants (*In German: "Schlüsselzuweisungen")* are institutionally separated from the horizontal equalization scheme on the federal state level ("*Länderfinanzausgleich*"), although distributed vertical means can result from this superordinate equalization level. The amount of support grants from the German equalization scheme is formula-based. The calculation design varies across the federal states, descriptions of the different calculation setups in the federal states are given by Lenk et al. (2013). In general, calculation includes the imputed financial needs and population of a municipality minus its endogenous fiscal capacities. The common basic understanding allows us to assume that appropriate analysis across federal states is possible (Eberle, 2019; Lenk et al., 2013).

The granted funds are unconditional and not earmarked to a specific project. The main purpose is to enhance the public budget of economically weak regions and allow municipalities with low fiscal income to fulfill their municipal tasks and provide public services and public goods at an adequate level. Average annual grants to municipalities amounted to 23.8 billion € in the period 2000-2014[1]. Thus, it is the by far largest regional redistribution policy and the most important income source for regions with comparatively low tax income (Lehmann & Wrede, 2019). The majority of formula-based grants is paid to municipalities in the Eastern German regions, but besides the city states of Berlin, Hamburg and Bremen every municipality received equalization payments in the investigated time period (*see Figure 2.1 for the spatial distribution of grants*).

The economic consequences of regional fiscal equalization schemes in general have been discussed over a long time period and for several countries (e.g. Buchanan, 1950; Buchanan & Wagner, 1970; Feldstein, 1970; Oakland, 1994; Albouy, 2012). The most common finding is that fiscal equalization towards less productive regions appears to be inefficient with respect to total national productivity, but promotes equity by providing necessary financial capabilities to regions with low tax capacities. As high economic productivity is linked to spatial concentration, redistribution of resources to structurally weak regions challenges the overall economic efficiency. Martin (1999) and Baldwin et al., (2005) refer to this as the inevitable trade-off between the equity and efficiency goals of public policies.

In contrast to its large volume and its economic and political relevance, scientific evidence on consequences of the German redistribution scheme is small. Henkel et al. (2018) estimate an equilibrium model for a scenario of abolished total fiscal redistribution (*federal state and*

[1] Calculation based on Quarterly Cash Statistics of the German Federal Government and the Federal States

municipality level, also including structural funds) and find evidence for increasing spatial disparities and the relocation of approximately 3.2 million inhabitants mainly from rural former recipient regions to urban areas within Germany. In this scenario national labor productivity would rise by 5.8% and real GDP per Capita by 3.7%, while negative growth effects in overcrowding cities inhibit total welfare gains. Eberle (2019) estimates a Panel VAR approach and finds that enhancing the fiscal equalization payments has significant effects on the regional employment rate, but not on other economic variables. Lehmann and Wrede (2019) confirm the common conclusions that the equity criterion of the equalization scheme is satisfied, while total efficiency is hampered by the Bavarian redistribution scheme, adapting the approach from Albouy (2012).

2.2.2 GRW

The structural fund GRW, the largest German regional economic development policy, was implemented in 1969 referring directly to the aim of regional equivalent living conditions (Bundesregierung 1969; Deutscher Bundestag, 2014). Its goals and functionality are closely related to the European Regional Development Fund (ERDF) including financial means from the European policy. In contrast to the fiscal equalization scheme, the program's main purpose is to explicitly procure primary and secondary effects on economic growth and employment by attracting mobile factors of production and stimulating private sector investments in regions as a kick-off for long-term local economic development.

Subsidies are split into two funding schemes. First, industrial investments of firms, especially labor costs and equipment capital, are subsidized. Second, municipalities are subsidized to improve economic relevant infrastructure, for instance traffic or communication infrastructure. The average annual grants amounted to 1.89 billion euros between 2000 and 2014, of which

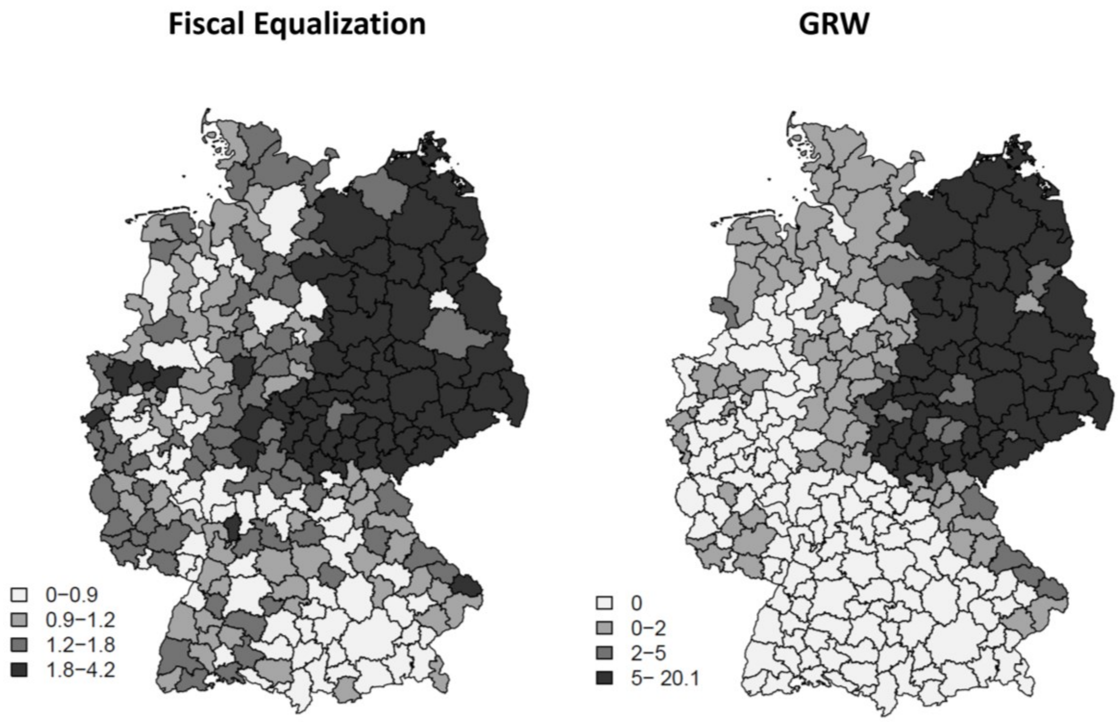

Figure 2.1: Spatial distribution of yearly average support grants from the fiscal equalization scheme and GRW funding intensity from 2000 – 2014 in € per GDP in %

1.32 billion were paid within the industrial scheme[2]. Both industry and infrastructure investments are earmarked to specific investment cases and limited to 35 – 60% of total investments to reduce windfall gains and stimulate further private investments (see Deutscher Bundestag (2014) and Alecke et al. (2013) for more details on GRW functionality). Subsidies are solely given to regions with high rates of unemployment and low gross salary levels. 122 of 258 labor market regions did not receive any GRW funds in the period considered, especially the economic stronger regions in the south. About 77.5% of the money was spent in East German regions, which are inhabited by just 15% of German population[3] (*see Figure 2.1 for spatial distribution of GRW funds*).

[2] Calculation based on Funding Data from the Federal Office for Economic Affairs and Export Control (BAFA)
[3] Own Calculations based on Funding Data by Federal Office for Economic Affairs and Export Control (BAFA) and Population data from Federal Statistic Office, Status 30.12.2017

Eberle et al. (2019) provide a detailed summary on the broad existing literature examining the economic effects of GRW funding. The majority of studies find some evidence that GRW grants support regional productivity, GDP growth and/or employment. However, up until now no study focusses explicitly on socioeconomic effects of the GRW funding scheme. Von Ehrlich and Seidel (2015) find positive effects on income and migration balances for historic equivalent funds for West German regions neighboring the Iron Curtain ("Zonenrandgebietförderung"), but also arising negative externalities of higher land rents and negative effects to neighboring regions. For the comparable EU structural funds, a small number of studies estimates effects on migration flows. Egger, Eggert & Larch (2014) find in a theoretical model that structural funds reduce net migration from economic weak to strong countries in the EU-15 over the period 1986-2004. Thomas (2013) finds analogous results for an econometric model of internal migration in Poland in the period 2004-2009.

2.3 Quality of life, appealing regions and interregional migration

Regional equalization implies the reduction of regional inequalities. Therefore, policies should contribute to compensate the disadvantages that peripheral and less economic developed regions face in terms of economic perspectives such as availability of jobs and wage level as well as non-economic factors that contribute to the quality of life in those regions. Thus, such policies should strengthen the regions' attractiveness for its current population and possible immigrants from other regions.

According to the utility maximization framework, places offer specific individual and subjective perceived utilities for its residents that depend on the fit of the places' values and the residents' individual goals and values plus their individual local social integration such as family and social contacts (Wolpert, 1965; Biagi et al., 2011). Residential choices rest upon expectations towards beneficial place utilities of alternative residences and perceived likelihoods to improve the personal well-being and achieve individual goals in those alternative places. Individual utility maximization behavior results in substantial migration flows, if place utilities are not evenly distributed in space and additional expected place values are larger than the total migration frictions and costs.

Cebula and Vedder (1973) found first that net benefits of individual migration behavior are not necessarily economic and get influenced by further residential amenities that determine the individual perception of living conditions in many ways. Gottlieb (1995, p. 1413) defines these amenities as "(…) place specific goods or services that enter the utility function of residents directly", such as regional advantages in natural or cultural conditions. Thus, migration decisions are reactions to perceived unequal distributions of regional economic strength as well as individual weighted further amenities.

It follows that regional net migration balances provide worthwhile information on the attractiveness of regions as a place to live. Faggian et al. (2012) refer to this as people "voting by their feet" for the best quality of life. Their study uses net migration as an indicator for the regional quality of life respectively well-being. This indicator has several advantages against other measurements by taking into account individual demands, preferences and subjective perception of living conditions and ensuring independency from researcher's preferences on objective indicators. Effective regional policies that improve the quality of life in regions by increasing its economic or non-economic utilities should have a direct impact on regional migration rates. Hence variations in the regional net migration rates become an appropriate indicator to measure the effects from regional redistribution and development policies on the perceived quality of life in a region.

Mobility frictions in the spatial behavior hamper migration flows, due to migration costs, insecurities in the relocation process, local social commitments or immobile possessions that create a long-term relationship between regions and their residents and alleviate the disposition of moving to another region. Hence, migration numbers are rather small compared to the dimension of spatial inequalities. Heise & Porzio (2019) describe this as the "home bias" of migration, which makes migration decisions inertial and less rational than stated above and supports the persistence of spatial inequalities. Therefore, individual migration decisions have to be provoked by changes in the personal environment that raise the perceived inequalities above a subjective threshold level. These can be either linked to specific individual chances in the destination area such as job offers, earnings, higher education opportunities and relationships, or are reactions to constraints in the current residence, such as the regional unemployment and income level, availability and quality of social infrastructure, public goods and public services. Individual weightings of amenities depend on life-cycle aspects as well as personal circumstances, such as employment status, income, education, marital status, sex or health (Greenwood, 1985).

Weaknesses from using net migration as an indicator for quality of life arises from various sources. Mobility friction and costs may bias the "voting with your feet" behavior towards the more educated and wealthy parts of the population as their mobility is higher than those who cannot afford costs and risks of migration. Thus, preferences of the former have higher impact on migration rates (Faggian et al., 2012). In addition, interregional migration patterns are also determined by developments in common preference, such as changes in attitudes towards cities or the development of fashionable locations that trigger interregional migration. Life-cycle aspects can alter the individual weighting of amenities and change place utilities without altering the regional conditions. At the same time, this aspect of using migration as an indicator provides a chance for a more detailed analysis, since migration behavior of specific demographic groups allows to draw further conclusions on which amenities triggered variations in the regional net migration.

In addition, all regional policies pursuing regional equity should aim at influencing migration streams since they can determine future economic potentials and inequalities. A constant negative local migration balance affects in particular the presence of skilled workforce, which are crucial for local innovative activities and endogenous regional growth potentials (Lucas, 1988; Romer, 1990). Out-migration causes further problems, such as real estate vacancies, investment backlogs and declining supply of public infrastructure, while workforce inflow and growth are self-enforcing in prosperous regions, which amplifies the polarization of regional development. This brings further interest to our analysis and migration rates become a reliable and comparable indicator stabilizing endogenous regional potentials and monitoring policy success.

2.4 Theoretical considerations and research hypothesis

A broad literature focusses on explaining interregional migration dynamics. Since we are interested in variations in the migration balances of individual regions, we focus on its local determinants and ignore more detailed approaches explaining complex migration patterns and interactions between regions. Internal net migration for a specific region can be modelled within the utility maximization framework as the regions' place specific average household utilities minus the national average utilities for the average household and monetary and non-monetary mobility costs and frictions. (Rappaport, 2004; Faggian et al., 2012). The utility function of the individual depends on the personal weighting of locational utilities and disutilities that affect the individual quality of life. These utilities can be categorized into economic incentives, natural amenities and cultural (man-made) residential amenities (Rodriguez-Pose & Ketterer, 2012). They will be explained in more detail in Section 2.4.1. Migration risks and costs are assumed to be constant over time and homogenous across regions, reducing the net migration of regions by the same unknown factor.

Place-based redistribution and development policies are set to affect its residents' quality of life by changing the composition of dynamic location utilities in a direct or indirect way. Approaches that model net migration as the outcome from more or less static regional differences in productivity and non-economic regional characteristics, such as Partridge et al. (2008), Biagi et al. (2011) and Rodriguez-Pose & Ketterer (2012), are good starting points to identify relevant amenities. However, these approaches are disadvantageous to investigate dynamic changes in migration flows as they consider mainly time-invariant amenities such as environmental conditions (climate, landscape) or distance to urban agglomerations. These factors cannot explain variations in migration rates over time and are not plausibly affected by regional policies. Investigating the impact of regional redistribution policy on the appeal of regions to migrants, we concentrate on dynamic local characteristics that are potentially affected by policy implementations and determine changes in the migration dynamics of regions by working as time-variant push and pull factors.

2.4.1 Factors of regional utilities

Economic incentives and potential economic returns based on employment opportunities and regional wage differences are well-known as key determinants of internal migration in high-developed countries, especially in Europe (Greenwood, 1975; Hunt & Mueller, 2004; Rodriguez-Pose & Ketterer, 2012). Economically growing labor markets will increase the probability to find a job in a region. In addition, human capital incentives in growing markets offer additional monetary returns to skills. Thus, regional economic growth can enhance the personal utility function of less and high-skilled workers in a direct way (Arntz, 2010). Vice versa, shrinking local economies with high unemployment rates lose high and less skilled population to thriving markets due to income maximizing behavior. Especially the high educated labor force is more sensitive to income inequalities and benefits from knowledge spillovers (Borjas et al., 1992; Hunt & Mueller, 2004; Arntz, 2010). These mobility patterns manifest long-term inequalities and labor market imbalances (Kanbur & Rapoport, 2005; Granato et al., 2015). Hence, we use regional productivity, employment and household income growth as direct economic utilities contributing to the utility function in a specific region.

In contrast, it has to be considered that regional income benefits are potentially offset by higher prices in high-income regions that likely compensate for additional amenities (Glaeser & Gottlieb, 2008). Especially housing prices should be added to the utility function as they can displace people from attractive cities, while shrinking regions in many cases cannot offer adequate housing supply due to lower returns of investments for owner and developer, resulting in investment backlogs.

In addition, migration can be affected by multiple residential socioeconomic or cultural amenities such as the public infrastructure (public transport, traffic infrastructure, education infrastructure), public services (medical care, child care) or leisure opportunities (recreational areas, public libraries, museums, public pools, sport facilities) that may enter the individual's utility function. They possibly arise as major pull-factor, in particular for urban areas if the supply of these amenities becomes insufficient in rural areas. Maintenance of public infrastructure is a serious problem in many regions that are challenged by demographic change and outward migration. In line with the strong impact of the "home-bias" (Heise & Porzio, 2019), it seems reasonable that additional supply of local amenities and public infrastructure increases the number of "stayers" especially in those regions and offsets lower income opportunities to a certain point. Moreover, education infrastructure is a key settlement factor for families and high-potentials determining future earning potentials, offering individual development potentials and creating freedom to pursue individual life-goals.

In contrast to the time constant natural environment, public or industrial construction projects might have positive or negative impacts on the constructed environment. Especially additional land sealing by industry investments can have negative effects on perceived quality of life in a region.

Converting the considered aspects into a reliable model is limited by three aspects. First, the literature provides limited knowledge about the actual importance of socioeconomic and cultural amenities as migration determining factors. Second, it is practically impossible to display the specific heterogeneity of individual migration decisions into an universal migration utility function on a regional level. Thus, omission of variables from the individual's function is unavoidable. Third, variable selection is limited to data availability. Available regional data is especially limited concerning the quality and dynamic development of regional infrastructure, public services, cultural amenities as well as the constructed environment. Variable selection will be explained in section 2.5.

2.4.2 Research hypothesis on policy impacts

Overall, policy funding should enhance local factors and generate variations in the regional migration flows towards recipient regions provoked by adjustments in regional amenities. One basic assumption of this study is that the policies are not the actual key factor for individual migration decisions, but single structural improvements in the personal environment initiated by policy interventions can become decisive in both directions by altering the individual's regional utility function. The different strategic orientations and intended goals of policies result in different funding specifications and cause distinct research hypotheses. Summarized expectations towards policy effects are displayed in Figure 2.2. Discussed regional factors are based on the literature on internal migration, concentrating on dynamic economic incentives and further time-variant residential amenities as presented in section 2.4.1. To derive detailed hypotheses on policy effects, we match the identified utilities with their expected reaction to both policies.

Structural funds, such as GRW, are designed to reduce the productivity gap between economically prosperous and lagging regions and provide incentives for firms and their employees to locate in regions with lower productivity (Kline & Moretti, 2014). The majority of studies confirm economic efficiency of GRW with regard to per capita output and employment development (Eberle et al., 2019; Dettmann et al., 2016; Rhoden, 2016 and others).

Productivity growth should enable firms to raise wages. Considering that unemployment and income opportunities are the main reasons for labor migration, GRW funding should create economic incentives to stay, respectively move to funded regions. The growth effects should in particular affect the high skilled and educated workforce, but less often those who already started a family, since families make migration decisions more rigid and economic returns to migration decrease over time (Hunt & Mueller, 2004). Hence, we should observe clear positive effects of GRW funding for the age groups 18-30 years, lower effects on groups above 30 years and no effects on retired persons.

Predictions on specific economic consequences of the equalization scheme are difficult, due to the lack of respective studies in the literature. The findings from Eberle (2019) suggest that regional employment effects are existent, which should have slightly positive effects on migration balances. As the policy is not designed for triggering economic growth, direct effects on prosperity cannot be expected to be large.

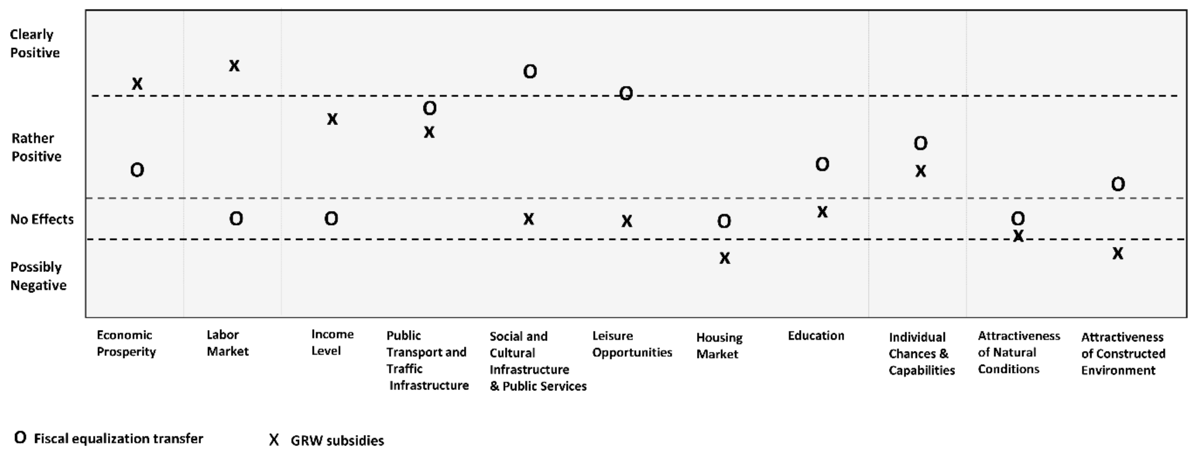

Figure 2.2: Expected reaction of important push & pull factors for interregional migration in Germany to the considered regional policies

Forming hypothesis on policy effects on non-economic amenities is more heterogeneous and less profound by existing literature. Fiscal equalization transfers should enable local governments to ensure long-term affordability and maintenance of public sourced social and socioeconomic infrastructure, regardless of their local economic situation and possible tax income crises (Kline & Moretti, 2014). German municipality task and expenditure structure is split into obligatory public tasks (e.g. fire protection, waste disposal, energy, water supply and school authority) and optional tasks (e.g. public transport, traffic infrastructure, public social infrastructure, and cultural infrastructure). Local governments can decide about the amount of expenditures for the latter and, in theory, abolish their supply if financial capacities are exhausted, so that financial capabilities should make a difference on the quality and quantity of optional tasks. Moreover, we assume that an increased municipality budget from equalization transfer potentially improves local school infrastructure. Although the educational system is basically comparable within Germany, spatial inequalities arise from the federalistic organization and local availability of certain types of schools. While federal states bear the costs for the teaching staff, municipalities are school authorities paying for public school infrastructure. Accordingly, local financial capabilities become important (Brückner & Böhm-Kasper, 2010). The local quality, reputation and distance to primary and secondary schools can be a large settlement factor for couples and young families. Concurrently, it is feasible that higher levels of education result in increasing out-migration from recipient regions in the long-term, due to higher skill-returns in donor regions (Zukowska-Gagelmann, 2017).

In total, equalization transfers should affect the individual's utility function in favor of regions with less financial resources. GRW is bound to funding economic activities, so that it does not plausibly affect cultural amenities, but can work negative on the perceived quality of life by additional land-sealing.

H1: *Fiscal equalization transfers do not affect economic disparities in a significant way, but improve regional quality of life by enabling regions to maintain an adequate quality and supply of public infrastructure and public services. Especially regions with low fiscal income capacities are expected to profit from this. Effects are not limited to certain age groups.*

H2: *GRW subsidies reduce the economic gap between regions. Potential labor market and income effects cause significant effects on the net migration balance in the age groups 18-30 years in funded regions, lower effects on 30-50-year-olds and no effects on retired persons.*

2.5 Data and descriptive statistics

We test the identified research hypotheses in an econometric analysis using a balanced panel data set on the spatial level of 258 German labor market regions.[4] In this structural unit administrative districts are bundled due to economic ties and commuting flows. Their main advantage is that short distance movements driven by life-cycle phenomena, such as suburbanism, are excluded from the analysis. To enhance the informative value, based on the theoretical considerations, it is adequate to include only migration acts that involve extensive personal relocations. Concurrently, the chosen regional units are small enough to expect measurable effects from local policy input.

Our main outcome variable is the annual regional net migration rate from the official German migration statistics. This includes all registered interregional inflow and outflow of persons moving within Germany. We exclude abroad movements, as immigrant location decisions are known to be driven by different factors, such as chain migration and ethnic networks in the host country (Barthel, 1989; Haug, 2008). The net migration rate at different age groups is used in comparative analysis to additionally explore the relationship of the policies and internal migration at different stages of the life cycle. While 18-24-year-olds are expected to move in

[4] Official Classification of labor market regions by the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) (Status 31.12.2015).

majority by educational reasons, labor market is decisive for many 25-29-year-olds. Reasons for middle-aged are heterogeneous, persons between 50-64 can be expected to move in preparation to retirement. Registration behavior brings some weakness to the dataset. The census of 2011 revealed mismatches and time lags between registered and real movements. Assuming that the occurring error is equally distributed over years, this produces negligible errors on the annual variation. Administrative second-residences registrations cause bias, if they are actually used as first-residence[5]. Finally, we had to omit the Göttingen region due to a major data bias. As the administration for their matters is located in this area, ethnic German late re-settlers from former soviet states get registered near Göttingen first. Their distribution all over Germany afterwards causes constant implausible statistical within-German out-migration from the region. The time period from 2000 to 2014 is chosen, because the first strong wave of relocations from east to west after German reunification was abated in 2000 and from 2015 onwards the increasing refugee migration would cause problems. [6]

The two considered policies are investigated in separate estimations and normalized by the regional GDP. Furthermore, we incorporate variables that are expected to influence interregional migration decisions based on the considerations in section 2.4. We include three economic variables: 1) the regional employment rate to account for increasing/decreasing numbers of jobs, 2) the disposable household income to consider individual profit maximizing behavior, 3) the gross domestic product to consider the general local economic dynamics. In addition, we include the prices of land that is ready for development to control for the regional level of housing prices. As variables that represent the development of further local amenities, we include 1) the number of elementary and secondary schools to take into account changes in

[5] The amount of this bias is in particular visible in regions with high student rates. The first-residence registration in Münster and Gießen significantly increased, after they implemented a taxation on second-residence registrations.

[6] Similar to the problem with Göttingen, refugee-registration stations for refugee migration (e.g. Fürth region) are problematic. However, these effects bring only minor limitations to our dataset as they are marginal until 2014, which we chose as the end of the analyzed time period.

Table 2.1: Variable description and data sources of variables

Acronym	Variable Description	Data Source
LFT	Unconditional financial assignments to municipalities as part of the municipal fiscal equalization scheme ("Schlüsselzuweisungen) in relation to regional GDP *[Fiscal Assignments in €/GDP in €]*	Fiscal Transfer: Quarterly Cash Statistics of the Federal Government and the Federal States GDP: Working Group "National Accounts of the Federal States." – „Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder"
LGRW	Total GRW funding intensity *[GRW Industry funding + GRW Infrastructure funding in €/GDP in €]*	GRW: Federal Office for Economic Affairsand Export Control (BAFA) GDP: Working Group "National Accounts of the Federal States. – „Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder"
LOVN	Overnight stays in tourism businesses *[Overnight stays in tourism businesses/population]*	Monthly Tourism Survey of Federal Government and Federal States
LSCO	General education schools per 10.000 inhabitants *[Sum of general education schools (elementary + secondary schools)/Population*10.000]*	Statistical Office of Federal Government and Federal States
LEMPL	Employment rate at workplace *[Employees total /Population aged 15 to 64 years]*	Employees: Institute for Employment Research (IAB) Population (15-64): Statistical Office of Federal Government and Federal states
LINC	Mean disposable household income *[Disposable income of private households/population]*	National Accounts of the Federal States („Arbeitskreis Volkswirtschaftliche Gesamtrechnung der Länder")
LLAPR	Prices of sold land plots ready for development per m² *[Total purchase value of sold land ready for development in €/sold land ready for development in m²]*	Statistical Office of Federal Government and Federal States
LGDP	Nominal gross-domestic product per capita *[GDP in €/population]*	GDP: Working Group "National Accounts of the Federal States. – „Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder"
LMIG	Internal net migration balance *[in-movers – out-movers from/to German regions)/ population]*	Migration Statistic of the Federal Government and the Federal States
LMIG18-24 **LMIG25-29** **LMIG30-49** **LMIG50-64** **LMIG65**	Internal net migration balance of 18-24 (25-29; 30-49[7] ;50-64; >65)-year olds. *[in-movers – out-movers in age group from/to German regions)/ population in age-group]*	Migration Statistic of the Federal Government and the Federal States

[7] *LMIG 30-49 also includes underaged*

the local education infrastructure, and 2) the number of overnight stays as a proxy for the development of cultural amenities and environmental quality. All indicators and data sources are displayed in Table 2.1. The selection especially of the non-economic variables is limited by the availability of reliable data within the whole research period and the lack of adequate indicators. Time invariant variables, such as natural amenities, are not integrated into the model, but controlled for in the use of fixed effects. All variables are set to the natural logarithm (ln), except for the net migration balance, due to the occurring negative numbers. The presence of non- stationarity in the time-series (unit roots) can become a serious problem for panel data with long time periods (Im, Pesaran & Shin, 2003). The corresponding test detected unit roots for the variable LEMPL and the spatial lags of LINC and LMIG (*see section 2.6 for computing and use of spatial lags*). For this reason, we created stationarity in these variables by eliminating linear time-trends in the variables LEMPL, LINC and LMIG and their spatial lag variables. Summary statistics of all variables are given in Table 2.2.

Table 2.2: Summary Statistics of Variables 2000 to 2014

ACRONYM	OBSERVATIONS	MIN	1.QUARTER	MEAN	3.QUARTER	MAX	STD. DEV.
LMIG	3855	-0.370	-0.023	0.003	0.039	0.263	0.058
LMIG18-24	3855	-1.009	-0.194	-0.080	0.049	1.340	0.241
LMIG25-29	3855	-0.665	-0.156	-0.070	0.037	1.062	0.172
LMIG30-49	3855	-0.424	-0.020	0.013	0.051	0.269	0.060
LMIG50-64	3855	-0.178	-0.005	0.015	0.032	0.173	0.031
LMIG65	3855	-0.238	-0.000	0.021	0.039	0.183	0.035
LFT	3855	-6.908	-4.668	-4.339	-3.960	-2.681	0.599
GRW	3855	-18.421	-18.421	-13.232	-6.690	-2.576	5.941
LOVN	3855	-0.693	0.693	1.278	1.825	3.764	0.850
LSCO	3855	0.793	1.250	1.410	1.562	2.296	0.234
LEMPL	3855	-0.949	-0.630	-0.532	-0.423	-0.202	0.145
LINC	3855	6.875	7.073	7.145	7.224	7.547	0.114
LLAPR	3855	0.793	3.800	4.327	4.845	6.847	0.748
LGDP	3855	9.393	9.962	10.139	10.309	11.115	0.266

Note: To overcome problems with zeros in the data sets, zeros in the policy input variables are replaced by very small numbers prior calculation of the ln

2.6 Econometric approach

The variety of considered regional policy effects represents the complex mutual interactions between economic and socioeconomic variables in time and space. This impedes model building and is reflected in the variety of methodological approaches in regional policy evaluation. We follow a flexible vector-autoregressive (VAR), first proposed by Sims (1980) that has become a standard part in econometric modelling of time series forecasting and recently drew some attention in related spatial policy analysis, used by Eberle et al. (2019) and Mitze et al. (2018). Our model basically follows their recent SpVAR approaches, including two main advancements that adapt the VAR for panel data analysis and account for the explicit spatial dimension by correcting for spatial autocorrelation (Holtz-Eakin et al., 1988; Beenstock & Felsenstein, 2007; Di Giacinto, 2010). The main advantages of the model are its ability to analyze dynamic direct and indirect relationships among variables while having marginal a priori model restrictions and the visualization of relationships between variables in impulse response functions (IRF). Moreover, the approach is able to consider that actual migrations are time lagged to changes in the push and pull factors of migration.

VAR estimations are based on the assumption that every variable depends on its own past and the past values of every other variable in the system. Variables are given in Table 2.1, LFT and LGRW as well as LMIG and its sub-variations define alternative models and are not used in the same equation models. Migration and inflation dynamics, trade cycle effects, especially the economic crisis beginning in 2008, and cross-sectional heterogeneity in the dataset require to control for regional and time fixed effects (μ and τ). Hence, we specify a reduced-form panel VAR equation system with M *(=8)* equations that can be aggregated to the following form by matrix notation (Rickman, 2010; Mitze et al., 2018):

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + \varepsilon_{\mathrm{it}}, \tag{2.1}$$

where A is a M*M matrix of regression coefficients that describes the relationship between past values and current values, ε is a vector of error terms with the covariance matrix Σ_e and i and t represent region and time. We account for the spatial dimension to overcome problems with spatial dependency and regional spillovers as proposed by Beenstock & Felsenstein (2007) and Di Giacinto (2010). Applying a Morans-I Test we found evidence for spatial autocorrelation in every variable except LEMPL. To calculate unbiased coefficients, we apply a Spatial-Durbin-Model and include spatial lag variables as additional independent variables to the M-equations of (2.1):

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + HWy_{it-1} + \varepsilon_{\mathrm{it}}, \qquad (2.2)$$

where H is a M*M matrix of regression coefficients equivalent to A and W is a region-specific identity spatial weight matrix representing neighboring regions that is constant over all M-equations and over time. Hence, lagged spatial lag variables represent average values of neighboring regions in the previous period. The considered lag length is one year as the Akaike information criterion (AIC) proves that further lags have no additional explanatory power.

However, the lack of theoretical assumptions treats all variables as completely endogenous. This is not appropriate for policy analysis, since real reciprocal relations are ignored and over-parametrization results in biased impulse response functions (Rickman, 2010). The structural VAR (SVAR) model uses a priori theoretical assumptions to the endogeneity of variables to account for the economic structure of variables and gain orthogonalized shocks for calculating impulse response functions (Bernanke, 1986). In line with the mentioned papers we use a recursive causal ordering on ascending endogeneity of variables to impose a correct specification and perform a triangular Choleski identification scheme to the covariance matrix of the residuals from the reduced form VAR. The variable ordering is used as in Table 2.1 based on theoretical assumptions on ascending endogeneity and indications from Granger causality test for panel data (proposed by Dumitrescu & Hurlin (2012); results reported in Table A2.3).

Results confirm that in particular GRW is exogenous, while the exogeneity of fiscal transfers is limited. The other variables in the VAR show mutual granger causality.

2.6.1 Impulse response functions

Based on the results of equation (2.2), we calculate impulse response functions of every variable m in the VAR to uncorrelated exogenous changes (shocks) in other variables by transforming them to the moving-average (MA) form (Lütkepohl, 2005).

The commonly used impulse response functions are non-spatial responses to uncorrelated shocks in region i based on the coefficients from $\mathrm{A}y_{it-1}$, as done i.e. by Eberle et al. (2019). This means that spatial dependencies are included in the statistical estimation in order to avoid biases due to ignored spatial effects, but the effects of changes in one variable on other variables is only examined within regions (non-spatial impulse response functions). We enhance these approach by calculating additional spatially indirect IRFs based on the coefficients of HWy_{it-1}.

In principle, the estimated model would allow to follow all responses through space. However, the responses lead to further responses that finally disperse over all variables and regions. As a consequence, the calculation of all spatially indirect responses would lead to different results for each region in which the original change occurs, resulting in 258 different IRFs for each pair of variables. Therefore, we restrict the calculation of spatial IRFs by considering spatial effects only from the original shock to all variables in the neighboring region, but no later spatial effects (while the further intra-regional dynamics are considered). The results represent responses within a region to orthogonal shocks in neighboring regions, which allows us to calculate one-time spatial-spillover effects (inward-responses). Initial shocks are equivalent to shocks for intra-regional IRFs and constant in space assuming spatial homogeneity. Responses to shocks in neighboring regions are time-lagged as they need time to diffuse into the region and have equivalent autoregressive impact over time in the region. Hence, spatially indirect responses are vectors representing the coefficients of HWy_{it-1} in the first year after the shock and the moving-average representation from Ay_{it-1} equivalent to direct IRFs in the following years.

To assess the statistical significance of the resulting IRFs, we calculated confidence intervals by performing Monte Carlo simulations and applied the approach to randomly generated data sets of same size that result from a redraw (with reclines) of random regions from the original data set with all their attributes over time, while the isolated initial shocks are hold constant.

Since regions are heterogeneous in their economic strength and quality of life, we examine conditional effects and different regional or structural transmission paths by running the presented SpVAR model separately for different sub-samples of our dataset. Subsamples represent the former Western and Eastern regions (SWEST; SEAST) [8], structural types of labor market regions (urban regions (SURBAN), rural regions with areas of concentrated population (SRUCO) and rural regions (SRURAL)[9]) and different levels of municipal tax income per capita (STAXLOW; STAXMED; STAXTOP; separated according to quantiles). Visualizations of subsamples are given in Figure A2.1. It might be considered that the average fiscal equalization transfers and GRW funding are larger in the subsamples with lower fiscal capabilities. Thus, latter sample building is not completely exogeneous. However, there is no indicator that allows to account for economic strength or regional living conditions and proves complete exogeneity from the used variables. Again, shocks are constant for all subsamples.

2.6.2 Robustness checks

We test the robustness of our results applying the following checks. First, we tested the effects of fiscal equalization policy by calculating the equalization grants in € per capita to control for

[8] Berlin is excluded due to its history in both subdivisions.
[9] Official Classification of labor market region types according to settlement structure by the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR, Status 31.12.2015).

possible correlation of transfer grants with regional GDP development. Second, we tested the robustness of GRW effects by estimating a SpVAR that includes only regions that received any GRW funds. Finally, we added the regional endogenous tax revenues and policy grants from the Federal Urban Development, Fiscal Equalization and GRW program as additional exogenous variables to the underlying estimation to make further controls on additional income sources. All results reported in section 2.7 are verified by these tests.

2.7 Empirical results

As we will show in this section, results from both policies differ strongly. However, all impulse responses that do not involve policy inputs remain remarkably robust in comparison of both SpVAR-models, which confirms adequate choice of the model and included variables. The results suggest that direct regional shocks in schools, GDP and in particular in the household income have significant positive effects on the regional net migration rate, while an increased number of jobs and land prices have no significant effects on the migration balance *(Figure A2.4 in the Appendix)*. In the following we present and discuss the effects of the two policy measures on the other variables, with a more detailed look on the effects on migration. The intra-regional and inter-regional spillover effects of the fiscal equalization payments are analyzed separately (*section 2.7.1 and 2.7.2*). In the case of the GRW funds no inter-regional spillover effects on migration are found, so that all results on the GRW funds are examined in one section (*2.7.3*).

2.7.1 Intra-regional fiscal equalization effects

The results for direct impulse responses to fiscal equalization payments within a region prove that the reaction of regional migration balances to fiscal equalization is positive from one year after funding up to four years after, whereas fiscal transfers have no significant positive effects on other variables except schools (*Figures 2.3 and A2.2*). The response of per capita GDP on fiscal transfers is found to be significantly negative. This may be explained by the increasing population due to the positive migration effect. The fiscal transfer seems to make the region more attractive, so that more people stay without implying more jobs, at least in the short run. As a consequence, the economic activity per inhabitant decreases. Overall, we do not observe any fiscal transfer induced economic growth effects. Comparing the subsamples explained in section 2.6, net migration responses to direct fiscal equalization are especially high in the eastern regions (SEAST), which have on average lower population density, are weaker in terms of regional economic situation and predominantly experience out-migration. The response is significant positive up to nine years after the initial funding, while it is not significant in the West (SWEST) (*Figure 2.4*).

In line with this, net-migration responds in particular positive in regions with low tax income (STAXLOW), which supports the hypothesis that especially regions with low tax income are able to improve their place-utilities due to enhanced fiscal capacities. Considering settlement structures, significant positive effects of fiscal transfers on migration are only found for urban

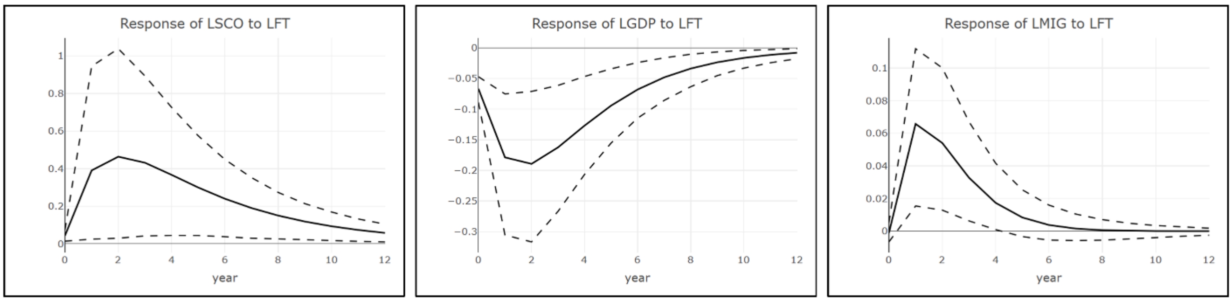

Figure 2.3: Selected impulse responses to isolated fiscal transfer shocks based on SpVar estimation with fiscal transfer inputs. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %.

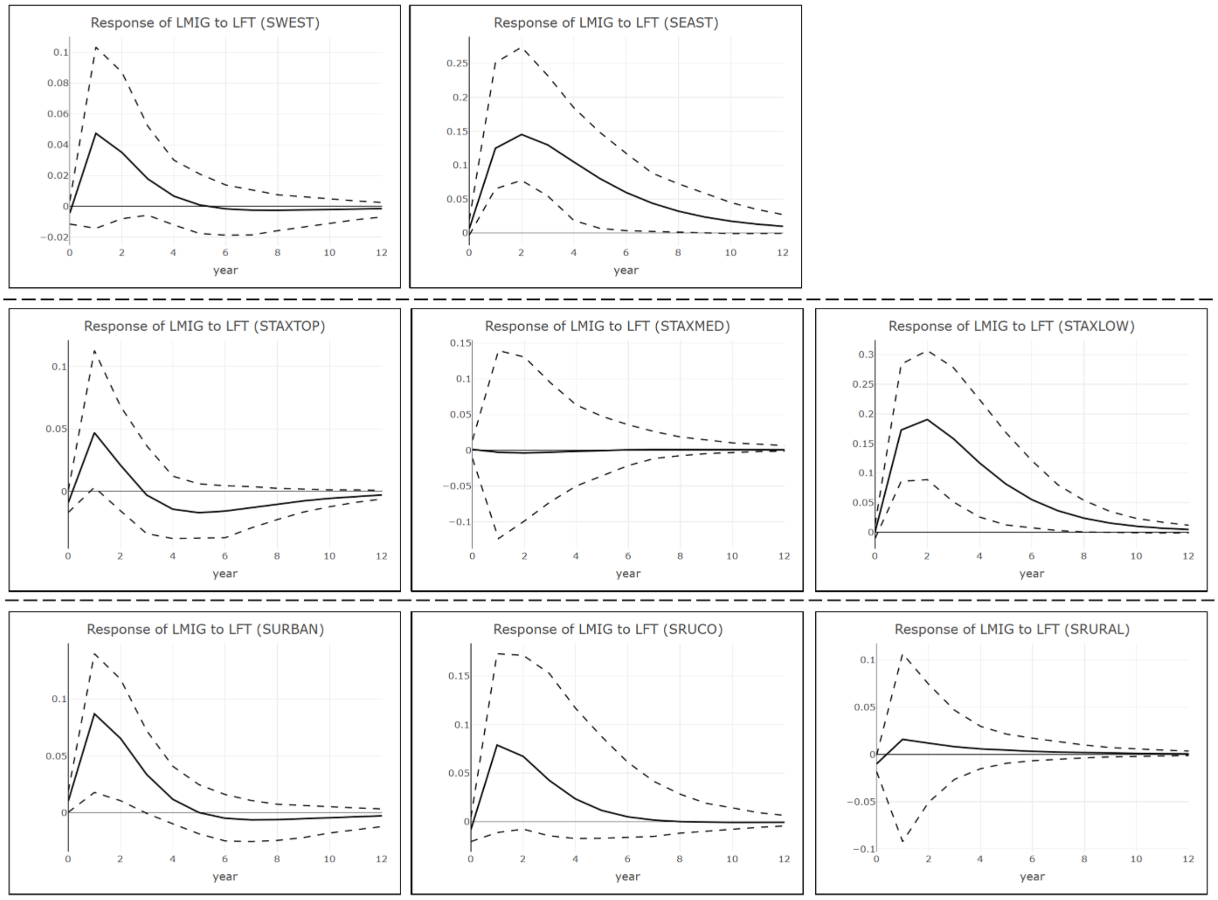

Figure 2.4: Response of net migration to fiscal transfers shocks in the defined subsamples. Specifications equal Figure 2.3. Estimated policy shocks are hold constant over subsamples

regions (SURBAN). Combining these findings, especially urban regions with low tax income can improve their attractiveness through fiscal transfers. We conclude that these findings primarily result from decreasing out-migration from structurally weak regions due to reductions of local push factors. Equalization grants seem to encourage regions with below-average residential utilities to improve the quality of life and stabilize migration dynamics. As we found no evidence for labor market or income effects, improvements in the supply and quality of non-economic local amenities seem to cause this effect. These results confirm the home-bias to be an important mechanism. Personal income opportunities are offset as long as local amenities do not fall below an individual threshold level.

Applying the SpVAR to the migration rates across age groups provides evidence that significant positive responses in the net migration rate persist for the groups LMIG25-29 and LMIG30-49.

Responses of 18-24-year-olds are visible, but not significant in the total sample (*Figure 2.5*). Migration decisions of above 50-year-olds show no reaction to additional amenities created by equalization grants. Thus, H1, stating effects for all age groups is not confirmed. However, it might also be the case that effects for older people are not observed, because they rarely migrate anyhow.

Detailed information for significant results in all subsamples and age-subgroups are given in table 2.3. The results indicate that equalization grants are an adequate instrument to reduce disparities in perceived regional quality of life. The rate of young and middle-age persons that decide to stay in underperforming regions instead of searching for better conditions elsewhere can be increased by shifting financial resources to regions with low endogenous income. The above findings suggest that equalization transfers are able to stabilize the demographic balance of the affected regions to a certain point, although they do not appear to reduce economic inequalities. The reduced out-migration should result in increasing regional labor-supply and endogenous economic growth effects in the long run, if the additional population is linked to increasing human capital.

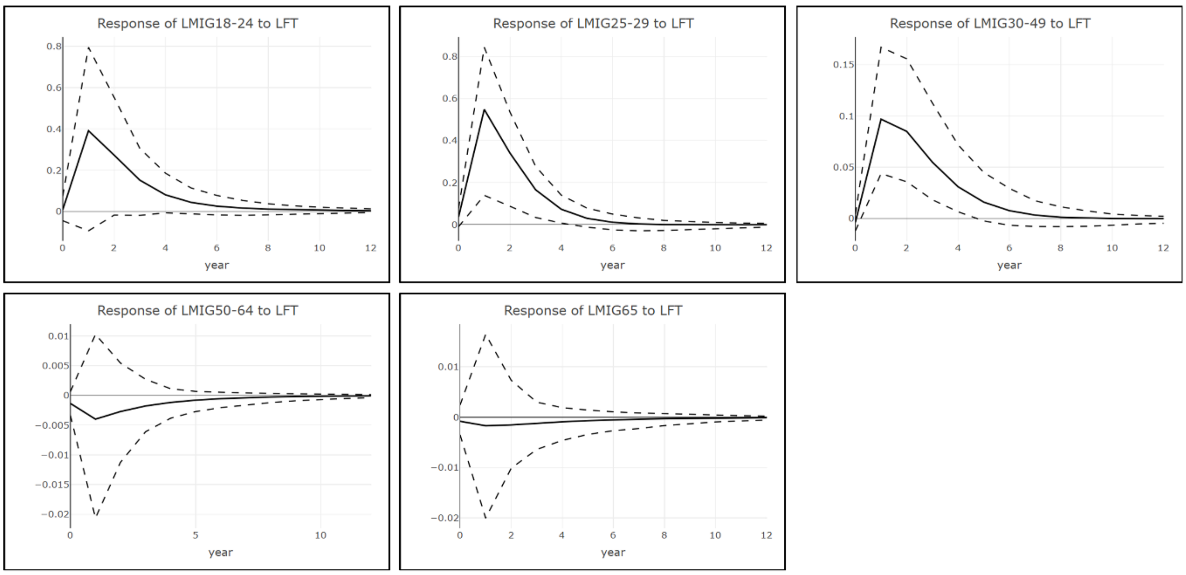

Figure 2.5: Responses of net migration in different age groups to fiscal transfer shock. Specifications equal Figure 2.3

2.7.2 Spatially indirect fiscal equalization effects

The results from the spatially indirect IRF estimation show that there is an explicit spatial aspect in the findings as we observe average negative responses of net migration to fiscal equalization shocks in neighboring regions. These responses are not significant for the complete sample but significant for West and East-German regions (*Figure 2.6*) as well as for rural and medium condensed areas and in particular for the age-groups 18-24 and 25-29 over all regions. This shows that some of the migration bonus, especially concerning the age groups between 18 and 29, is rather short-distance migration at the expense of neighboring labor market regions. Interestingly, this is more the case for regions with a medium or strong economy. Economically weak regions that profit significantly from fiscal equalization, do not show spatial spillover population losses to neighboring regions.

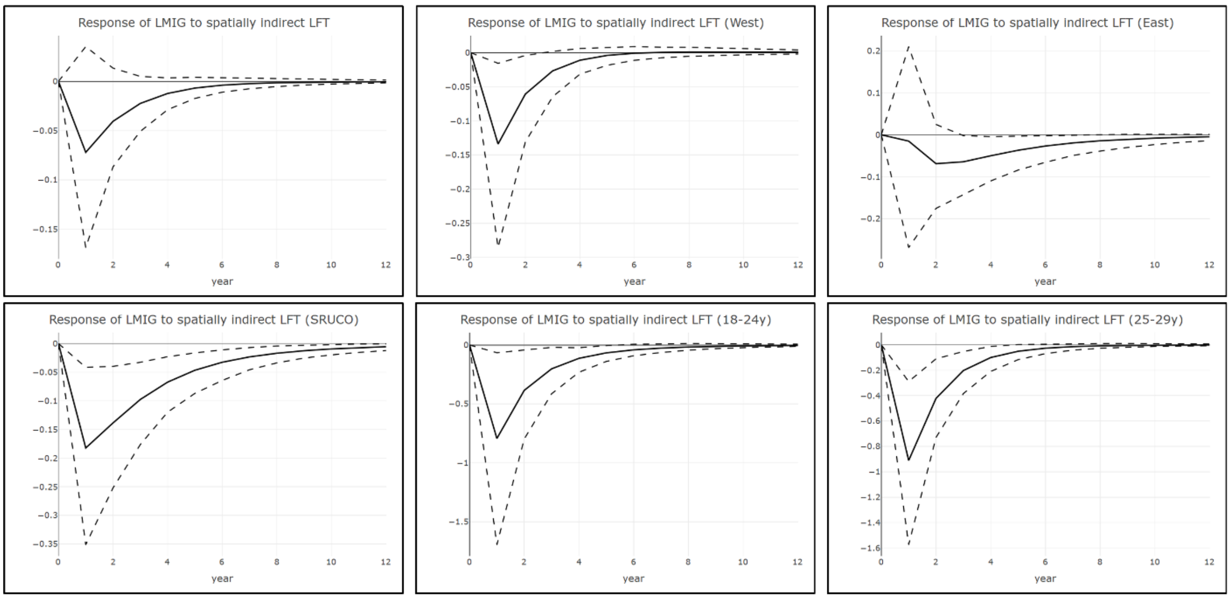

Figure 2.6: Selected spatially indirect impulse responses to isolated fiscal transfer shocks in neighboring regions based on SpVar estimations with fiscal transfer inputs. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %.

2.7.3 GRW effects

In line with the respective Granger causality test (*Table A2.3*), we do not find significant effects of GRW funding on regional net migration rates (*Figure 2.7*). The impulse responses depicting the reactions of the various variables to direct GRW inputs are shown in Figure 2.7 and A2.3. The results indicate that GRW has negative impact on regional tourism. This might be provoked by additional industry infrastructure that possibly affects the appeal of a region in a negative way. Furthermore, we detect a significant negative response of schools in the funding year. Both employment and GDP responses show an immediate negative non-significant reaction to GRW. The reaction of both variables turns into a positive response after a few years (significant in the case of employment), but total effects are not necessarily positive.

However, GRW funding seems to improve the economic situation in the long-term. The household income indicates no significant response to GRW as well as the net migration rate. This remains true for both GRW-Industry and GRW-Infrastructure scheme subsidies

Figure 2.7: Selected impulse responses to isolated GRW shocks based on SpVar Estimation with GRW subsidies (LGRW). Specifications equal Figure 2.3

Further results do neither indicate significant responses of net migration rates to GRW funds in West- nor in East-German regions. Short-time significant effects appear in the year of funding in the subsample STAXTOP, but not in regions with lower tax income. Since only 5 out of 86 regions in the STAXTOP subsample received any GRW subsidies, results are built on small numbers.

The significant positive response of net migration in rural regions (SRURAL) up to three years after funding indicates that GRW has positive effects on living conditions in rural regions, although we find no evidence that this is accompanied by a significant GRW induced economic growth effects (Figure 2.8).

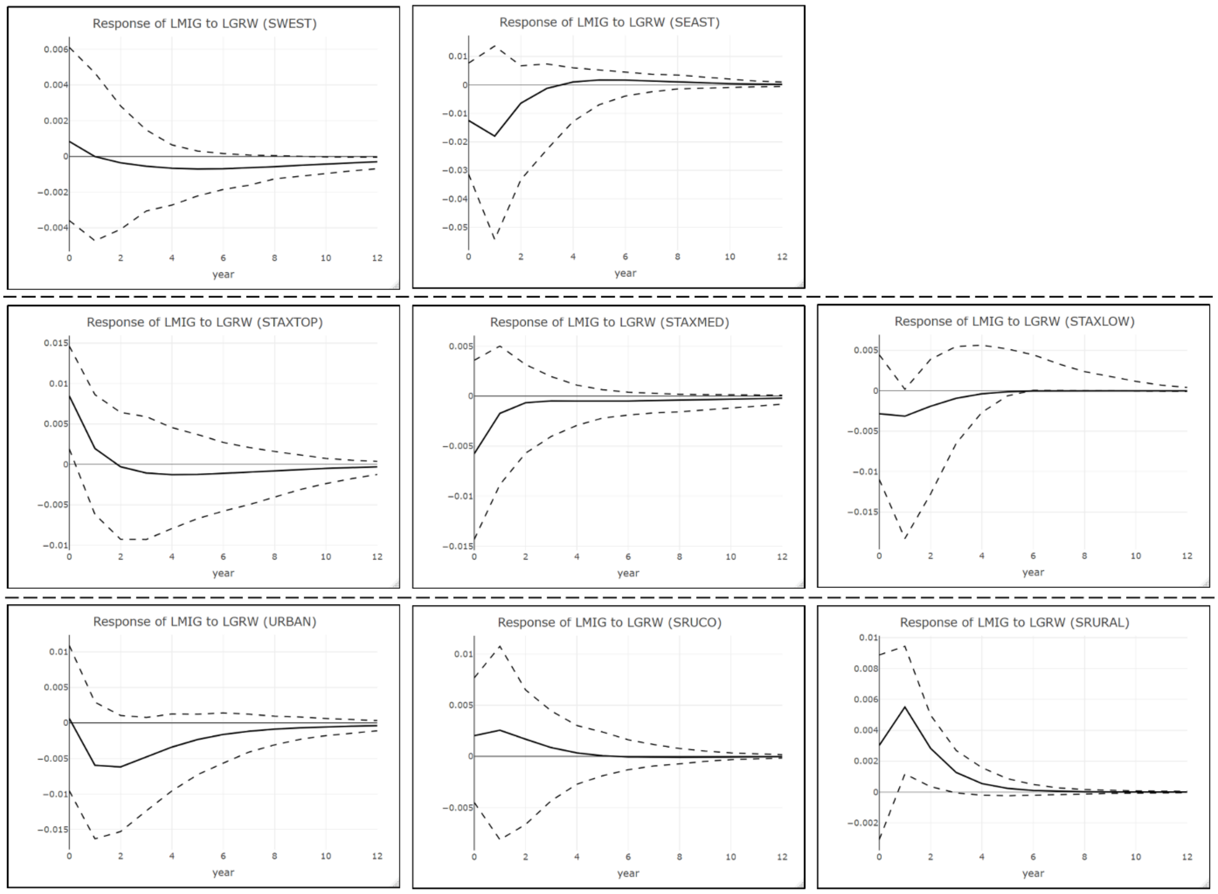

Figure 2.8: Response of net migration to GRW subsidy shocks in the defined subsamples. Specifications equal Figure 2.7. Estimated policy shocks are hold constant over subsamples

This is accompanied by negative spatial-spillover effects on migration from spatially indirect shocks in neighboring regions, which suggests that the positive direct results in rural regions are driven by a small number of movers from neighboring regions.

A look into the age groups within different subsamples reveals positive responses to direct GRW funding for the age group 25-29 in the intersection of STAXTOP, SRUCO and SRURAL. This proves the hypothesis H2 stating age group 25-29 to be most sensitive to GRW funding, probably due to the economic effects. Against this hypothesis, we observe slight positive short-time migration responses for the age group 50-64 in the East and in rural regions. This might be caused by supporting low-level jobs in these regions. Less explainable, significant effects for persons older than 65 years are found one year after funding in the western regions. Detailed information for significant effects on direct funding in all subsamples and age-subgroups are again given in Table 2.3.

Table 2.3: Summary of estimated responses of LMIG and its variations to policy input in the defined subsamples.

Effect strength	**significant positive response (at least one time point)**	
Policy	***LFT***	***GRW***
Total Sample	*Total* *25-29* *30-49*	-
SWEST	*30-49*	*65+*
SEAST	***Total*** ***18-24*** ***25-29*** *30-49*	*50-64*
STAXTOP	-	*25-29*
STAXMED	-	
STAXLOW	***Total*** *18-24* ***25-29*** ***30-49***	-
SURBAN	*Total* *25-29* *30-49*	-
SRUCO	*30-49*	*25-29*
SRURAL	-	*Total* *25-29* *50-64*

Notes: The results displayed in Table 2.3 are verified by robustness checks. Bold variations respond significant positive within the whole time period.

We can conclude that GRW funding has only small effects on regional living conditions as there is no significant response in the total sample and only few significant responses in specific subsamples. Present effects are found mainly for regions with high tax income and for rural regions, which indicates differing mechanisms between GRW and equalization grants. In addition, we do not find any evidence for spatial spillover effects on migration due to GRW shocks in neighboring regions.

In summary, GRW does not satisfy the equity criterion of funding, as migration rates do not show any measurable improvements in the regional utility function in regions with low endogenous capabilities.

2.8 Conclusions

The central aim of this paper is to investigate whether regional redistribution policies are able to contribute to the decline of regional inequalities and improve the quality of life in supported regions. A further aim is to examine whether different policy measures have different effects. Variations in regional net migration rates are used as indicator for the development of regional living conditions. Germany is an adequate study object because it applies two large and quite different regional redistribution policies. Indeed, the results from our SpVAR-model point to very different effects of fiscal equalization and structural GRW funding in Germany. Given their different aims this is not surprising, but the detailed differences in their effects on the migration rates has not been studied before. This provides insights beyond the German case on how redistribution policies should be designed to change the regional quality of life and the resulting migration flows.

First, we find empirical evidence that the German fiscal equalization scheme is an appropriate and effective policy to enhance regional quality of life in supported regions, since it is able to significantly improve migration development in particular in regions with low endogenous fiscal capacities and for all age groups up to 50-year-old persons. Especially labor market regions with small tax incomes that predominantly experience outward migration and are structurally lagging behind seem to benefit from the additional financial capabilities. As no evidence for substantial economic growth is found, we conclude that the higher degree of financial freedom allows to enhance or maintain supply and quality of public infrastructure, public goods and further cultural amenities financed by the municipal budget. This results in enhancements in the individual's regional utility function and hampers outward migration from structurally weak regions. However, part of this effect, especially in the case of younger people, seems to be rather local, influencing the migration between neighboring regions. Second, we find no evidence for an overall impact on migration rates of GRW policy. In contrast to fiscal equalization grants, some positive effects on migration are found in rural regions and regions with higher endogenous tax revenues. We find no evidence that GRW funding increases regional equity in the form of improving quality of life in poor regions. Taking into account all findings, both examined policy measures contribute to quality of life in a specific way. Fiscal equalization seems to have no short- or medium-run economic effects but is quite effective in regions with low fiscal income to improve living conditions, especially in urban areas. In contrast, GRW funding rather affects the economy and is most effective in rural regions with comparably high fiscal income.

It seems likely that the basic insights of our study apply also to other countries, especially other developed countries as well as in the European context. Hence, the obtained knowledge can be helpful also for the European Structural and Cohesion Policy. If the reduction of migration flows is the main aim, fiscal transfers seem to be most adequate, especially for very poor and rather urban regions. However, they do not improve the economic situation – so that permanent transfers might be necessary – and seem to address to some extend the short-distance migration. Economic orientated policies, such as the GRW funds, seem to be effective only in regions with some economic strength and in the very rural regions and seem to have, on average, much lower effects on migration.

The conducted analysis can be easily applied to further place-based policies. For instance, we did not find any empirical evidence for significant effects on migration rates for the German Federal Urban development program in any of the presented subsamples. Beyond that, it would be interesting to apply our approach to the EU structural cohesion funds or to similar policies in other countries. Since our model has some limitations in terms of selection and availability of appropriate indicators displaying non-economic amenities, future research can refer to these findings and attain a more detailed look into the actual transmission paths and the underlying mechanisms.

2.9 References

Albouy, D. (2012). Evaluating the efficiency and equity of federal fiscal equalization. *Journal of Public Economics*, 96, 824-839.

Alecke, B., Mitze, T. & Untiedt, G. (2013). Growth effects of regional policy in Germany: Results from a spatially augmented multiplicative interaction model. *The Annals of Regional Science*, 50, 535–554, DOI 10.1007/s00168-012-0503-7.

Arntz, M. (2010). What Attracts Human Capital? Understanding the Skill Composition of Interregional Job Matches in Germany, *Regional Studies*, 44, 423-441, DOI: 10.1080/00343400802663532.

Baldwin, R., Forslid, R., Martin, P., Ottaviano, G. & Robert-Nicoud, F. (2005). *Economic Geography and Public Policy*, Princeton: Princeton University Press.

Beenstock, M. & Felsenstein, D. (2007). Spatial vector autoregressions. *Spatial Economic Analysis*, 2, 167–196, DOI: 10.1080/17421770701346689.

Bernanke, B. S. (1986). Alternative Explanations of the Money-Income Correlation, *Carnegie-Rochester Conference Series on Public Policy*, 25, 49-99.

Biagi, B., Faggian, A. & McCann, P. (2011). Long and Short Distance Migration in Italy: The Role of Economic, Social and Environmental Characteristics, Spatial Economic Analysis, 6, 111-131, DOI: 10.1080/17421772.2010.540035.

Blöchliger, H. & Charbit, C. (2008). Fiscal Equalization. *OECD Economic Studies*, 44, 1-22 DOI: 10.1787/19952856.

Borjas, G. J., Bronars, S. G. & Trejo, S. J. (1992). Self-Selection and Internal Migration in the United States. *Journal of Urban Economics,* 32, 159-185.

Brachert, M., Dettmann, E. & Titze, M. (2019). The regional effects of a place-based policy – Causal evidence from Germany. *Regional Science and Urban Economics,* 79, 1-17. DOI: 10.1016/j.regsciurbeco.2019.103483.

Brückner, Y. & Böhm-Kasper, C. (2010). Finanzierung des allgemeinbildenden Schulwesens. In Barz, H. (Ed.): *Handbuch Bildungsfinanzierung*. (pp. 201-212), Wiesbaden: Springer Fachmedien.

Buchanan, J. M. (1950). Federalism and fiscal equity. *American Economic Review,* 40, 583-599.

Buchanan, J. M. & Wagner, R. E. (1970). An efficiency basis for federal fiscal equalization. In: Margolis, J. (Ed.), *The Analysis of Public Output.* New York: Columbia University Press

Bundesregierung (1969*). Gesetz über die Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur"* v*om 6. Oktober 1969*. In *Bundesgesetzblatt Teil I* (pp. 1861-1863). Bonn.

Cebula, R. & Vedder, R. (1973). A Note on Migration, Economic Opportunity and the Quality of Life. *Journal of Regional Science*, 13, 205-211.

Deutscher Bundestag (2014*). Koordinierungsrahmen der Gemeinschaftsaufgabe „Verbesserung der regionalen Wirtschaftsstruktur" ab 1. Juli 2014*. In Deutscher Bundestag 18. Wahlperiode, *Drucksache 18/2200.* Berlin.

Di Giacinto, V. (2010). On vector autoregressive modelling in space and time. *Journal of Geographical Systems*, 12, 125-154, DOI: 10.1007/s10109-010-0116-6.

Dijkstra, L., Poelman, H. & Rodríguez-Pose, A. (2020). The geography of EU discontent, *Regional Studies*, 54, 737 – 753. DOI: 10.1080/00343404.2019.1654603.

Dumitrescu, E. I. & Hurlin, C. (2012). Testing for granger non-causality in heterogenous panels. *Economic Modelling*, 29, 1450-1460, DOI: 10.1016/j.econmod.2012.02.014.

Eberle, J. (2019). Regional fiscal equalization in Germany – A simultaneous equation approach to assess the economic effects of fiscal policy. *Working Papers on Innovation and Space*. Marburg: Geography Department, Philipps-University Marburg.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98, 701-735, DOI: 10.1111/pirs.12373.

Egger, P., Eggert, W. & Larch, M. (2014). Structural Operation and Net Migration Across European Union Member Countries. *Review of International Economics*, 22, 352-378, DOI:10.1111/roie.12112.

Faggian, A., Olfert & M., Partridge, M. (2012). Inferring regional well-being from individual revealed preferences: the voting with your feet approach. *Cambridge Journal of Regions, Economy and Society,* 5, 163-180. DOI: 10.1093/cjres/rsr016.

Feldstein, M. (1970). Comment on an efficiency basis for federal fiscal equalization. In Margolis, J. (Ed.), *The Analysis of Public Output.* New York: Columbia University Press.

Glaeser E. & Gottlieb, J. (2008). "The Economics of Place-Making Policies.". *Brookings Papers on Economic Activity*, 39, 155-253.

Gottlieb, P. (1995). Residential Amenities, Firm Location and Economic Development. *Urban Studies*, 32, 1413-1436.

Granato, N., Haas, A., Hamann, S. & Niebuhr, A. (2015). The Impact of Skill-Specific Migration on Regional Unemployment Disparities in Germany. *Journal of Regional Science*, 55, 513-539, DOI: 10.1111/jors.12178.

Greenwood, M. J. (1975). Research on Internal Migration in the United States: A Survey. *Journal of Economic Literature,* 13, 397-433.

Greenwood M. J. (1985). Human Migration: Theory, Models and Empirical Studies. *Journal of Regional Science*, 25, 521-544.

Haug, S. (1998). Migration Networks and Migration Decision Making. *Journal of Ethnic and Migration Studies*, 34, 587-605.

Heise, S. & Porzio, T. (2019). Spatial Wage Gaps and Frictional Labor Markets. (Staff Report No. 898). New York: Federal Reserve Bank of New York.

Henkel, M., Seidel, T. & Suedekum, J. (2018). Fiscal Transfers in the Spatial Economy. (DICE Discussion Paper No. 322). Düsseldorf: Düsseldorf Institute for Competition Economics.

Holtz-Eakin, D., Newey, W. & Rosen, H.S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica*, 56, 1371-1395.

Hunt, G. L. & Mueller, R.E. (2004). North American Migration: Returns to Skill, Border Effects and Mobility Costs. *The Review of Economics and Statistics*, 86, 988-1007.

Iammarino, S., Rodrguez-Pose, A. & Storper, M. (2019). Regional Inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*, 19, 273-298.

Im, K. S., Pesaran, M. H. & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115, 53-74.

Kanbur, R. & Rapoport, H. (2005). "Migration Selectivity and the Evolution of Spatial Inequality," *Journal of Economic Geography*, 5, 43-57.

Kline, P. & Moretti, E. (2014). Local Economic Development, Agglomeration Economies, and the Big Push: 100 Years of Evidence from the Tennessee Valley Authority. *Quarterly Journal of Economics*, 128, 275-331.

Lehmann, I. & Wrede, M. (2019). The Bavarian Municipal Fiscal Equalization Scheme: Emphasis on Equity Rather than Efficiency. *FinanzArchiv,* 75, 127-151.

Lenk, T., Hesse, M. & Lück, O. (2013). *Synoptische Darstellung der kommunalen Finanzausaugleichssysteme der Länder aus finanzwissenschaftlicher Perspektive*. Leipzig: Studie im Auftrag des Landesrechnungshofs Mecklenburg-Vorpommern.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics,* 22, 3-42.

Lütkepohl, H. (2005*). New introduction to multiple time series analysis*. Berlin: Springer.

Martin, P. (1999). Public Policies, Regional Inequalities and Growth, *Journal of Public Economics,* 73, 85-105.

Mitze, T., Schmidt, T. D., Rauhut, D. & Kangasharju, A. (2018). Ageing shocks and short-run regional labour market dynamics in a spatial panel VAR approach. *Applied Economics*, 50, 870-890, DOI: 10.1080/00036846.2017.1346360.

Oakland, W. H. (1994). Fiscal equalization: an empty box? *National Tax Journal,* 47, 199-209.

Partridge, M., Rickman, D., Ali, K. & Olfert, M. (2008). Lost in space: population growth in the American hinterlands and small cities. *Journal of Economic Geography,* 8, 727-757.

Pieńkowski, J. & Berkowitz, P. (2016). Econometric Assessments of Cohesion Policy Growth Effects: How to Make Them More Relevant for Policymakers? In Bachtler, J., Berkowitz,P., Hardy,S. and Muravska, T. (Eds.), *EU Cohesion Policy: Reassessing Performance and Direction* (pp. 55-68), Abingdon and New York: Routledge.

Rappaport, J. (2004). Why are population flows so persistent? *Journal of Urban Economics, 56,* 554-580.

Rickman, D. S. (2010). Modern macroeconomics and regional economic modeling. *Journal of Regional Science*, 50, 23-41.

Rodriguez-Pose, A. (2018). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society,* 11, 189-209, DOI: 10.1093/cjres/rsx024.

Rodriguez-Pose, A. & Ketterer, D. (2012). Do Local Amenities Affect the Appeal of Regions in Europe for Migrants? *Journal of Regional Science,* 52, 535-561.

Romer, P. M. (1990). Endogenous technical change. *Journal of Political Economics,* 98, 71-102.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48, 1-48.

Storper, M. (2011). Justice, efficiency and economic geography: should places help another to develop? *European Urban and Regional Studies,* 18, 3-21. DOI: 10.1177/0969776410394553.

Thomas (2013). The effect of EU accession on internal migration in Poland. *Studies in comparative international development,* 48, 482-502, DOI 10.1007/s12116-013-9141-z.

von Ehrlich, M. & Seidel, T. (2015). The persistent effects of place-based policy: Evidence from the West-German Zonenrandgebiet. (CESifo Working Paper No. 5373). Munich: CESifo Group.

Wolpert, J. (1965). Behavorial Aspects of the Decision to Migrate. *Papers in Regional Science,* 15, 159-169.

Zukowska-Gagelmann, K. (2017). Do EU Regional Funds Hamper or Foster Interregional Migration? A panel data analysis for Poland (*DHBW Working & Discussion Paper* No. 2/2017). Lörrach: Cooperative State University Lörrach.

A2. Appendix

Table A2.1: Regression results of SpVar fixed effects panel models with fiscal equalization grants and time lag =1

DEPENDENT VARIABLES REGRESSORS (T-1)	LFT	LOVN	LSCO	LEMPLL	LINC	LLAPR	LGDP	LMIG
LFT	0.491*** (0.000)	-0.020* (0.012)	0.016* (0.015)	$-3.45e^{-4}$ (0.796)	0.001 (0.671)	-0.012 (0.581)	-0.009* (0.013)	0.005* (0.037)
LOVN	0.001 (0.967)	0.758*** (0.000)	-0.037*** (0.000)	0.002 (0.282)	0.003 (0.097)	0.099** (0.001)	0.006 (0.254)	0.006** (0.091)
LSCO	0.134** (0.001)	-0.027 (0.113)	0.727*** (0.000)	0.002 (0.557)	0.004 (0.088)	-0.045 (0.324)	0.005 (0.480)	0.010 (0.055)
LEMPL	0.249 (0.250)	-0.160 (0.080)	-0.193 (0.802)	0.524*** (0.000)	-0.007 (0.590)	0.230 (0.350)	-0.106* (0.010)	0.029 (0.279)
LINC	-0.266 (0.296)	-0.031 (0.774)	0.010 (0.915)	0.115*** (0.000)	0.627*** (0.000)	0.263 0.361	0.061 (0.208)	0.145*** (0.000)
LLAPR	0.021 (0.160)	-0.003 (0.687)	-0.003 (0.528)	-0.001 (0.384)	-0.002 (0.101)	0.272*** (0.000)	-0.003 (0.270)	3.04^{e-6} (0.987)
LGDP	-0.607*** (0.000)	0.016 (0.597)	0.068** (0.008)	0.025*** (0.000)	-0.006 (0.191)	-0.226** (0.005)	0.657*** (0.000)	0.037*** (0.000)
LMIG	-0.226 (0.098)	0.022 (0.703)	-0.004 (0.930)	0.005 (0.618)	-0.022** (0.009)	0.002 (0.988)	-0.080** (0.002)	0.374*** (0.000)
SPL_FT	0.021 (0.481)	0.028* (0.026)	0.038*** (0.000)	0.003 (0.187)	-0.004* (0.047)	-0.030 (0.367)	0.004 (0.443)	-0.005* (0.149)
SPL_OVN	-0.038 (0.407)	0.001 (0.966)	0.003 (0.833)	-0.004 (0.248)	0.001 (0.693)	-0.171*** (0.001)	-0.016 (0.064)	-0.003 (0.654)
SPL_SCO	0.071 (0.221)	-0.026 (0.292)	-0.038 (0.062)	-0.023*** (0.000)	-0.004 (0.325)	0.110 (0.092)	-0.019 (0.067)	-0.014* (0.045)
SPL_EMP	-0.574 (0.109)	-0.025 (0.870)	0.337** (0.008)	$-1.45e^{-4}$ (0.995)	0.019 (0.389)	0.224 (0.581)	0.014 (0.839)	- 0.227*** (0.000)
SPL_INC	0.403 (0.337)	0.145 (0.412)	0.378* (0.012)	-0.012 (0.676)	-0.168*** (0.000)	-0.243 (0.609)	-0.091 (0.253)	-0.001 (0.988)
SPL_LAPR	0.057* (0.30)	0.028* (0.012)	-0.017 (0.072)	-0.007*** (0.000)	-0.004* (0.015)	0.194*** (0.000)	-0.012* (0.018)	-0.006 (0.057)
SPL_GDP	-0.364** (0.005)	0.063 (0.256)	0.114* (0.014)	$-2.88e^{-4}$ (0.975)	-0.021* (0.012)	-0.549*** (0.000)	0.087*** (0.000)	2.34^{e-4} (0.989)
SPL_MIG	-0.446 (0.112)	0.038 (0.748)	0.067 (0.505)	0.027 (0.174)	-0.153*** (0.000)	-0.601 (0.058)	-0.043 (0.417)	-0.071* (0.042)
N	3598	3598	3598	3598	3598	3598	3598	3598
R^2	0.428	0.794	0.714	0.714	0.596	0.159	0.944	0.278

Notes: Number of regions = 257, P-values are given in parentheses. Significance codes: *** p<0.001 **p<0.01, *p< 0.05.

Table A2.2: Regression results of SpVar fixed effects panel models with GRW subsidies and time lag = 1

DEPENDENT VARIABLES / REGRESSORS (T-1)	LFT	LOVN	LSCO	LEMPLL	LINC	LLAPR	LGDP	LMIG
LGRW	0.491***	-0.002**	0.001	$1.84e^{-4}$	$5.87e^{-5}$	$-3.28e^{-4}$	0.001**	$-1.30e^{-4}$
	(0.000)	(0.001)	(0.265)	(0.075)	(0.521)	(0.843)	(0.008)	(0.477)
LOVN	-0.226	0.759***	-0.038***	0.002	0.003	0.100**	0.008	0.005**
	(0.440)	(0.000)	(0.000)	(0.212)	(0.109)	(0.001)	(0.134)	(0.143)
LSCO	-0.325	-0.037*	0.732***	0.002	0.005	-0.048	0.002	0.012*
	(0.448)	(0.031)	(0.000)	(0.582)	(0.064)	(0.291)	(0.744)	(0.021)
LEMPL	1.946	-0.151	-0.030	0.524***	-0.007	0.231	-0.106**	0.029
	(0.401)	(0.098)	(0.701)	(0.000)	(0.598)	(0.348)	(0.010)	(0.281)
LINC	2.570	-0.021	0.020	0.113***	0.626***	0.261	0.059	0.145***
	(0.345)	(0.843)	(0.823)	(0.000)	(0.000)	0.365	(0.218)	(0.000)
LLAPR	-0.358*	-0.002	-0.002	-0.001	-0.002	0.270***	-0.003	$-2.53e^{-5}$
	(0.023)	(0.785)	(0.680)	(0.443)	(0.078)	(0.000)	(0.259)	(0.989)
LGDP	-2.365**	0.033	0.044	0.025***	-0.006	-0.207**	0.670***	0.031***
	(0.001)	(0.250)	(0.069)	(0.000)	(0.155)	(0.007)	(0.000)	(0.000)
LMIG	-0.857	0.024	-0.015	0.005	-0.022*	0.003	-0.080**	0.375***
	(0.557)	(0.675)	(0.763)	(0.641)	(0.011)	(0.983)	(0.002)	(0.000)
SPL_GRW	0.068	-0.001	-0.001	$2.418e^{-4}$	$9.06e^{-6}$	-0.006*	$-1.27e^{-4}$	$2.01e^{-4}$
	(0.002)	(0.465)	(0.329)	(0.095)	(0.943)	(0.015)	(0.743)	(0.431)
SPL_OVN	-0.057	-0.011	-0.011	0.004	0.002	-0.185***	-0.016	-0.001
	(0.907)	(0.582)	(0.501)	(0.193)	(0.460)	(0.000)	(0.059)	(0.901)
SPL_SCO	0.671	-0.012	-0.020	-0.021***	-0.005	0.090	-0.019	-0.017*
	(0.262)	(0.603)	(0.319)	(0.000)	(0.126)	(0.157)	(0.079)	(0.017)
SPL_EMP	-7.695*	-0.082	0.249	$-4.349e^{-5}$	0.025	0.236	0.023	-0.226***
	(0.043)	(0.584)	(0.051)	(0.999)	(0.255)	(0.559)	(0.731)	(0.000)
SPL_INC	0.038	0.154	0.424**	-0.012	-0.170***	-0.254	-0.094	$-1.99e^{-4}$
	(0.993)	(0.385)	(0.005)	(0.698)	(0.000)	(0.593)	(0.235)	(0.997)
SPL_LAPR	0.446*	0.027*	-0.011	-0.007***	-0.004*	0.192***	-0.012*	-0.006
	(0.101)	(0.015)	(0.229)	(0.000)	(0.010)**	(0.000)	(0.015)	(0.058)
SPL_GDP	-1.815	0.021	0.056	-0.003	-0.015*	-0.514***	0.083***	0.006
	(0.173)	(0.61)	(0.213)	(0.699)	(0.049)	(0.000)	(0.000)	(0.644)
SPL_MIG	-6.019*	0.028	0.018	0.025	-0.151***	-0.558	-0.036	-0.071*
	(0.044)	(0.814)	(0.858)	(0.205)	(0.000)	(0.078)	(0.490)	(0.040)
N	3598	3598	3598	3598	3598	3598	3598	3598
R^2	0.259	0.794	0.711	0.714	0.596	0.160	0.944	0.278

Notes: Number of Regions = 257, P-values are given in parentheses. Significance codes: *** p<0.001 **p<0.01, *p< 0.05.

Table A2.3: *Panel Granger Causality Test (lag =1)*

GRANGER CAUSES (↓ →)	LFT		*LGRW*		LUDP		LOVN		LSCO		LEMPL		LINC		LLAPR		LGDP		LMIG	
	value	p-value	*value*	*p-value*	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value
LFT	x	x	-	-	-	-	5.647	0.000	7.805	0.000	12.25	0.000	-2.70	0.007	0.821	0.411	-0.40	0.689	6.666	0.000
LGRW	-	-	x	x	-	-	1.679	0.093	2.983	0.003	4.114	0.000	-0.36	0.717	2.066	0.039	-0.26	0.788	1.309	0.191
LUDP	-	-	-	-	x	x	6.102	0.000	3.618	0.000	8.631	0.000	0.638	0.524	2.545	0.011	-1.53	0.125	2.513	0.012
LOVN	11.76	0.000	7.962	0.000	7.217	0.000	x	x	11.16	0.000	25.89	0.000	0.054	0.957	3.086	0.002	2.259	0.024	18.14	0.000
LSCO	5.24	0.000	3.079	0.002	5.776	0.000	16.42	0.000	x	x	21.39	0.000	2.808	0.005	2.424	0.015	5.93	0.000	6.174	0.000
LEMPL	1.61	0.107	-1.39	0.163	-1.18	0.237	6.359	0.000	9.565	0.000	x	x	8.891	0.000	0.555	0.579	5.961	0.000	19.31	0.000
LINC	-0.02	0.977	-2.34	0.019	-1.38	0.166	3.782	0.000	4.304	0.000	3.863	0.000	x	x	0.773	0.439	9.307	0.000	7.561	0.000
LLAPR	1.08	0.279	1.889	0.059	1.659	0.097	4.348	0.000	2.769	0.006	5.994	0.000	1.953	0.051	x	x	1.135	0.257	1.661	0.096
LGDP	17.0	0.000	12.39	0.000	10.59	0.000	25.41	0.000	9.617	0.000	29.73	0.000	-4.89	0.000	10.64	0.000	x	x	10.29	0.000
LMIG	1.13	0.255	-1.32	0.186	-0.54	0.584	3.158	0.002	2.441	0.015	6.392	0.000	3.301	0.001	-6.85	0.493	-1.41	0.158	x	x

Note: Granger Causality Test is performed for every region, test as given in Dumitrescu & Hurlin (2012). Alternative hypothesis = Granger causality given for at least one region. For LFT, LGRW_IND, LGRW_INF and LUDP: Only regions that are not =0 get tested

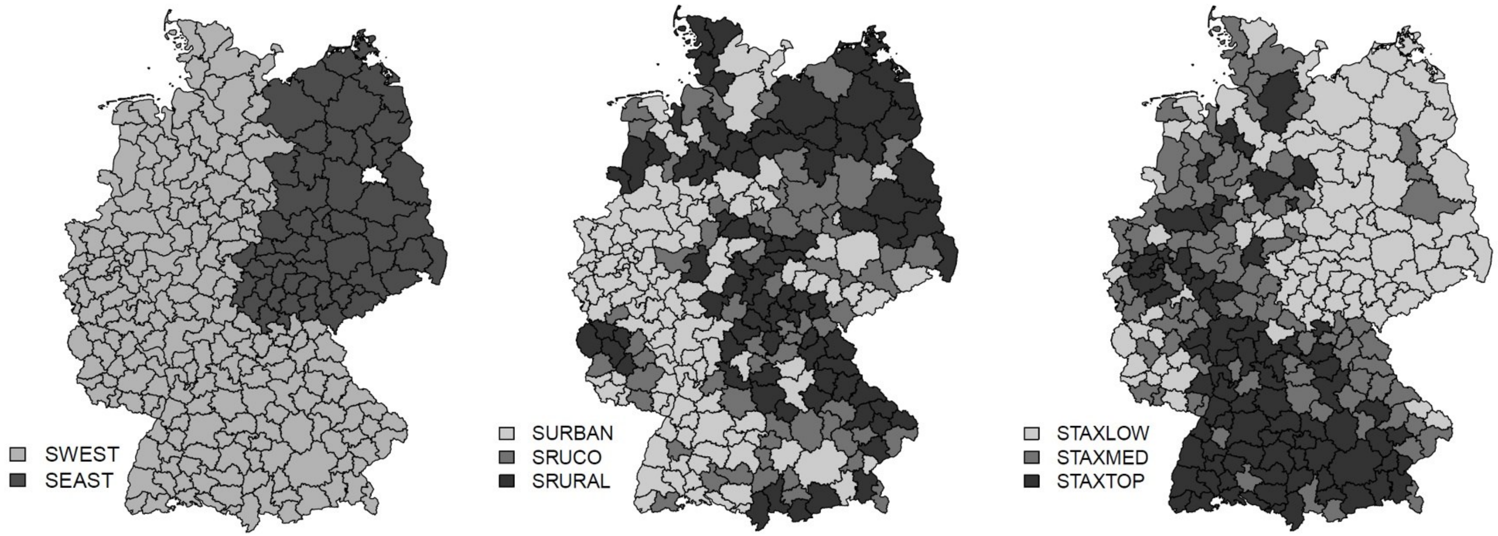

Figure A2.1 Regional subsamples used for the region-specific SpVAR analyses. SpVAR, spatial vector autoregressive

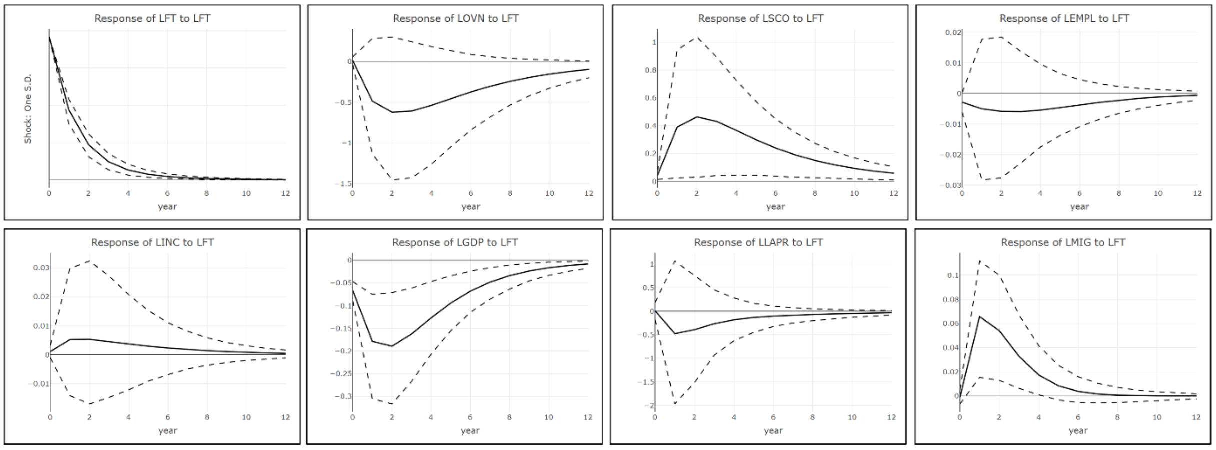

Figure A2.2: Full impulse responses to isolated fiscal transfer shocks based on SpVar estimation with fiscal transfer inputs in total subsample. Graph specification equal Figure 2.3

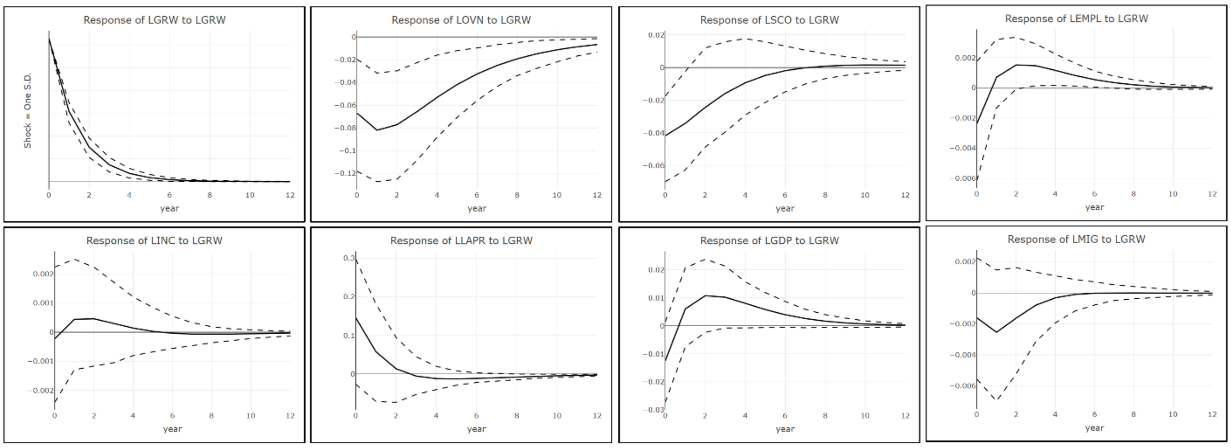

Figure A2.3: Full impulse responses to isolated GRW shocks based on SpVar estimation with GRW inputs in total subsample

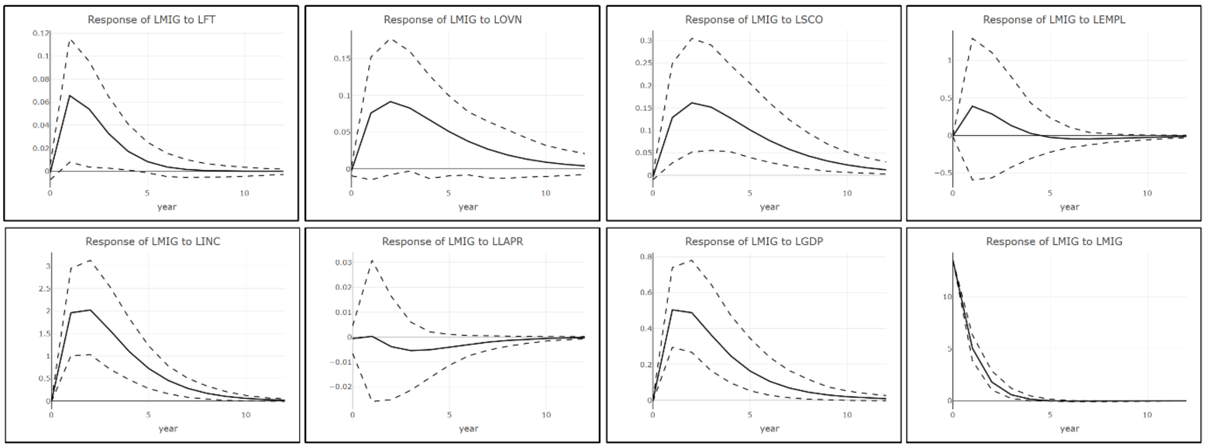

Figure A2.4: Full impulse responses to isolated variable shocks on regional net migration rates based on SpVar estimation with fiscal transfer inputs in total subsample

3. Measuring the regional, multifaceted, direct and indirect Effects of European Cohesion Policies

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Notes: This paper was submitted for publication in the *Journal of Regional Science* (11.02.2021). The paper is co-authored by Thomas Brenner.

Abstract: European structural and investment funds (ESIF's) are the European Union's main instrument for ensuring spatially equitable and sustainable regional development in its member states. The efficacy of these funds is a multi-billion-dollar issue and of great interest to policy makers from the European Commission to local governments. The paper complements the existing literature by applying an advanced econometric method to study the multifaceted, direct and indirect regional effects of three ESI-funds at European NUTS-2 level based on panel data estimations for 258 European regions and the years from 2007 to 2017. We test the efficacy of the ERDF, ESF and Cohesion Fund separately on regional indicators of economic growth and on regional migration rates, using a spatial panel vector-autoregressive (SpVAR) model considering time-lagged effects and indirect effects between the variables in the economic system. Furthermore, we analyze if effects depend on regional characteristics such as regional economic strength.

We find evidence that the ERDF can support economic growth by having positive effects on employment growth, regional productivity growth and growth of household incomes, especially in less developed regions, while ESF and Cohesion Fund do not reveal overall robust effects. We do not find significant effects of all three funds on regional migration rate changes, which is used as a proxy indicator for the development of living conditions that are not measurable by economic indicators.

Keywords: European regional policy, Cohesion Funds, economic growth, employment, migration, SpVAR, impulse response functions

JEL classification: C33, R10, R15, R23, R58

3.1 Introduction

European regions experience heterogeneous recent economic, social and political development trends that cause asymmetric living conditions and development challenges throughout Europe. These regional disparities, especially between eastern and western, but also between northern and southern European regions, have arisen as a remnant of Europe's historic development. Moreover, disparities between dynamic metropolitan core areas that pull skill-intensive high wage jobs and less prosperous and declining peripheral and rural areas are getting more intense in many countries in recent years (Charron, 2016). A third thread of challenges for Europe's regional development arises from the aftermath of the economic crisis from 2008 onwards whose consequences are still noticeable particularly in southern European countries, as well as the economic impact of the COVID-19 pandemic.

Hence, the European Union is confronted with major structural inequalities that determine economic dynamics and citizens living standards, such as employment opportunities, personal incomes or access to education, social and health-care infrastructure and public services. In the recent literature, the outcome of regional inequalities is discussed as the geography of discontent (Dijkstra et al., 2020). Inequalities are accused of threatening economic development and political stability by triggering rising nationalist parties, especially in more remote and declining areas, resulting in mistrust in politics that caused for example the Brexit vote in 2016, which has a strong impact on the future development of Europe (Iammarino et al., 2019; Dijkstra et al., 2020).

Regional Cohesion Policy addressing social and economic convergence is a key issue in the EUs development strategy. European Structural and Investment Funds (henceforth ESIFs) aim to reduce economic and social disparities as well as to improve economic competitiveness and citizens' living standards by reallocating financial resources predominantly to less developed regions with manifold individual policy actions (European Union, 2012). It is a key task of the

ESIFs to ensure a balanced development, while at the same time not undermining total welfare by reallocating production factors to less productive regions (Fiaschi et al., 2018). This conflict is often declared as a trade-off from spatial development policies (Glaeser, 2011; Storper, 2011). It implies that policy measures can be efficacious in terms of convergence among regions by enhancing economic growth, creating jobs or improving quality of life in a less developed region, while being not necessarily efficient, if the same expenses would create more positive outcomes in more developed regions. Hence, there is a need to distinguish between efficacy and efficiency of Cohesion Policy. By targeting regional convergence, Cohesion Policies have to be efficacious in promoting local factors towards convergence, while macroeconomic efficiency in terms of creating maximum output is subordinate. Further research on the efficacy of cohesion-oriented policy needs to provide new insights into policy mechanisms, since the European Commission aims to setup more result-based and more efficient Cohesion Policy in order to maximize outcomes in the forthcoming program period 2021 – 2027 (European Commission, 2018).

Since the Treaty of the European Union (Lisbon Treaty) identifies three development objectives: Economic, social and territorial cohesion (European Union, 2012), policy evaluation should not be limited to economic growth measures, but should also assess effects on the social dimension, although all policies are primarily economic policies (Ferrara et al., 2020). Barca (2009) points out that improving the people's well-being and living standards is the ultimate goal of Cohesion Policy. Iammarino et al. (2020) emphasize the role of regional and local living conditions apart from economic conditions as gateways for building personal capacities and personal freedom to participate in society and economy. Studies that examine non-economic outcome of Cohesion Funds are underrepresented in quantitative research and limited to Ferrara et al.'s (2020) recent working paper. This paper simultaneously addresses the versatile policy objectives - economic growth and non-economic regional development– and gains new insights into the contribution of ESIF investments to these factors.

For this purpose, we investigate the effects of the three strands of the Cohesion Policy Framework (European Regional Development Fund (ERDF), European Social Fund (ESF) and Cohesion Fund). Our flexible spatial vector autoregressive estimation approach (henceforth: SpVAR) is able to represent the complex and interdependent regional dynamics triggered by policy measures using simultaneous equations and considering indirect funding effects between variables through various transmission channels and has not been used yet in the context of European Cohesion Policy. Our paper contributes to the existing research by emphasizing the variety of effects on regional outputs of ESIF policy measures, namely public investment rate, employment, GDP growth, household income and regional net migration rates. We find evidence, that the ERDF works towards economic convergence by having positive effects on employment, GDP and household income growth, while ESF effects are limited to income effects in Eastern Europe and the Cohesion fund only affects regional migration rates in a significant matter.

The paper starts with a brief presentation of the investigated policies in Section 3.2, while section 3.3 provides an overview of related existing research on European Cohesion Policy efficacy. Research hypotheses, variable selection and the econometric model setup are discussed in section 3.4 and 3.5. Our empirical results are given in section 3.6. Section 3.7 concludes.

3.2 Cohesion Policy Framework

Cohesion Policy is a solidarity framework aiming at interregional convergence across Europe. Strong economies within the EU redistribute a part of their wealth to less developed regions to enable them to create smart, sustainable and inclusive economic growth paths in line with the

Europe 2020 strategy. The individual policies within the framework target several dimensions of regional development in funded regions: Productivity and competitiveness of the local economy, in particular sustainable development, combating unemployment, inequalities and economic discrimination (European Commission, 2015). However, it is widely accepted that the objective of European cohesion is not equal to perfect convergence across regions.

The ESIF consist of five specific funds with individual objectives that interact complementary to a holistic policy framework. Out of these, the ERDF, the ESF and the Cohesion Fund are investigated in this paper. We would have liked the European Agricultural for Rural Development (EAFRD), but the used dataset reveals inconsistencies that mainly concern the year 2014 and analyses with this limited dataset show no significant effects of the policy. The European Maritime and Fisheries Fund (EMFF) is not an actual regional development fund. The detailed individual specifications indicate that the outcome is supposed to vary between policies, which provides a specific interest in analyzing the individual mechanisms of the funds in separate analysis. Funding details are presented in Table 3.1, the spatial distribution of funding intensity is displayed in Figure 3.1.

The fund allocation is based on the classification of regions into categories based on their GDP level per inhabitant that alters by funding period. Policy strategies, management and implementations are organized individually by the member countries under supervision of the European Committee through partnership-agreements (until 2013: "National Strategic Reference Frameworks"), which allows countries to pursue individual goals within the cohesion framework, but implies that policy efficacy and efficiency may be heterogeneous on country level. Funds are designed to serve as a catalyst for further capital investments in the regions by requiring co-financing of received subsidies by recipient countries and creating incentives for further private investments, due to improved local infrastructure or business amenities. (European Commission, 2014).

Table 3.1: Overview on ESIF funding objectives

Fund	Major Objectives	Average annual amount (2007 – 2017)*	Remarks
ERDF	Economic growth, regional competitiveness, employment, innovation, entrepreneurship, research & technological development, sustainable transformations & green growth	20.8 bn €	The majority of funds is directly paid to supported firms (especially SMEs).
ESF	Employment growth, human capital development & job training, inclusive labor market accessibility, fight against poverty risks, social exclusion and discrimination	8.77 bn €	A restructuring of fund design into ESF+ for the new funding period starting in 2021 is under negotiations.
CF	(technical) infrastructure development, in particular (trans-European) transport and energy infrastructure, environment protection, climate change adaption, enhance institutional capacities of public administrations and authorities	8.18 bn €	Funding is limited to countries with a gross national product below 90% of the EU average level.

References: (European Union, 2013a; 2013b; 2013c). * Modelled annual expenditures published by the European Commission.

3.3 Related studies

Given the total amount spent on Cohesion Policy, it is not surprising that various econometric studies examine its economic impact. However, the results do not yet reach any consensus and depend on model specifications, time-period, regional sample (EU15 or EU27) and the regional units chosen.

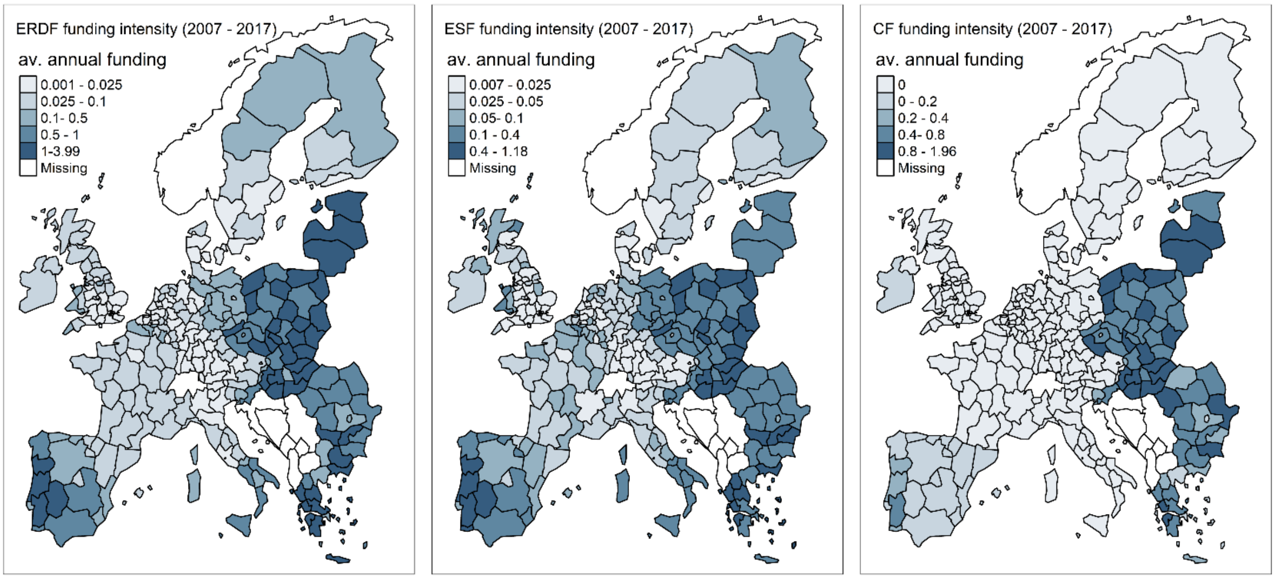

Figure 3.1: Average annual Cohesion policy funding intensity (Modelled annual expenditures) 2007 – 2017 per fund. Data source: Lo Piano et al. (2018)

Hagen and Mohl (2009) provide an older comprehensive summary on econometric ex-post studies that find mixed effects of policy interventions on economic growth between 1981 and 2005. The authors outline that most of these studies show conditional positive policy effects, but argue that all methods used have some empirical drawbacks.

The EU enlargements of 2004 and 2007 changed the situation dramatically, as the new member countries increase inequalities, bring further variety of economic and institutional preconditions and now receive a major share of the funds. Although some time has passed since the enlargement, most recent studies still concentrate on the EU15 countries. Pieńkowski & Berkowitz (2016) provide an extensive summary on econometric Cohesion Policy analysis studies up to 2015, studies published later are shown in Table 3.2. The majority of these studies find positive impact of the ESIF on economic growth, but differ widely in terms of methodology, used samples, programming periods and policy variables.

Table 3.2: Comparison of recent econometric studies measuring Cohesion Policy efficiency

Authors	Model	Policy Variable	Time period	Regional Unit of observation	Dependent Variable	Findings
Bondonio (2016)	Propensity Score Matching estimation	Objective-1 Treatment Dummy	1995 - 2006	NUTS-2 (EU15)	GDP per Capita growth rate	Positive effects on regional growth rate
Pellegrini & Cerqua (2017)	Regression Discontinuity Design	All ESIF expenditures	1994 - 2006	NUTS-2 (Objective 1 regions in EU-15)	GDP per Capita	Positive effect on regional growth
Percoco (2017)	Regression Discontinuity Design (HLATE)	Objective-1 Treatment Dummy	2000 - 2006	NUTS-3 (EU15)	GDP per capita	Regions with a lower level of public services profit more from funds
Gagliardi & Percoco (2017)	Regression Discontinuity Design (HLATE)	Objective-1 Treatment Dummy	2000 - 2006	NUTS-3(EU15)	GDP per capita	Heterogeneity in policy efficiency. Highest benefits for rural areas located next to city centers
Ferrara et al. (2017)	Regression Discontinuity Design	Objective-1 Treatment Dummy	2000 - 2006	NUTS-2 (EU15)	Patent applications & road accessibility	Positive effects on research & Innovation and on transport infrastructure
Becker et al. (2018)	Regression Discontinuity Design	Objective-1 Treatment Dummy	1989 - 2013	NUTS-2	GDP per capita growth, employment growth, total and public investment intensity	Positive, but short-time effects on economic growth of Objective-1 status, negative effects if status gets lost.
Fiaschi et al. (2018)	Spatial panel fixed effects model	Total objective-1 funding intensity	1991 - 2008	NUTS-2	GDP/worker	Positive effects on growth in objective-1 region funds, limited for others. Increasing effectiveness over time. Reduction of regional disparities, but diminishing marginal utility of funding.
Breidenbach et al. (2019)	Dynamic Panel data model	Aggregated ESIF funding expenditure	1997 - 2007	NUTS-2 (EU15)	GDP per Capita	Insignificant or in some regions negative impact on growth, driven by spatial spillovers
Bachtrögler et al. (2020)	Difference-in-Difference (	Treatment Dummy	2007 - 2013	Firm-level (7 countries)	Value added and employment and productivity (value added per employee) on firm level	Conditional positive effects on firm growth. Smaller effects on firm productivity. Strong Variations in effectiveness across regions. Larger for underdeveloped countries.
Crescenzi & Guia (2020)	Regression Discontinuity Design	Treatment Dummy	2000 - 2014	NUTS-3 regions (selected countries)	Gross Value Added; Employees in manufacturing sector	Positive effects on economic growth and employment. Heterogeneity across countries. Germany and UK benefit most.
Ferrara et al. (2020)	Generalized Propensity Score & Dose-Response function estimation	Aggregated ERDF & ESF funding expenditure	2000 - 2006	NUTS-2 (EU15)	Self-computed well-being index	Positive effects of ERDF & ESF on individual well-being

Moreover, a strand of studies discusses the Cohesion Policy effects on individual countries and regions. For example, Guia (2017) finds positive effects on regional employment in Italian regions, Fortuna et al. (2016) conclude that loosing Cohesion funds would cause a GDP and consumption drop on the Azores, Medeiros (2017) finds positive effects on environmental sustainability and governmental, but not on economic cohesion in Spanish regions.

In contrast to earlier research, a relevant share of more recent studies increasingly focuses on the essential finding, that policy effectiveness is heterogeneous and location-dependent (Rodriguez-Pose & Garcilazo, 2015; Crescenzi & Guia, 2020). This results in different findings across member states and types of regions. Reasons for this conditionality are suspected in national policy implementations due to partnership agreements as well as in heterogenous administrative and institutional capacities that are determined by local economic, social and natural conditions and the quality of government and local institutions (Ederveen, de Groot & Nahuis, 2006; Rodriguez-Pose & Garcilazo, 2015; Fratesi & Wishlade, 2017; Dotti, 2016). Moreover, the differing economic structure across European regions creates preconditions that are expected to cause different reactions to policy interventions and require customized solutions. Therefore, conditionality of funding effects is an important part of our analysis.

Recently, Ferrara et al. (2020) and Rodriguez-Pose and Dijkstra (2020) added a new thread to the literature considering for the first time social and socioeconomic effects of Cohesion Policy. The former address regional well-being by creating a well-being indicator that is based on a number of objective regional measures such as individual income, education & health care. They find a positive relationship between ERDF & ESF funding and growth of regional well-being. The latter find a political correlation between Cohesion funds and lower eurosceptic votes.

3.4 Theoretical considerations and research hypotheses

Although Cohesion Policy aims to support structural lagging regions to start an economic catching-up process that enables future income and career opportunities in a region (European Commission, 2017), regional economic growth is not necessarily equal to growth of the citizens' individual well-being that depends on various personal circumstances, such as the individual employment status, job satisfaction, income, housing situation, quality of health care & public services, education infrastructure and further residential amenities. Since the treaty of the European Union mentions economic cohesion in line with the objectives of social and territorial cohesion, efficient cohesion policy should have positive impact on all these dimensions (European Union, 2012). In consequence, a measure of the effectiveness of European Cohesion policy should consider multiple regional outcome variables. Therefore, we have developed the research questions *Is European cohesion policy efficacious in terms of regional economic development and individually perceived quality of life?*

Neoclassical growth theory is often used to explain the impact of public investments on regional growth in a specific region (Dall'Erba & Fang, 2017; Eberle et al., 2019). Starting with the extended neoclassical regional production function from Mankiw et al. (1992) (MRW-Model), the economic output *Y* from a region *i* at time *t* is defined as:

$$Y_{it} = K_i^{\alpha} H_i^{\beta} (A_{it} L_{it})^{1-\alpha-\beta}, \tag{3.1}$$

where *K* and *H* are physical and human capital stocks, *A* denotes the technology level and *L* represents the regional labor supply. α and β are coefficients describing the returns to both types of capital with $\alpha + \beta < 1$, under the assumption of decreasing returns to capital. Both types of capital depreciate at the same rate. *A* and *L* grow at an exogenous rate, where labor supply equals the working-age population. In a spatially augmented MRW-model, Lopez-Baso et al. (2004) argue that technology additionally depends on capital investments as well as the technology level of neighboring regions that spill over into the regional economy, which causes interdependencies between regions.

Following Crihfield et al.'s (1995) extension to this model, which allows for distinguishing between private and public capital, capital investments from Cohesion Policy should work as exogenous shocks on (public) physical capital stocks. While the ERDF & CF mainly focus on physical capital investments, the ESF mainly invests in human capital resources. All policies therefore enhance the regional steady state output Y_{it} and support further capital accumulation. Considering the marginal product of private capital, decreasing returns cause that benefits are higher for regions with a low initial capital stock. In consequence, economies with similar economic conditions converge towards a common steady state income level (ß-convergence), with low-income regions growing faster than high-income regions (Durlauf et al., 2005). Additionally, economic market integration and free trade due to EU-membership should align the economic condition and strengthen convergence throughout Europe. Barro (2012) argues that this would render the need for Cohesion Policy superfluous. In practice, however, short-term convergence without regional policy interventions is not realistic, since income inequalities originate in persistent local factors that determine the regions absorptive capacity such as infrastructure, production factor endowments (resources and knowledge capacities) and quality of local institutions, which cannot simply converge (Pienkowski & Berkowitz, 2016).

While in neoclassical models growth is limited to the new steady state levels, we argue that technology level is not necessarily exogenous, but can be strengthened by R&D and human capital investments as emphasized by endogenous growth models (Romer, 1990; Jones, 1995). Therefore, we argue that policy measures including investments in R&D should have long-term effects on economic output. Furthermore, the new economic geography framework (Krugman, 1991; Fujita et al., 1999) points out that regional economic development benefits from infrastructure investments, especially in the transportation and energy sectors by improving accessibility and local conditions for economic development, which may possibly stimulate further private sector investments. This leads to hypothesis 1:

H1: Public investments from Cohesion Policy increase regional (public) capital stocks which stimulate (short-time) regional economic growth (steady state shift) and result in increasing outputs and employment rates; Long-term growth depends on investments in technology and infrastructure.

The mentioned theoretical approaches do not directly suggest expectations regarding the population's participation in economic growth, growth of regional living standards and well-being. We consider average disposable household income as an important indicator for material living conditions. Following the MRW-Model, at a given population, labor supply remains constant. However, the output growth due to public investment assumed in *H1* is an exogenous shock increasing labor demand that should result in rising wages, at least in the long-run and have positive effects on disposable household incomes by reducing unemployment.

H2: If H1 (GDP and employment growth) applies, public funds cause increasing wages and primary incomes.

Assessing non-economic outcome of policy interventions, we face the lack of comprehensive social or socioeconomic regional data and the absence of a common indicator to measure regional quality of life and well-being and the individual perception of well-being. Hence, different approaches appeared in similar studies. First well-being and happiness scores provide information about the individual perception of well-being. However, Bond & Lang (2019) argue that this produces systematic errors and are not necessarily comparable across countries and in time, as people tend to adapt to new living conditions. Second, studies such as Ferrara et al. (2020) construct objective well-being indices build upon available regional data. However, these indices tend to be biased due to the authors variable selection and cannot possibly reflect the individual dimension of well-being.

Faggian et al. (2012) use regional net-migration rates as a proxy indicator of regional well-being based on the hypothesis that regions with below-average living conditions experience out-migration and vice versa. We enhance this to an explicitly dynamic context in which Cohesion Policy that successfully improves the quality of life in a region, should increase regional net migration rates by creating incentives to either stay in a region or move into a region. Pfaffermayr (2012) models net immigration ξ in a number of regions $(y_1 \ldots, y_N)$ as:

$$\xi(y_1 \ldots, y_N) \approx \kappa\left[(y_i - y_i^*) - \sum_{j=1}^{N} m_{ij}(y_j - y_j^*)\right] \tag{3.1}$$

In this formula, $y_i - y_i^*$ denotes the difference of the regional income to the regions steady state income, m_{ij} represents exogenous spatial weights that represent the fact that short-distance migration between neighbouring regions appears to be more likely and decreases with distance, due to financial and social migration costs. The constant parameter κ denotes the sensivity to migrate at a given spatially weighted income differential (Pfaffermayr, 2012).

Thus, a regional net migration rate highly depends on the regions income level. However, Rodriguez-Pose & Ketterer (2012), Faggian et al. (2012) and Wardenburg & Brenner (2020) argue that individual migration decisions do not only depend on economic considerations, but also on regional natural and cultural amenities that determine the individual well-being, such as the weather, local infrastructure, availability of public services and public goods, education, health care and other individual preferences. Thus, dynamic changes in the net migration rates also reflect the development of regional non-economic amenities and emphasize individually weighted demands and preferences of economic welfare and non-economic well-being and become a reasonable indicator for the development of the individually perceived regional quality of life. Wardenburg & Brenner (2020) find that investments in public goods may prevent out-migration from structurally lagging regions. By concentrating on a dynamic setting, the initial level of in- or out-migration is not relevant. The same applies to migration frictions, assuming them to be constant for every region.

H3: Public investment in the regional quality of life, especially in public goods and services, should lead to increasing net migration rates, especially to reduced outward migration from economically lagging regions.

At least it should be mentioned that migration and growth are not independent. Population growth cannot be handled as exogenous in modelling economic growth, since it is directly affected by net migration. Net migration brings additional output capacities and development potentials by enhancing labor supply and human capital within a region, while regions with negative net migration suffer from brain-drain dynamics. On the other hand, immigration should decrease the labor-capital ratio and returns to human capital, which negatively affects labor productivity.

3.5 Econometric strategy

The search for new quantitative methods to best measure the outcome of Cohesion Policy is an ongoing debate in this field resulting in various approaches (*see Table 3.2*). We decided to test our hypotheses with a flexible recursive dynamic spatial vector-autoregressive model (SpVar) that is not used in this context before and is becoming increasingly popular in policy analysis for several reasons. The SpVar is able to investigate short-time policy effects on various output variables, while controlling for the mutual endogeneity among variables and considering indirect effects between variables in the regional economic system over time through other transmission channels. Thus, we overcome the common problem of econometric policy analysis that not perfectly exogenous controls or instruments that are affected by the policy itself bias the results (Angrist & Pischke, 2009). The simultaneous equation approach origins in Sims

(1980) approach on time-series forecasting, enhanced for the use of panel data estimations by Holtz-Eakin et al. (1988) and allows to build dynamic regression designs that are able to represent that the outcome effects are time-lagged to the funding input and enables to visualize relationships and temporal dynamics between variables via associated impulse response functions.

We basically follow the econometric SpVAR estimation strategy used in comparable research settings (Mitze et al., 2018; Eberle et al., 2019). Therefore, we specify a dynamic simultaneous panel equation system with *M* (=6) equations, in which every variable in the system appears as dependent variable once, depending on lagged values of all variables in the system. Variable selection is based on theoretical considerations from Section 3.4, including regional capital, labor, output productivity, primary income and migration. Information on used variables are given in Section 3.5.2. The reduced form VAR can be written in its aggregated form as follows (Rickman, 2010; Mitze et al., 2018):

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + \varepsilon_{\mathrm{it}} \tag{3.3}$$

where *A* is a *M*M* size matrix of regression coefficients that describes the relationship y_{it} to the time-lagged variables in the system. The choice of one-year lags is based on the Akaike-Criterion. The use of individual fixed effects (μ_i) considers strong regional heterogeneity controlling for time-invariant preconditions across the EU. In addition, heterogeneous economic dynamics should be considered, especially during and after the economic crisis beginning in 2008/2009. Thus, pooling all regional units into standard invariant time-fixed effects (τ_t) can thus not adequately capture this heterogeneity. To address this problem, we cluster all regions into four more homogenous development groups (*g*) and estimate four separate group specific time-fixed effects (τ_{tg}). Two parameters are used for the grouping: First the GDP level in 2007 to obtain an exogenous measure of economic strength and the GDP growth between 2007 and 2017 to measure the economic dynamics within the region. Then we group the regions as follows: (1) If both GDP and growth rates are below the median; (2) If their economic strength is above median, but growth rates below median; (3) If GDP level is below median, but growth rates above the median and (4) if both values are above the median level. The groups are displayed in Figure 3.2. The time fixed effects are added to equation (3.3):

$$y_{it} = \mu_i + \tau_{tg} + Ay_{it-1} + \varepsilon_{\mathrm{it}}. \tag{3.4}$$

Several further adjustments must be made to the unrestricted reduced model presented in equation (3.4): To consider the impact of spatial externalities on the regression results, we include additional independent spatial lag variables to calculate unbiased coefficients in *A* as follows (Beenstock & Felsenstein, 2007):

$$y_{it} = \mu_i + \tau_{tg} + \mathrm{A}y_{it-1} + HWy_{it-1} + \varepsilon_{\mathrm{it}}. \tag{3.5}$$

In this equation, the supplementary $M*M$ coefficient matrix *H* represents coefficients of variables lagged in space and time, representing possible spatial spillover from neighboring regions. *W* is an identity spatial weight matrix that is constant over equations and time, with W_{ij} = 1 if regions have a common border (Spatial-Durbin-model). In the case of remaining island regions in the dataset (Greek Islands, Baleares, Sardinia, Sicilia), we define the nearest regions as neighboring regions. Comparing model fits confirms, that using an identity weight matrix is more efficient for our data than computing spatial lags based on inverse-distance weighting.

As Elhorst (2012) points out different estimators are feasible to estimate dynamic panel models. Since dynamic OLS-fixed effects estimators are known to be biased if *t* is small (Nickell, 1981), different techniques have been proposed. GMM estimators are common to dynamic panels. However, they are very sensitive to incorrect or weak instruments and categorization of endogenous and exogenous variables and other factors (Kiviet et al., 2017).

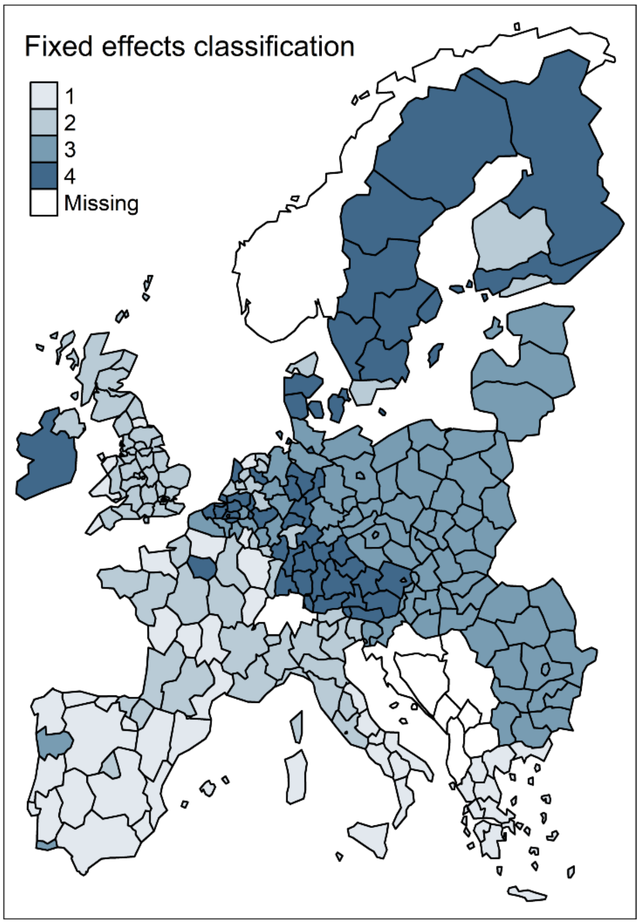

Figure 3.2: Regional classification into subgroups used for groupwise estimation of time fixed-effects

Hsiao et al. (2002) propose a quasi-maximum-likelihood estimator including fixed effects that is found to be consistent in the case of heterogeneous individuals in the estimation. However, we find QMLs estimations to perform weak in our estimation context if independent variables are not clearly exogenous. This is the case, since spatial lags of all variables are considered in the estimation (Beenstock & Felsenstein, 2007). Similar problems appear for bootstrap corrected OLS estimators (Kiviet, 1995; Everaert & Pozzi, 2007) since the authors clarify that exogeneity of dependent variables is a necessary precondition. As t is not considerably small (=10), we argue, that the OLS-FE indicator is still not unbiased, but more robust than alternative estimators.

However, these considerations and restrictions make robustness checks essential. In order to ensure the robustness of the results, we additionally estimate equation to in a twostep system-

GMM estimation (see Blundell & Bond, 1998) with further lags of the dependent and independent variables as instrument variables, with collapsed instruments. To ensure the stability of the IRF-process, the variable calculation is slightly different in this robustness check. Furthermore, due to the GMM functionality ordinary time-fixed instead of grouped effects are used for GMM estimation.

3.5.1 Impulse response functions

In a next step, we estimate associated IRFs that visualize the relationship between an orthogonal uncorrelated shock in one variable to the other variables in the system that includes indirect effects between variables over time based on the coefficients from A. However, treating all variables as completely endogenous as in (3.5) causes over-parametrization of the error-term that leads to biased IRFs (Di Giacinto, 2010; Rickman, 2010). Following Rickman (2010), we define a structural VAR with a-priori recursive causal ordering of the variables based on assumptions towards ascending endogeneity corresponding to (3.5) as follows:

$$By_{it} = \mu_i + \tau_{tg} + Cy_{it-1} + HWy_{it-1} + D\varepsilon_{it} \qquad (3.6)$$

where B includes contemporaneous structural parameters, C is a coefficient matrix similar to A and D is a diagonal matrix linking uncorrelated exogenous shocks in ε_t to the endogenous variables. We restrict contemporaneous effects from right to left (more endogenous to more exogenous) performing a Choleski-Decomposition to the variance-covariance matrix of the variance-covariance matrix as proposed by Lütkepohl (2005). We then apply the moving average representation of C in which C^z represents the effects of one unit shock after z time-steps (Lütkepohl, 2005). This means that, although we display the development of responses to shocks over years in the IRFs, this is the direct and indirect replication based on the short-term (year to year) estimates from the structural VAR model with a one-year time lag. Finally, we calculate 95% confidence intervals of the IRFs based on Monte Carlo simulations in which the estimation is performed with similar, randomly generated same-size datasets in which regions are drawn from the original data set (with reclines) with all their original attributes (500 repetitions). The initial exogenous shock is hold constant over repetitions.

3.5.2 Data and variables

To test our hypotheses, we investigate the impacts of ERDF, ESF and the Cohesion Fund on NUTS-2 level in the period 2007 – 2017, which allows to consider effects for 258 regions in all EU27 countries, including the member states that joined in 2004 and 2007. We use the open policy Dataset "Historic EU payments – regionalized and modelled" provided by the European Commission with latest updates from May 2020. This data includes all annual expenditures by policy and funding period at NUTS-2 level. In our analysis, we aggregate the total annual amount of subsidies regardless of the funding period they belong to, so that total annual expenditures may include projects from different funding periods. However, the use of annual payments within calendar years is somehow problematic for policy evaluation, as they become effective at a later date. Depending on the specific projects this can happen rather quickly or, in the case of complex infrastructure construction several years later. To address this problem, we use the model-based measure "modelled annual expenditure" that models the funding that becomes effective on the ground in the specific year instead of payment. Details on the modelling approach are given by Lo Piano et al. (2018). However, the complexity of funded projects raises some doubt whether a one-year time lag is enough to measure the majority of outcomes of those subsidies, especially if the subsidies become effective at the end of the year. Therefore, we also estimated the model with an additional one-year time-lag on the policy variable. The results will be presented in Section 3.6.

We integrate regional variables based on the theoretical assumptions, namely the regional private sector investment rate, as a proxy for private physical capital investments and regional employment rate. The regional GDP per active working population is included to measure labor productivity as a measure for economic growth and regional competitiveness as a major goal of Cohesion Policy. To test H2 and H3, we include primary incomes of private households and regional net migration rates. We calculate the net migration rate of a region i at time t as

$$\frac{NM_{i,t}+Pop_{i,t-1}}{Pop_{i,t-1}}, \tag{3.7}$$

where $NM_{i,t}$ denotes net migration as the difference between all immigrants and emigrants to a region and POP is the region's population. In case of balanced migration its value will be 1, if in-migration exceeds out-migration the variable is larger. This transformation avoids negative values and ensures the possibility to use the logarithm form (Mitze, 2019).

Due to lack of data, we have not been able to include additional national public or regional development funds, which may be further sources of economic growth or regional development within European regions. We decided to omit further variables that may influence the socioeconomic system in order to limit the number of variables, which would reduce the degrees of freedom of the SpVAR model and cause further endogeneity problems. This is mainly the technological progress, but also socio-economic variables that may affect the migration rates. Our model is explicitly dynamic which means that more or less constant regional factors such as natural conditions and geographic location do not influence the dynamic development of the regional factors studied.

Detailed use of variables and data sources are displayed in Table 3.3. The majority of data was obtained from the Eurostat database. In some cases, we had to supplement missing data by data from the OECD statistics database. This applies for France and Poland and results from problems with NUTS-2 reorganizations within the time period that complicates to build up a continuous panel data set. For the same reason, we had to merge the regions within Ireland and Lithuania to their NUTS-1 shape. In the special cases of London, Budapest and Warsaw, that were divided into 5 (London) respectively 2 regions for NUTS-2016, we use the NUTS 2013

Table 3.3: Variable descriptions and data sources

Acronym	Variable Description	Data Source
POL	Policy Input (either ERDF, ESF or Cohesion Fund) in relation to regional GDP *[Policy Input/GDP in] €*	European Commission GDP: Eurostat/OECD
INVQ	Gross Capital Investment Rate *[Gross Capital Investment/GDP in €*	Eurostat GDP: Eurostat/OECD
EMPL	Employment rate of economically active population *[Employees total /Population aged 15 to 64 years]*	Eurostat
GDP	Nominal gross-domestic product per capita *[GDP in €/population]*	Eurostat/OECD
INC	Primary income of private households *[Primary income of private households/population]*	Eurostat/OECD
MIG	Regional net migration rate *[Net migration as a function of population as defined in equation (7)]*	Eurostat

boundaries with 2 (London) and 1 (Budapest, Warsaw) regions. We also omitted several regions from the dataset to improve the reliability of the analysis. First, we did not include oversea territories and islands that are more than 500 km away from the European continent or geographically belong to another continent (including the Canary Islands, Madeira, the Azores, Cyprus and the autonomous cities of Ceuta and Melilla) due to their different economic structure and limited migration possibilities. Malta had to be omitted due to poor data quality. Croatia cannot be part of the analysis as its EU accession only took place in 2013, Great Britain is still part of the analysis. Finally, we work with a balanced and reliable data set covering 11 years and 258 regions. All variables are used in their natural logarithm form. Zeros are replaced by very small numbers before transformation. The SpVAR models fail if non-stationarity is given in any variable. The results from the corresponding IPS-test (Im et al., 2005) are displayed in Table A3.1. The results indicate non-stationarity in the variables GDP and income.

Table 3.4: Variable summary statistics

Acronym	Observations	Min	1.Quarter	Mean	3. Quarter	Max	Std. Dev.
ERDF	2838	-18.421	-8.661	-7.142	-5.314	-2.504	2.018
ESF	2838	-18.421	-8.470	-7.494	-6.289	-3.958	1.600
CF	2838	-18.421	-18.421	-14.228	-6.412	-3.256	6.012
INVQ	2838	-2.546	-1.709	-1.577	-1.450	-0.507	0.221
EMPL	2838	-0.944	-0.491	-0.422	-0.323	-0.187	0.127
GDP	2838	8.392	10.165	10.463	10.857	12.014	0.609
GDP_detr	2838	8.352	10.178	10.358	10.730	11.880	0.629
INC	2838	7.492	9.347	9.636	10.056	10.899	0.615
INC_detr	2838	7.373	9.422	9.571	9.975	10.763	0.634
MIG	2838	-0.026	-0.001	0.003	0.005	0.054	0.005

To overcome this problem, a linear detrending is applied to the concerned variables. Table 3.4 provides summary statistics of all variables.

The use of NUTS-2 regions brings several advantages and shortcomings to the analysis. First, the measurement of economic and socioeconomic effects that take place at a more local level is imprecise at such a large regional scale. The use of the migration indicator on NUTS-2 regions may not be optimal, as a significant part of personal relocations are not noticed in the data because they take place within these regions, especially if prosperous core regions and economic lagging regions or urban and peripheral regions belong to the same NUTS-2 region. If people live in countries that consist out of just one NUTS-2 region (e.g. Latvia), they have to leave/enter the country to be present in the migration statistics. In such cases, migration barriers (language, culture, social and monetary costs) are substantially larger than at a more local level. On the opposite, the NUTS-2 scale is the regional level which defines regional eligibility for funding in the European regulations. Another advantage is that we are able to measure effects with a wider geographical scope. Policy funding should provide incentives to trigger further public and private investments into the region and potentially cause direct and indirect spillovers on the local and regional scale. However, the pragmatic reason for using NUTS-2 regions is the availability of data and regional classification of policy allocations. In particular, funds for interregional infrastructure projects (e.g. freeways) cannot be assigned to NUTS-3 regions in a reliable way.

In contrast to many existing studies, we are able to distinguish between policies. Moreover, considering regional conditionality, we conduct our analysis additionally on selected subsamples of the dataset to obtain a further understanding of which economic preconditions lead to more effective policy implementation. For this purpose, we divide the regions in the dataset following the European commission's official regional development classification that defines the eligibility of funding levels. This status is based on the on the regional GDP per capita on NUTS-2 level in comparison to the EU average: Regions are classified as less developed regions (former Objective-1 regions), transition regions and more developed regions (*See figure 3.3*).

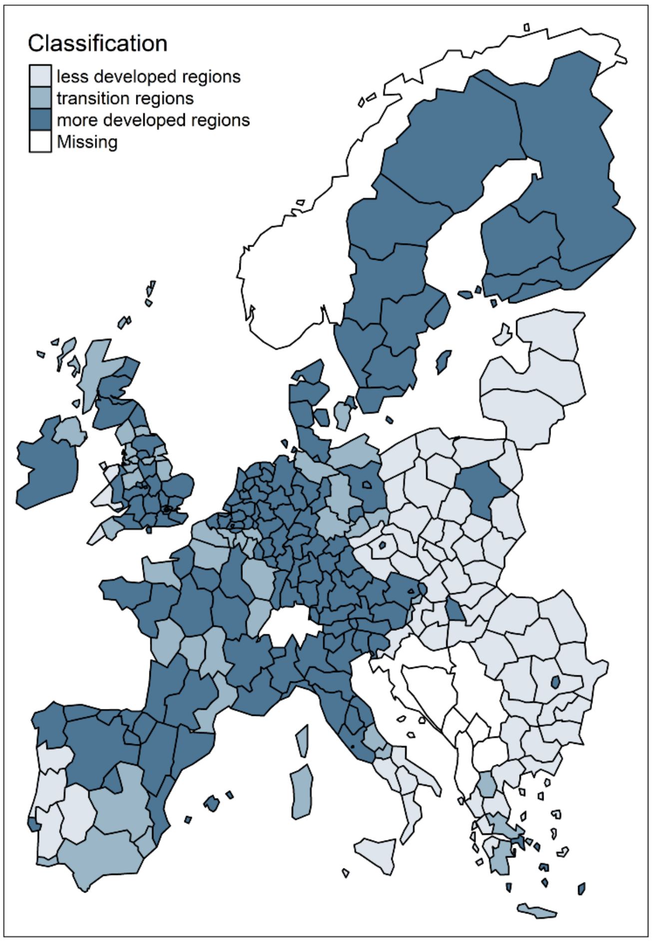

Figure 3.3: Classification of regions to define the eligibility of Cohesion funds (2014 to 2020)

3.6 Empirical results

In this section, we present the empirical findings. As expected, our results are heterogeneous across funds. This supports the assumption that each fund has its own transmission channel. The presented results are supported by the additional system-GMM estimation. Regression tables and GMM-based IRFs are presented in the Appendix.

3.7 European Region Development Fund (ERDF)

The various estimated responses to monetary ERDF policy input shocks are shown in the IRFs displayed in Figure 3.4. As explained above, two analyses are performed. The upper row presents IRFs based on an estimation as described in section 3.4. Thus, it shows the long-term autoregressive and indirect reproduction of estimated coefficients for the year-to-year relationships between the variables. The bottom row presents the results from an identical estimation with an additional time-lag only in the policy variable. The x-axis shows the persistence of the effects in the moving-average of the estimated coefficients. This MA can be calculated to infinity, regardless how the underlying coefficients are estimated.

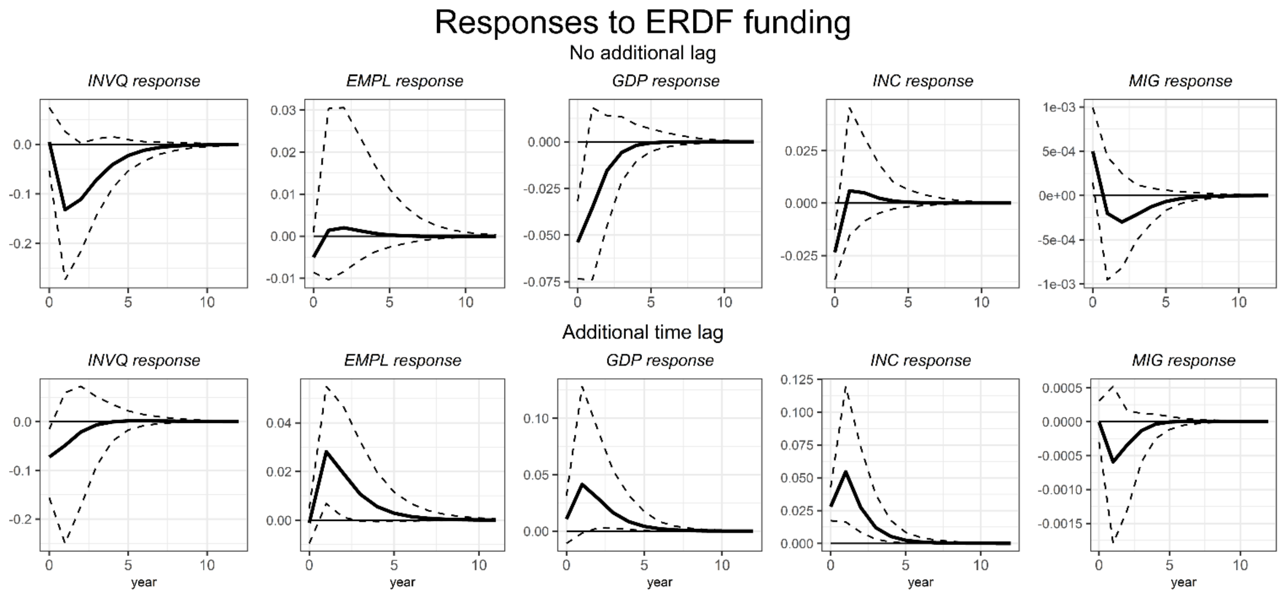

Figure 3.4: Responses to ERDF funding shocks. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %.

We find that there are no short-time positive effects of ERDF funding. However, the additional GMM estimation, suggests significant negative effects on GDP and household income development *(Figure A3.1).* As expected, the effect persistence is estimated to be much longer with GMM estimation, since the estimated autoregressive coefficients are higher than in the OLS estimation. This is true for all GMM-robustness checks. However, these finding do not mean that ERDF is counterproductive. If we look at the results with a longer time interval between funding and outcome measure in the estimation, we find that employment rates, GDP and household income growth seem to react significantly positive to ERDF funding after some time. This means that ERDF funding has rather medium than short-time effects. GMM estimates confirm these results *(Figure A3.1).* We can thus partially confirm the hypotheses *H1* and *H2* for ERDF funds, ERDF funding has positive impact on regional employment rates, GDP growth and income growth. However, this cannot be found by only looking at short-time outcome of policy measures. Migration rates in the OLS and the GMM estimation do not react significantly to ERDF funding, which means that we have to reject *H3* in this case.

The regional patterns of these effects can be examined by applying the SpVAR to sub-samples of the data, which is grouped by the eligibility status of regions (*see Figure 3.3*).

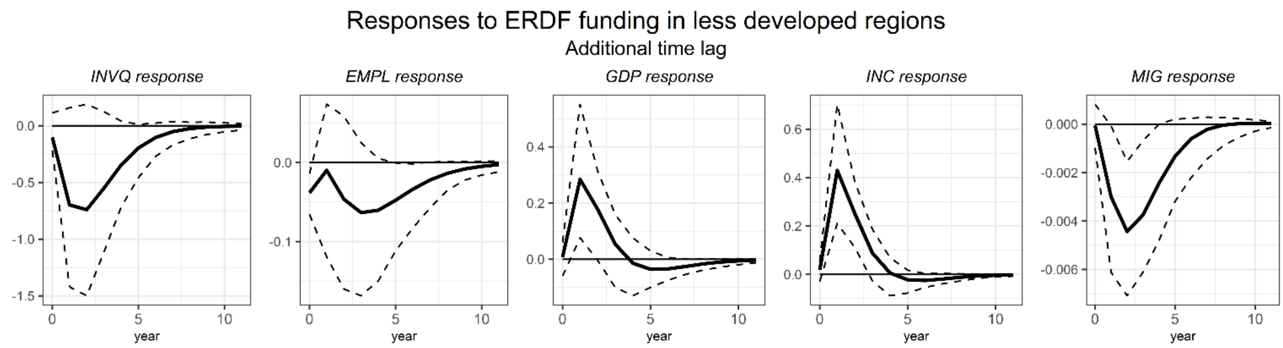

Figure 3.5: Responses to ERDF funding shocks in less developed regions. Specifications and shock strength equal Figure 3.4

While the short time estimation, again, reveals no significant effects in any of these sub-samples, significant effects on GDP and household income are observed with the additional lag structure for less developed regions *(Figure 3.5).* The effect strength is higher than in the total subsample. Furthermore, we observe significant negative effects to migration for several years. Both is replicated in GMM estimation results *(Figure A3.2).* This indicates that although ERDF funding triggers economic growth in economically lagging regions, non-financial living standards seem not to improve to the same extent. This result suggests that the ERDF is promoting economic convergence within Europe by supporting economic growth in Eastern Europe and lagging Southern-European regions. One interpretation of the estimated negative effects to migration is that non-economic living conditions will converge in the long run in a similar way, but need more time to adapt to growth processes. Another interpretation is that with the improvement of the economic situation in this regions people are enabled to move to more prosperous regions, lowering migration barriers.

3.7.1 European Social Fund (ESF)

According to the results of our SpVar estimation, monetary shocks in ESF funding have limited effects on the regional socio-economic system in the funded regions *(Figure 3.6).*

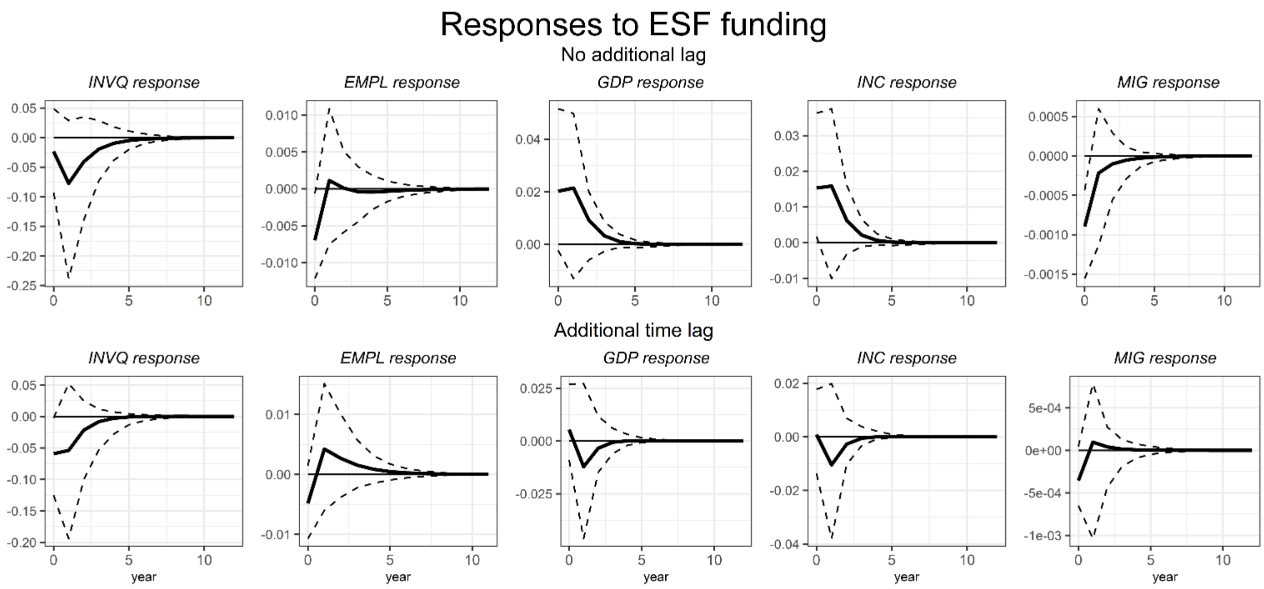

Figure 3.6: Responses to ESF funding shocks. Specifications equal Figure 3.4

While the estimation points to a significant negative co-development in the specific year of funding for migration and positive for income growth that are not significant afterwards, no particular significant effects can be found with the alternative time-lag or GMM estimation (*Figure A3.3)*.

However, in the estimation without additional time-lag the effects on GDP and household income seem to be rather positive (but not significant). Again, we find conditionality in the effect intensity across the subsamples, but not as strong as in the case of ERDF and not resulting in significant effects. Figure 3.7 shows this for less developed regions with the additional lag structure analogous to Figure 3.5. It indicates, that effects on income growth are rather positive in less developed regions. This effect gets significant if we limit the data-sample to Eastern European regions. Therefore, in the case of the European Social fund we cannot confirm any of our hypotheses. It seems to have some positive effects on household incomes in Eastern Europe.

However, this rather seems to be the result of individual cases rather than structural growth, as we observe neither significant employment nor significant productivity effects. Again, there are no significant effects on investment rates or migrations found on the regional level. We find no evidence for the ESF enhancing regional migration rates and thus the quality of life. Thus, we

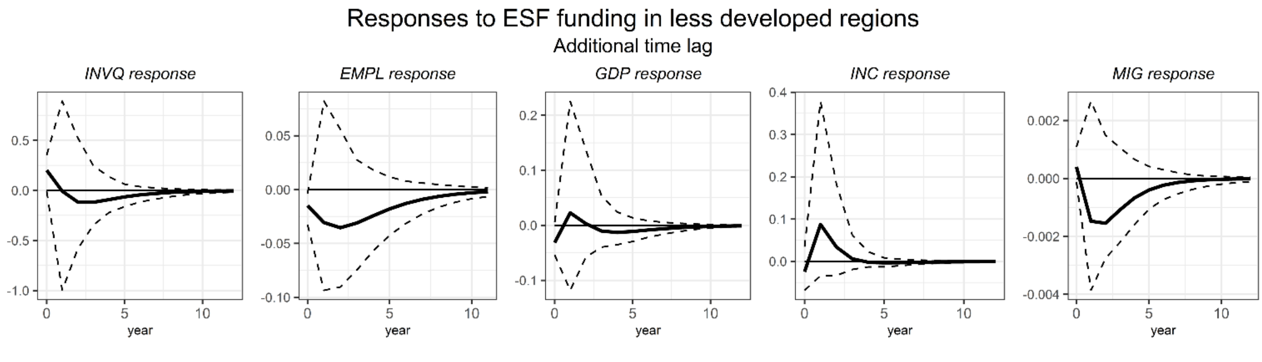

Figure 3.7: Responses to ESF funding shocks in less developed regions. Specifications equal Figure 3.4. Shock strength equals Figure 3.6

conclude that the ESF contribution to economic and socioeconomic convergence is rather small However, the education based policy objectives may cause that effects on an individual basis are not displayed in regionally aggregated data or take much longer to develop than considered in our analysis. Thus, the results do not automatically imply that ESF funds do not fall on fertile ground on the individual (personal) level, which is with the level aimed at by the policy objectives.

3.7.2 Cohesion Fund

The Cohesion Fund is the only considered funding scheme that is not available in all regions in the EU. The criterion of less than 85% of the EU's average gross national income was fulfilled in 13 of the 25 investigated countries within the EU. These are the new member states from 2004 and 2007 as well as Greece, Portugal and a few Spanish regions on a transitional fading out basis. Only those regions who received funds are part of the analysis. An analysis of the subsamples is not possible in this case, since most funded regions are less developed regions. The IRFs from the SpVAR estimation do not report significant economic effects from monetary shocks in the Cohesion Fund to the regional economy *(Figure 3.8)*.

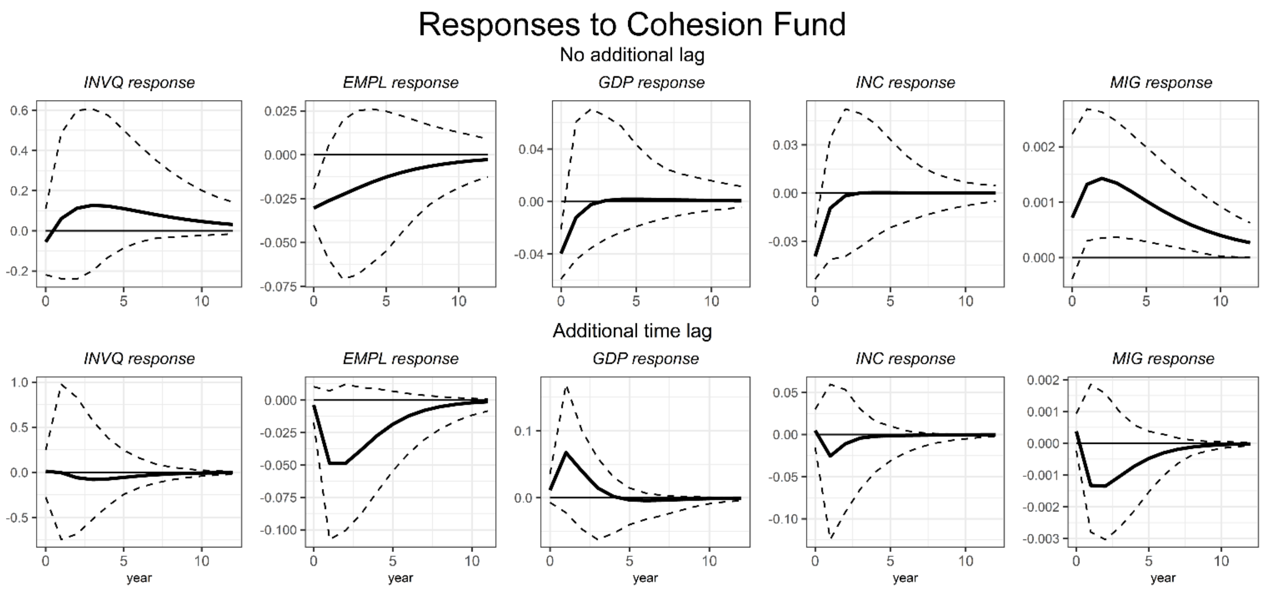

Figure 3.8: Responses to Cohesion Fund shocks. Specifications equal Figure 3.4

The estimation results without additional time-lags show significant effects on migration rates, however this is not a robust result, because it cannot be reproduced by GMM estimations *(Figure A3.4).* Therefore, we have no evidence, that the Cohesion Fund produces measurable outcome on the investigated variables.

3.8 Conclusion & Policy implications

The aim of the paper was to gain new insights into the simultaneous responses of economic growth, socio-economic convergence and perceived quality of life to EU Cohesion Policy at the regional level. Our results from a SpVAR using regional and funding data from 258 NUTS-2 regions in the period 2007 – 2017 support previous studies that the economic efficacy of Cohesion Policy as a whole is not easy to assess because results vary between funds and between regional subsamples. It is clear that only a small spectrum of effects could be examined in this study. Individual policy objectives such as sustainability or infrastructure development need to be investigated in more detailed studies, as they require more complex indicators.

Of the policies examined, the ERDF is the only one that showed significant effects on economic growth at the aggregated level of NUTS-2 regions, namely employment rate, productivity (GDP per working age population) and disposable household income growth. The effects are time-lagged, as these effects are only observable by measuring the effects two years after funding and robust to different estimation techniques. Furthermore, the ERDF contributes to economic convergence by having positive effects, particularly in regions classified as less developed. However, the non-existent effects on migration rates indicate that the funds do not make the regions more attractive to live or stay in. None of the investigated funds seems to significantly contribute to this issue.

We conclude that the presence of policy efficacy is not self-evident, but depends strongly on the combination of policy design and conditional local economic or political preconditions. In order to gain even more insights into the conditionality of fund effectiveness, an analysis of the specific responses for each individual member state or smaller subsamples would be interesting, but requires a different approach, as the number of regions turns too small for a valid SpVAR analysis on NUTS-2 level. The conditionality of responses suggests that to increase future effectiveness, policy designs and individual funding implementation have to be individually tailored to specific regional challenges in order to unfold their impact on regional development. The chosen approach offers various advantages to econometric policy evaluation, but like any regional econometric analysis it simplifies and aggregates complex regional dynamics, which automatically leads to simplified results. Especially the rather large geographical scale implies that we cannot be sure about more detailed effects at the local level. The limited number of examined variables causes that the funds may have additional positive effects for instance on the quality of life or on regional sustainability that may not be found in this paper. Furthermore, we are not able to make statements about processes at the micro-level that include concrete regional transition channels. As a consequence, we are unable to assess individual or regional success stories of Cohesion Policy. Further research is needed on this issue.

3.9 References

Angrist, D. & Prischle, J.-S. (2009). *Mostly Harmless Econometrics. An Empiricist Companion.* New Jersey: Princeton University Press.

Bachtrögler, J., Fratesi, U. & Perucca, G. (2020). The influence of the local context on the implementation and impact of EU Cohesion Policy. *Regional Studi*es, 54, 21-34. DOI:10.1080/00343404.2018.1551615.

Barca, F. (2009). *An agenda for a reformed Cohesion Policy.* Independent report prepared at the request of Danuta Hübner, the Commissioner for Regional Policy, April 2009.

Barro, R. (2012). Convergence and Modernization Revisited. *NBER Working Paper No. 18295.*

Becker, S., Egger, P. & von Ehrlich, M. (2018). Effects of EU Regional Policy: 1989 - 2013. *Regional Science and Urban Economics,* 69, 143-152.
DOI: 10.1016/j.regsciurbeco.2017.12.001.

Beenstock, M. & Felsenstein, D. (2007). Spatial vector autoregressions. *Spatial Economic Analysis,* 2, 167–196. DOI: 10.1080/17421770701346689.

Berkowitz, P., Monfort, P. & Pieńkowski, J. (2020). Unpacking the growth impacts of European Union Cohesion Policy: transmission channels from Cohesion Policy into economic growth. *Regional Studies*, 54, 60-71, DOI: 10.1080/00343404.2019.1570491.

Blundell, R. & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics,* 87, 115–143. DOI: 10.1016/S0304-4076(98)00009-8.

Bond, T. & Lang, K. (2019). The Sad Truth about Happiness Scales. *Journal of Political Economy,* 127, 1629-1640. DOI: 10.1086/701679.

Bondonio, D. (2016). The impact of varying per capita intensities of EU funds on regional growth: Estimating dose–response treatment effects through statistical matching. In: *Ex post evaluation of Cohesion Policy programmes 2007–2013 (Work Package No. 14d).* Brussels: European Commission, Directorate-General for Regional and Urban Policy.

Breidenbach, P., Mitze, T. & Schmidt, C. (2019). EU Regional Policy and the Neighbour`s Curse: Analyzing the Income Convergence Effects of ESIF Funding in the Presence of Spatial Spillovers. *Journal of Common Market Studies,* 57, 388-405. DOI: 10.1111/jcms.12807

Charron, N. (2016). Diverging cohesion? Globalisation, state capacity and regional inequalities within and across European countries. *European Urban and Regional Studies,* 23, 355-373. DOI: 10.1177/0969776413512844.

Crescenzi, R. & Guia, M. (2020). One or Many Cohesion Policies of the European Union? On the differential economic impacts of Cohesion Policy across Member States. *Regional Studies, 54, 10-20. DOI: 10.1080/00343404.2019.1665174.*

Crihfield, J., Giertz, J. & Mehta, S. (1995). Economic growth in the American states: The End of convergence? *The Quarterly Review of Economics and Finance,* 35, 551-577. DOI: 10.1016/1062-9769(95)90054-3.

Dall'Erba, S. & Fang, F. (2017). Meta-analysis of the impact of European Union Structural Funds on regional growth, *Regional Studies,* 51, 822-832. DOI: 10.1080/00343404.2015.1100285.

Dijkstra, L., Poelman, H. & Rodríguez-Pose, A. (2020). The geography of EU discontent *Regional Studies,* 54, 737-753. DOI: 10.1080/00343404.2019.1654603.

Di Giacinto, V. (2010). On vector autoregressive modelling in space and time. *Journal of Geographical Systems,* 12, 125-154. DOI: 10.1007/s10109-010-0116-6.

Dotti, N. (2016). Unwritten Factors Affecting Structural Funds: The Influence of Regional Political Behaviours on the Implementation of EU Cohesion Policy. *European Planning Studies,* 24, 530-550. DOI: 10.1080/09654313.2015.1047328.

Durlauf, S., Johnson, P. & Temple, J. (2005). Growth Econometrics. In: Philippe Aghion & Steven Durlauf (eds) *Handbook of Economic Growth*. Elsevier.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98, 701-735. DOI: 10.1111/pirs.12373.

Ederveen, S., de Groot, H. & Nahuis, R. (2006). Fertile Soil for Structural Funds? A Panel Data Analysis of the Conditional Effectiveness of European Cohesion Policy. *Kyklos,* 59, 17-42. DOI: 10.1111/j.1467-6435.2006.00318.x.

Elhorst, J. P. (2012). Dynamic Spatial Panels: Models, Methods, and Inferences. *Journal of Geographical Systems,* 14, 5–28. DOI: 10.1007/s10109-011-0158-4.

European Commission (2018). *Proposal for a regulation of the European Parliament and of the Council laying down common provisions (COM/2018/375 final).* Brussels: European Commission.

European Commission (2017). *Competitiveness in low-income and low-growth regions. The lagging regions report.* Commission Staff Working Document. Brussels: European Commission.

European Commission (2015). *European Structural and Investment Funds 2014 – 2020: Official Text and commentaries.* Luxemburg: Publications Office of the European-Union.

European Union (2013a). Regulation (EU) No 1301/2013 of the European Parliament and of the Council of 17 December 2013 on the European Regional Development Fund and on specific provisions concerning the Investment for growth and jobs goal and repealing Regulation (EC) No 1080/2006. *Official Journal of the European Union.*

European Union (2013b). REGULATION (EU) No 1304/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 December 2013 on the European Social Fund and repealing Council Regulation (EC) No 1081/2006. *Official Journal of the European Union.*

European Union (2013c). REGULATION (EU) No 1300/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 December 2013 on the Cohesion Fund and repealing Council Regulation (EC) No 1084/2006. *Official Journal of the European Union.*

European Union (2012). Consolidated Version of the Treaty on the Functioning of the European Union. *Official Journal of the European Union* C 326/47.

Everaert, G. & Pozzi, L. (2007). Bootstrap-based bias correction for dynamic panels. *Journal of Economic Dynamics and Control,* 31, 1160-1184. DOI: 10.1016/j.jedc.2006.04.006.

Faggian, A., Olfert, M. & Partridge, M. (2012). Inferring regional well-being from individual revealed preferences: the voting with your feet approach. *Cambridge Journal of Regions, Economy and Society,* 5, 163-180. DOI: 10.1093/cjres/rsr016.

Ferrara, A., Dijkstra, L., McCann, P. & Nistico, R. (2020). The Response of Regional Well-Being to EU Cohesion Policy Interventions. *SSRN Working Paper.* DOI: http://dx.doi.org/10.2139/ssrn.

Ferrara, A., McCann, P., Pellegrini, G., Stelder, D. & Terribile, F. (2017). Assessing the impacts of Cohesion Policy on EU regions: A non-parametric analysis on interventions promoting research and innovation and transport accessibility. *Papers in Regional Science,* 96. 817-841. DOI: 10.1111/pirs.12234.

Fiaschi, D., Lavezzi, A. & Parenti, A. (2018) Does EU cohesion policy work? Theory and evidence. *Journal of Regional Science,* 58, 386 – 423. DOI: 10.1111/jors.12364.

Fortuna, M., Silva, F. & Medeiros, A. (2016) A CGE approach to measuring the impacts of EU structural funds in a small open economy. *Papers in Regional Science,* 95, 507-39. DOI: 10.1111/pirs.12137.

Fratesi, U. & Wishlade, F. (2017). The impact of European Cohesion Policy in different contexts, *Regional Studies* 51, 817-821. DOI: 10.1080/00343404.2017.1326673.

Fujita, M., Krugman, P. & Venables, A. (1999). *The Spatial Economy. Cities, Regions, and International Trade.* Cambridge, MA: MIT Press.

Gagliardi, L. & Percoco, M. (2017). The impact of the European Cohesion Policy in urban and rural regions. *Regional Studies,* 51, 857-868. DOI:10.1080/00343404.2016.1179384.

Glaeser, E. L. (2011). *The Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier.* Harmondsworth: Penguin.

Giua, M. (2017). Spatial discontinuity for the impact assessment of the EU regional policy: The case of Italian objective 1 regions. *Journal of Regional Science,* 57, 109-131. DOI: 10.1111/jors.12300.

Hagen, T. & Mohl, P. (2009) Econometric evaluation of EU Cohesion Policy: A survey. *Discussion Paper 09-052.* Mannheim: ZEW.

Holtz-Eakin, D., Newey, W. & Rosen, H.S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica,* 56, 1371-1395.

Hsiao C., Pesaran, M. & Tahmiscioglu, A. (2002). Maximum likelihood estimation of fixed effects dynamic panel data models covering short time periods. *Journal of Econometrics,* 109, 107–150. DOI: 10.1016/S0304-4076(01)00143-9.

Iammarino, S., Rodriguez-Pose, A. & Storper, M. (2019). Regional Inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*, 19, 273-298. DOI: 10.1093/jeg/lby021.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics,* 115, 53-74. DOI: 10.1016/S0304-4076(03)00092-7.

Jones, C. (1995). R & D Based Models of Economic Growth. *Journal of Political Economy,* 103, 759-784.

Kiviet J., Pleus, M. & Poldermans, R. (2017). Accuracy and Efficiency of Various GMM Inference Techniques in Dynamic Micro Panel Data Models. *Econometrics, MDPI* 5, 1-54. DOI: 10.3390/econometrics5010014.

Kiviet, J. (1995). On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. *Journal of Econometrics,* 68, 53-78.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy,* 99, 483-499. DOI: 10.1086/261763.

Lopez-Bazo, E., Vaya, E. & Artis, M. (2004). Regional Externalities and Growth: Evidence from European Regions. *Journal of Regional Science,* 44, 43-73. DOI: 10.1111/j.1085-9489.2004.00327.x.

Lo Piano, S., Chifari, R., Saltelli, A., Vidoni, D. & Strand, R. (2018*). Regionalization of ESIF payments 1989 – 2015*. Luxemburg: Publications Office of the European-Union.

Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. Berlin: Springer.

Mankiw, G., Romer, D. & Weil, D. (1992). A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics,* 107, 407- 437. DOI: 10.2307/2118477.

Medeiros, E. (2017). European Union cohesion policy and Spain: A territorial impact assessment. *Regional Studies,* 51, 1259-1269. DOI: 10.1080/00343404.2016.1187719.

Mitze, T. (2019). The migration response to local labour market shocks: Evidence from EU regions during the global economic crisis. *Oxford Bulletin of Economics and Statistics,* 81, 271-298. Oxford Bulletin of Economics and Statistics, 81, 271-298. DOI: 10.1111/obes.12271.

Mitze, T., Schmidt, T., Rauhut, D. & Kangasharju, A. (2018). Ageing shocks and short-run regional labour market dynamics in a spatial panel VAR approach. *Applied Economics,* 50, 870– 890. DOI: 10.1080/00036846.2017.1346360 .

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica,* 49, 1417-1426. DOI: 10.2307/1911408.

Pellegrini, G. & Cerqua, A. (2017). Are we spending too much to grow? The case of structural funds. *Journal of Regional Science,* 58, 535-563. DOI: 10.1111/jors.12365.

Pellegrini, G., Terribile, F., Tarola, O., Muccigrosso, T. & Busillo, F. (2013). Measuring the effects of European regional policy on economic growth: A regression discontinuity approach. *Papers in Regional Science,* 92, 217–233. DOI: 10.1111/j.1435-5957.2012.00459.x.

Percoco, M. (2017). The impact of European Cohesion Policy on regional growth: Does local economic structure matter? *Regional Studies,* 51, 833-843. DOI:10.1080/00343404.2016.1213382.

Pfaffermayr, M. (2012). Spatial convergence of regions revisited: A spatial maximum likelihood approach. *Journal of Regional Science,* 52, 857-873. DOI: 10.1111/j.1467-9787.2012.00773.x.

Pieńkowski, J. & Berkowitz, P. (2016). Econometric Assessments of Cohesion Policy Growth Effects: How to Make Them More Relevant for Policymakers? In: Bachtler, J., Berkowitz, P., Hardy, S. and Muravska, T. (eds) *EU Cohesion Policy: Reassessing Performance and Direction*. Abingdon and New York: Routledge.

Rickman, D. (2010). Modern macroeconomics and regional economic modeling. *Journal of Regional Science,* 50, 23–41. DOI: 10.1111/j.1467-9787.2009.00647.x.

Rodríguez-Pose, A. (2018). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions Economy and Society,* 11, 189-209. DOI: 10.1093/cjres/rsx024.

Rodriguez-Pose, A. & Dijkstra, L. (2020). Does cohesion policy reduce EU discontent and Euroscepticism? *Regional Studies.* Epub ahead of print. 06. November 2020. DOI: 10.1080/00343404.2020.1826040.

Rodríguez-Pose, A. & Garcilazo, E. (2015). Quality of Government and the Returns of Investment: Examining the Impact of Cohesion Expenditure in European Regions. *Regional Studies,* 49, 1274-1290. DOI: 10.1080/00343404.2015.1007933.

Rodriguez-Pose, A. & Ketterer, T. (2012). Do Local Amenities Affect the Appeal of Regions in Europe for Migrants? *Journal of Regional Science,* 52, 535:561 DOI: 10.1111/j.1467-9787.2012.00779.x.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy,* 98, 71-102.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica,* 48, 1-48. DOI: 10.2307/1912017.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics,* 70, 65-94. DOI: 10.2307/1884513.

Storper, M. (2011). Justice, efficiency and economic geography: should places help another to develop? *European Urban and Regional Studies,* 18, 3-21. DOI: 10.1177/0969776410394553.

Wardenburg, S. & Brenner, T. (2020). How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany. *Journal of Regional Science,* 60, 1047-1073. DOI: 10.1111/jors.12500.

A3. Appendix

Table A3.2: Test results for Im-Pesaran-Shin Unit-Root Test

Acronym	Test-statistic (Wtbar)	p-value
ERDF	-15.981	0.000
ESF	-11.202	0.000
CF	-	-
EARDF	-7.32	-0.000
INVQ	-16.931	-0.000
EMPL	-2.726	-0.003
GDP	18.237	1.000
GDP_detr	-28.793	0.000
INC	11.697	1.000
INC_detr	-32.884	0.000
MIG	-15.814	-0.000

Notes: Im-Pesaran-Shin-Test for unit roots in Panel data as in Im, Pesaran, Shin (2005). Alternative hypothesis: Stationarity.

TableA3.2a: Model 1: ERDF – no additional lag

	Dependent variable:					
	ERDF	INVQ	EMPL	GDP	INC	MIG
plm::lag(ERDF, 1)	0.318***	-0.005	0.0002	-0.001	0.001	-0.0001
	(0.021)	(0.004)	(0.001)	(0.001)	(0.001)	(0.0001)
plm::lag(INVQ, 1) 0.002***	-0.128	0.462***	0.005	0.004	-0.002	
	(0.110)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
plm::lag(EMPL, 1)	1.878***	0.122	0.580***	0.156***	0.084**	0.008**
	(0.619)	(0.106)	(0.021)	(0.043)	(0.039)	(0.003)
plm::lag(GDP, 1)	0.166	0.092	-0.043***	0.301***	0.053**	0.005**
	(0.414)	(0.071)	(0.014)	(0.029)	(0.026)	(0.002)
plm::lag(INC, 1)	-0.962*	0.004	-0.019	0.055	0.254***	-0.009***
	(0.525)	(0.090)	(0.018)	(0.037)	(0.033)	(0.003)
plm::lag(MIG, 1)	2.646	2.802***	0.217	-0.040	-0.004	0.384***
	(4.965)	(0.848)	(0.166)	(0.346)	(0.314)	(0.025)
plm::lag(sppol, 1)	0.077**	-0.005	-0.001	-0.001	0.001	-0.001***
	(0.035)	(0.006)	(0.001)	(0.002)	(0.002)	(0.0002)
plm::lag(spinv, 1)	0.269	0.150***	0.006	0.028**	0.023**	0.0001
	(0.172)	(0.029)	(0.006)	(0.012)	(0.011)	(0.001)
plm::lag(spemp, 1)	-1.067	0.167	0.249***	0.031	0.140***	0.008**
	(0.814)	(0.139)	(0.027)	(0.057)	(0.052)	(0.004)
plm::lag(spgdp, 1)	0.910	-0.237**	0.054***	-0.085**	-0.048	0.007**
	(0.579)	(0.099)	(0.019)	(0.040)	(0.037)	(0.003)
plm::lag(spinc, 1)	-0.194	0.028	-0.037***	0.004	0.007	-0.004**
	(0.385)	(0.066)	(0.013)	(0.027)	(0.024)	(0.002)
plm::lag(spmig, 1)	-10.103	-1.686	-1.153***	-0.460	-0.581	-0.001
	(6.318)	(1.078)	(0.212)	(0.440)	(0.400)	(0.032)
g1_2008	0.247*	0.087***	-0.005	-0.035***	-0.037***	-0.0003
	(0.136)	(0.023)	(0.005)	(0.009)	(0.009)	(0.001)
g2_2008	0.083	0.024	-0.002	0.010	0.009	0.001*
	(0.106)	(0.018)	(0.004)	(0.007)	(0.007)	(0.001)
g3_2008	0.070	0.122***	-0.026***	0.035***	0.042***	0.0004
	(0.118)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2008	-0.038	0.059***	-0.007*	0.011	0.018**	-0.001
	(0.120)	(0.020)	(0.004)	(0.008)	(0.008)	(0.001)
g1_2009	0.286**	-0.003	-0.037***	-0.081***	-0.071***	-0.001*
	(0.131)	(0.022)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2009	0.023	-0.063***	-0.027***	-0.074***	-0.063***	0.0004
	(0.100)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2009	0.497***	0.009	-0.048***	-0.111***	-0.095***	-0.0001
	(0.114)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2009	0.283**	-0.055***	-0.029***	-0.071***	-0.045***	-0.001
	(0.116)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2010	0.078	0.010	-0.031***	-0.058***	-0.059***	-0.0003
	(0.126)	(0.021)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2010	-0.012	-0.006	-0.020***	-0.019***	-0.013**	0.001***
	(0.101)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2010	0.287***	0.040**	-0.043***	-0.035***	-0.041***	0.001
	(0.110)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2010	0.106	-0.044**	-0.018***	-0.00002	-0.011	0.001
	(0.119)	(0.020)	(0.004)	(0.008)	(0.008)	(0.001)
g1_2011	0.263**	-0.022	-0.041***	-0.067***	-0.066***	-0.001*
	(0.120)	(0.020)	(0.004)	(0.008)	(0.008)	(0.001)
g2_2011	0.037	-0.021	-0.015***	-0.015**	-0.015**	0.001
	(0.099)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2011	0.569***	0.085***	-0.035***	-0.023***	-0.038***	0.001**
	(0.108)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2011	0.424***	0.039**	-0.005	0.012	0.008	0.001
	(0.116)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2012	0.361***	-0.091***	-0.054***	-0.080***	-0.087***	-0.001**
	(0.120)	(0.021)	(0.004)	(0.008)	(0.008)	(0.001)
g2_2012	-0.157	-0.024	-0.014***	0.013**	0.007	0.002***

	(0.097)	(0.017)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2012	0.570***	0.043**	-0.031***	-0.044***	-0.046***	0.001**
	(0.111)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2012	0.069	0.003	-0.010**	-0.001	0.009	0.001
	(0.118)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2013	0.438***	-0.063***	-0.050***	-0.073***	-0.085***	0.001**
	(0.121)	(0.021)	(0.004)	(0.008)	(0.008)	(0.001)
g2_2013	0.168*	-0.030*	-0.014***	-0.005	-0.015**	0.003***
	(0.094)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2013	0.556***	0.023	-0.029***	-0.051***	-0.050***	0.001*
	(0.108)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2013	0.358***	-0.030	-0.009**	-0.010	0.001	0.001**
	(0.116)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2014	0.382***	-0.004	-0.018***	-0.044***	-0.051***	-0.0003
	(0.124)	(0.021)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2014	0.278***	-0.006	-0.005	0.031***	0.024***	0.001
	(0.098)	(0.017)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2014	0.520***	0.062***	-0.014***	-0.045***	-0.054***	0.002***
	(0.105)	(0.018)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2014	0.344***	-0.004	-0.007*	-0.009	-0.002	0.002***
	(0.117)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2015	0.194	-0.001	-0.010**	-0.022**	-0.033***	0.0004
	(0.122)	(0.021)	(0.004)	(0.008)	(0.008)	(0.001)
g2_2015	0.013	0.024	-0.004	0.067***	0.068***	0.002***
	(0.100)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2015	0.185*	0.065***	-0.016***	-0.030***	-0.053***	0.003***
	(0.103)	(0.018)	(0.003)	(0.007)	(0.007)	(0.001)
g4_2015	0.020	0.018	-0.004	0.0003	-0.005	0.005***
	(0.117)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2016	-1.091***	-0.025	-0.002	-0.024***	-0.031***	0.002***
	(0.117)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2016	-1.118***	0.016	0.002	0.010	0.005	0.001**
	(0.097)	(0.017)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2016	-0.910***	-0.054***	-0.009***	-0.039***	-0.040***	-0.001
	(0.099)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g4_2016	-0.865***	0.017	0.002	-0.0005	-0.004	0.001
	(0.113)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
Observations	2,580	2,580	2,580	2,580	2,580	2,580
R2	0.478	0.564	0.788	0.501	0.512	0.372
Adjusted R2	0.408	0.506	0.760	0.434	0.447	0.287
F Statistic (df = 48; 2274)	43.395***	61.370***	176.131***	47.514***	49.802***	28.007***

Note: *p<0.1; **p<0.05; ***p<0.01

Table A3.2b: Model 2 - ERDF – additional lag

	Dependent variable:					
	ERDF(t-1)	INVQ	EMPL	GDP	INC	MIG
plm::lag(ERDF, 2)	0.178*** (0.025)	-0.001 (0.004)	0.002*** (0.001)	0.002 (0.002)	0.003** (0.002)	-0.0001 (0.0001)
plm::lag(INVQ, 1)	-0.001 (0.121)	0.415*** (0.020)	0.004 (0.004)	-0.003 (0.008)	-0.005 (0.008)	0.002*** (0.001)
plm::lag(EMPL, 1)	1.269* (0.682)	0.097 (0.112)	0.550*** (0.023)	0.150*** (0.048)	0.083* (0.043)	0.005 (0.003)
plm::lag(GDP, 1)	-0.935** (0.449)	0.088 (0.074)	-0.036** (0.015)	0.299*** (0.031)	0.059** (0.028)	0.006*** (0.002)
plm::lag(INC, 1)	0.266 (0.599)	0.014 (0.098)	-0.002 (0.020)	0.056 (0.042)	0.246*** (0.038)	-0.009*** (0.003)
plm::lag(MIG, 1)	8.225 (5.433)	3.049*** (0.893)	0.118 (0.180)	-0.222 (0.380)	-0.276 (0.343)	0.345*** (0.028)
plm::lag(sppol, 1)	0.113*** (0.042)	-0.011 (0.007)	-0.001 (0.001)	-0.008*** (0.003)	-0.002 (0.003)	-0.001*** (0.0002)
plm::lag(spinv, 1)	0.126 (0.191)	0.112*** (0.031)	0.004 (0.006)	0.022 (0.013)	0.006 (0.012)	-0.0001 (0.001)
plm::lag(spemp, 1)	-1.154 (0.912)	0.041 (0.150)	0.234*** (0.030)	0.047 (0.064)	0.175*** (0.058)	0.006 (0.005)
plm::lag(spgdp, 1)	-0.725 (0.647)	0.018 (0.106)	0.071*** (0.021)	-0.046 (0.045)	-0.006 (0.041)	0.009*** (0.003)
plm::lag(spinc, 1)	0.125 (0.457)	0.002 (0.075)	-0.038** (0.015)	0.025 (0.032)	0.020 (0.029)	-0.002 (0.002)
plm::lag(spmig, 1)	1.632 (6.986)	-1.470 (1.148)	-1.098*** (0.232)	-0.757 (0.488)	-0.694 (0.441)	-0.033 (0.036)
g1_2009	1.400*** (0.126)	0.023 (0.021)	-0.035*** (0.004)	-0.078*** (0.009)	-0.063*** (0.008)	-0.001** (0.001)
g2_2009	1.232*** (0.089)	-0.071*** (0.015)	-0.028*** (0.003)	-0.074*** (0.006)	-0.059*** (0.006)	-0.0002 (0.0005)
g3_2009	1.006*** (0.121)	-0.006 (0.020)	-0.053*** (0.004)	-0.116*** (0.008)	-0.091*** (0.008)	-0.002*** (0.001)
g4_2009	0.943*** (0.112)	-0.062*** (0.018)	-0.032*** (0.004)	-0.073*** (0.008)	-0.044*** (0.007)	-0.001** (0.001)
g1_2010	1.410*** (0.119)	0.032 (0.020)	-0.030*** (0.004)	-0.056*** (0.008)	-0.052*** (0.008)	-0.001 (0.001)
g2_2010	1.054*** (0.094)	-0.001 (0.015)	-0.019*** (0.003)	-0.015** (0.007)	-0.005 (0.006)	0.001** (0.0005)
g3_2010	1.268*** (0.111)	0.037** (0.018)	-0.045*** (0.004)	-0.036*** (0.008)	-0.032*** (0.007)	-0.001 (0.001)
g4_2010	1.129*** (0.113)	-0.046** (0.019)	-0.019*** (0.004)	-0.001 (0.008)	-0.007 (0.007)	-0.0002 (0.001)
g1_2011	1.185*** (0.115)	-0.006 (0.019)	-0.040*** (0.004)	-0.065*** (0.008)	-0.060*** (0.007)	-0.001** (0.001)
g2_2011	1.012*** (0.092)	-0.021 (0.015)	-0.015*** (0.003)	-0.012* (0.006)	-0.009 (0.006)	0.0004 (0.0005)
g3_2011	1.133*** (0.106)	0.075*** (0.017)	-0.038*** (0.004)	-0.024*** (0.007)	-0.032*** (0.007)	0.0001 (0.001)
g4_2011	1.004*** (0.110)	0.028 (0.018)	-0.007** (0.004)	0.010 (0.008)	0.009 (0.007)	0.0001 (0.001)

g1_2012	1.335***	-0.086***	-0.054***	-0.081***	-0.080***	-0.002***
	(0.113)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2012	1.070***	-0.028*	-0.015***	0.015**	0.013**	0.001**
	(0.091)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2012	1.430***	0.030*	-0.035***	-0.045***	-0.039***	-0.00001
	(0.106)	(0.017)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2012	1.347***	-0.012	-0.013***	-0.004	0.011	-0.0001
	(0.109)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2013	1.431***	-0.067***	-0.052***	-0.073***	-0.079***	0.0004
	(0.111)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2013	0.929***	-0.040***	-0.015***	-0.005	-0.011**	0.002***
	(0.089)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2013	1.454***	0.013	-0.033***	-0.051***	-0.044***	0.0001
	(0.101)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g4_2013	1.018***	-0.041**	-0.012***	-0.012	0.002	0.001
	(0.110)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2014	1.483***	-0.014	-0.020***	-0.043***	-0.044***	-0.001*
	(0.113)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2014	1.207***	-0.020	-0.005*	0.030***	0.029***	-0.0003
	(0.090)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2014	1.432***	0.053***	-0.018***	-0.045***	-0.049***	0.001**
	(0.097)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2014	1.246***	-0.018	-0.010***	-0.011	-0.0002	0.002***
	(0.109)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2015	1.429***	-0.008	-0.012***	-0.022***	-0.028***	-0.0004
	(0.111)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2015	1.390***	0.006	-0.006**	0.065***	0.071***	0.001**
	(0.087)	(0.014)	(0.003)	(0.006)	(0.006)	(0.0004)
g3_2015	1.393***	0.059***	-0.018***	-0.029***	-0.047***	0.002***
	(0.094)	(0.015)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2015	1.230***	0.006	-0.006*	-0.001	-0.003	0.005***
	(0.109)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2016	1.294***	-0.034*	-0.004	-0.026***	-0.028***	0.001*
	(0.109)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2016	1.206***	-0.005	-0.002	0.007	0.005	0.0004
	(0.090)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2016	1.090***	-0.057***	-0.010***	-0.037***	-0.035***	-0.001**
	(0.093)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g4_2016	0.890***	0.007	0.00004	0.001	-0.001	0.001
	(0.110)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
Observations	2,322	2,322	2,322	2,322	2,322	2,322
R2	0.434	0.458	0.767	0.456	0.458	0.311
Adjusted R2	0.350	0.377	0.732	0.374	0.377	0.208
F Statistic (df = 44; 2020)	35.212***	38.770***	151.095***	38.418***	38.751***	20.685***

Note: *p<0.1; **p<0.05; ***p<0.01

Table A3.3a: Model 3 - ESF – no additional lag

	Dependent variable:					
	ESF	INVQ	EMPL	GDP	INC	MIG
plm::lag(ESF, 1)	0.096***	-0.003	0.0001	0.001	0.001	-0.00003
	(0.025)	(0.003)	(0.001)	(0.001)	(0.001)	(0.0001)
plm::lag(INVQ, 1)	-0.090	0.462***	0.005	0.004	-0.002	0.002***
	(0.139)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
plm::lag(EMPL, 1)	-0.607	0.117	0.579***	0.154***	0.083**	0.007**
	(0.783)	(0.106)	(0.021)	(0.043)	(0.039)	(0.003)
plm::lag(GDP, 1)	0.153	0.098	-0.043***	0.303***	0.053**	0.006***
	(0.524)	(0.071)	(0.014)	(0.029)	(0.026)	(0.002)
plm::lag(INC, 1)	-0.596	-0.003	-0.019	0.054	0.253***	-0.009***
	(0.666)	(0.090)	(0.018)	(0.037)	(0.033)	(0.003)
plm::lag(MIG, 1)	-10.187	2.712***	0.221	-0.023	0.028	0.382***
	(6.312)	(0.850)	(0.167)	(0.347)	(0.315)	(0.025)
plm::lag(sppol, 1)	0.115***	-0.005	-0.002	-0.004**	-0.006***	-0.0003*
	(0.039)	(0.005)	(0.001)	(0.002)	(0.002)	(0.0002)
plm::lag(spinv, 1)	-0.388*	0.148***	0.006	0.027**	0.021**	0.00004
	(0.218)	(0.029)	(0.006)	(0.012)	(0.011)	(0.001)
plm::lag(spemp, 1)	0.473	0.158	0.247***	0.026	0.131**	0.008*
	(1.033)	(0.139)	(0.027)	(0.057)	(0.051)	(0.004)
plm::lag(spgdp, 1)	-1.123	-0.226**	0.056***	-0.083**	-0.047	0.007**
	(0.734)	(0.099)	(0.019)	(0.040)	(0.037)	(0.003)
plm::lag(spinc, 1)	-0.426	0.026	-0.037***	0.004	0.008	-0.004**
	(0.488)	(0.066)	(0.013)	(0.027)	(0.024)	(0.002)
plm::lag(spmig, 1)	11.272	-1.636	-1.164***	-0.490	-0.629	-0.002
	(8.018)	(1.080)	(0.212)	(0.441)	(0.400)	(0.032)
g1_2008	0.759***	0.085***	-0.004	-0.032***	-0.025***	-0.001
	(0.168)	(0.023)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2008	1.331***	0.029	-0.0002	0.016**	0.023***	0.001
	(0.144)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g3_2008	0.024	0.120***	-0.025***	0.036***	0.046***	0.0002
	(0.148)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2008	0.594***	0.058***	-0.007*	0.013*	0.027***	-0.001*
	(0.148)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2009	0.749***	-0.005	-0.036***	-0.078***	-0.061***	-0.002***
	(0.161)	(0.022)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2009	1.274***	-0.059***	-0.025***	-0.069***	-0.050***	0.0003
	(0.135)	(0.018)	(0.004)	(0.007)	(0.007)	(0.001)
g3_2009	0.448***	0.006	-0.047***	-0.110***	-0.091***	-0.0003
	(0.143)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2009	0.635***	-0.055***	-0.028***	-0.069***	-0.036***	-0.001
	(0.146)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2010	0.302**	0.007	-0.031***	-0.056***	-0.049***	-0.001
	(0.154)	(0.021)	(0.004)	(0.008)	(0.008)	(0.001)
g2_2010	0.623***	-0.001	-0.018***	-0.014*	0.0001	0.001***
	(0.139)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g3_2010	0.156	0.036**	-0.043***	-0.035***	-0.035***	0.0002
	(0.134)	(0.018)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2010	0.050	-0.046**	-0.018***	0.002	-0.003	0.0004
	(0.146)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2011	0.722***	-0.025	-0.041***	-0.065***	-0.058***	-0.001**
	(0.146)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)

g2_2011	0.729***	-0.018	-0.013***	-0.011	-0.005	0.001
	(0.130)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2011	0.418***	0.081***	-0.035***	-0.023***	-0.032***	0.001
	(0.131)	(0.018)	(0.003)	(0.007)	(0.007)	(0.001)
g4_2011	0.337**	0.035*	-0.005	0.013	0.014**	0.0004
	(0.140)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2012	0.703***	-0.093***	-0.054***	-0.078***	-0.078***	-0.002***
	(0.147)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2012	0.902***	-0.021	-0.013***	0.018**	0.018***	0.001***
	(0.129)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2012	0.634***	0.038**	-0.031***	-0.043***	-0.039***	0.001
	(0.134)	(0.018)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2012	0.401***	-0.002	-0.010***	-0.0002	0.017**	0.0004
	(0.141)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2013	0.475***	-0.066***	-0.050***	-0.071***	-0.075***	0.001*
	(0.147)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2013	0.416***	-0.024	-0.012***	-0.00003	-0.004	0.003***
	(0.129)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2013	0.567***	0.019	-0.028***	-0.050***	-0.042***	0.001
	(0.131)	(0.018)	(0.003)	(0.007)	(0.007)	(0.001)
g4_2013	0.607***	-0.033*	-0.009**	-0.008	0.009	0.001**
	(0.142)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2014	0.328**	-0.009	-0.017***	-0.042***	-0.041***	-0.001
	(0.148)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2014	0.794***	-0.006	-0.004	0.033***	0.033***	0.0003
	(0.123)	(0.017)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2014	0.279**	0.058***	-0.014***	-0.043***	-0.046***	0.002***
	(0.127)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g4_2014	0.041	-0.006	-0.007*	-0.007	0.007	0.002***
	(0.144)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2015	0.295**	-0.006	-0.010***	-0.020**	-0.025***	-0.0001
	(0.144)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2015	0.651***	0.024	-0.003	0.070***	0.079***	0.002***
	(0.125)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g3_2015	-0.002	0.060***	-0.015***	-0.029***	-0.045***	0.002***
	(0.121)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2015	-1.607***	0.012	-0.004	0.002	0.002	0.005***
	(0.140)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2016	-0.870***	-0.030	-0.002	-0.023***	-0.023***	0.001**
	(0.141)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2016	-1.031***	0.017	0.003	0.013*	0.015**	0.001
	(0.124)	(0.017)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2016	-0.755***	-0.059***	-0.009***	-0.038***	-0.034***	-0.001**
	(0.118)	(0.016)	(0.003)	(0.006)	(0.006)	(0.0005)
g4_2016	-0.598***	0.008	0.002	0.001	0.003	0.0002
	(0.141)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
Observations	2,580	2,580	2,580	2,580	2,580	2,580
R2	0.484	0.564	0.788	0.502	0.514	0.370
Adjusted R2	0.414	0.506	0.760	0.435	0.449	0.286
F Statistic (df = 48; 2274)	44.350***	61.357***	176.290***	47.665***	50.159***	27.834***

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3.3b: Model 4 - ESF – with additional lag

	Dependent variable:					
	ESF(t-1)	INVQ	EMPL	GDP	INC	MIG
plm::lag(ESF, 2)	0.014	-0.002	0.0003	-0.001	-0.001	0.00002
	(0.027)	(0.003)	(0.001)	(0.001)	(0.001)	(0.0001)
plm::lag(INVQ, 1)	0.076	0.415***	0.004	-0.002	-0.005	0.002***
	(0.155)	(0.020)	(0.004)	(0.008)	(0.008)	(0.001)
plm::lag(EMP, 1)	-0.444	0.099	0.549***	0.144***	0.074*	0.006*
	(0.875)	(0.112)	(0.023)	(0.047)	(0.042)	(0.003)
plm::lag(GDP, 1)	0.139	0.093	-0.037**	0.303***	0.060**	0.006***
	(0.576)	(0.074)	(0.015)	(0.031)	(0.028)	(0.002)
plm::lag(INC, 1)	-1.066	-0.003	-0.001	0.037	0.231***	-0.010***
	(0.769)	(0.098)	(0.020)	(0.041)	(0.037)	(0.003)
plm::lag(MIG, 1)	-23.827***	3.027***	0.122	-0.208	-0.254	0.344***
	(6.982)	(0.894)	(0.181)	(0.376)	(0.339)	(0.028)
plm::lag(sppol, 1)	0.033	-0.007	-0.001	-0.015***	-0.015***	-0.00003
	(0.046)	(0.006)	(0.001)	(0.002)	(0.002)	(0.0002)
plm::lag(spinv, 1)	-0.402	0.114***	0.004	0.024*	0.007	0.0001
	(0.245)	(0.031)	(0.006)	(0.013)	(0.012)	(0.001)
plm::lag(spemp, 1)	-1.308	0.039	0.234***	0.042	0.169***	0.006
	(1.171)	(0.150)	(0.030)	(0.063)	(0.057)	(0.005)
plm::lag(spgdp, 1)	1.305	0.025	0.070***	-0.043	-0.007	0.010***
	(0.830)	(0.106)	(0.021)	(0.045)	(0.040)	(0.003)
plm::lag(spinc, 1)	-0.476	-0.010	-0.038**	0.013	0.011	-0.003
	(0.587)	(0.075)	(0.015)	(0.032)	(0.028)	(0.002)
plm::lag(spmig, 1)	13.182	-1.460	-1.123***	-0.975**	-1.002**	-0.018
	(8.985)	(1.151)	(0.233)	(0.484)	(0.436)	(0.036)
g1_2009	1.769***	0.024	-0.035***	-0.070***	-0.053***	-0.002***
	(0.162)	(0.021)	(0.004)	(0.009)	(0.008)	(0.001)
g2_2009	2.411***	-0.067***	-0.028***	-0.063***	-0.046***	-0.0005
	(0.119)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2009	0.693***	-0.001	-0.053***	-0.113***	-0.092***	-0.001
	(0.153)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2009	1.343***	-0.054***	-0.032***	-0.060***	-0.029***	-0.002***
	(0.155)	(0.020)	(0.004)	(0.008)	(0.008)	(0.001)
g1_2010	1.601***	0.032	-0.030***	-0.052***	-0.047***	-0.001
	(0.153)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2010	2.388***	0.001	-0.019***	-0.010	0.002	0.001*
	(0.121)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g3_2010	0.889***	0.040**	-0.045***	-0.039***	-0.038***	-0.0002
	(0.140)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2010	1.317***	-0.038*	-0.020***	0.009	0.003	-0.0002
	(0.153)	(0.020)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2011	1.201***	-0.006	-0.040***	-0.062***	-0.056***	-0.002***
	(0.147)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2011	1.953***	-0.018	-0.015***	-0.006	-0.001	0.0002
	(0.119)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2011	0.874***	0.076***	-0.038***	-0.025***	-0.033***	0.0003
	(0.136)	(0.017)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2011	0.865***	0.033*	-0.008**	0.019**	0.019***	-0.0002
	(0.149)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)

g1_2012	1.524***	-0.086***	-0.054***	-0.082***	-0.083***	-0.002***
	(0.145)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2012	1.934***	-0.027*	-0.015***	0.015**	0.013**	0.001*
	(0.116)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2012	1.109***	0.030*	-0.035***	-0.046***	-0.040***	0.0001
	(0.136)	(0.017)	(0.004)	(0.007)	(0.007)	(0.001)
g4_2012	1.085***	-0.009	-0.013***	-0.0003	0.016**	-0.0003
	(0.146)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2013	1.490***	-0.066***	-0.052***	-0.072***	-0.078***	0.0004
	(0.143)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2013	2.103***	-0.039***	-0.015***	-0.003	-0.009*	0.002***
	(0.114)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2013	1.355***	0.014	-0.032***	-0.048***	-0.040***	-0.00000
	(0.130)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g4_2013	1.144***	-0.038**	-0.012***	-0.005	0.011	0.0005
	(0.147)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2014	1.337***	-0.014	-0.019***	-0.040***	-0.040***	-0.001**
	(0.145)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2014	1.602***	-0.016	-0.006*	0.035***	0.033***	-0.0001
	(0.115)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2014	1.363***	0.054***	-0.017***	-0.039***	-0.041***	0.001*
	(0.125)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2014	1.363***	-0.012	-0.010***	-0.002	0.010	0.001**
	(0.147)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2015	1.281***	-0.009	-0.012***	-0.020***	-0.025***	-0.001
	(0.142)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2015	1.937***	0.004	-0.006**	0.062***	0.068***	0.001**
	(0.112)	(0.014)	(0.003)	(0.006)	(0.005)	(0.0004)
g3_2015	1.138***	0.060***	-0.017***	-0.023***	-0.039***	0.002***
	(0.121)	(0.015)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2015	0.875***	0.012	-0.006*	0.011	0.010	0.004***
	(0.148)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2016	1.208***	-0.035*	-0.004	-0.025***	-0.026***	0.001
	(0.139)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2016	1.815***	-0.006	-0.002	0.009	0.008	0.0001
	(0.115)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2016	0.843***	-0.058***	-0.010***	-0.034***	-0.030***	-0.001***
	(0.119)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g4_2016	-0.807***	0.009	0.0001	0.007	0.008	0.0001
	(0.146)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
Observations	2,322	2,322	2,322	2,322	2,322	2,322
R2	0.459	0.458	0.766	0.467	0.473	0.299
Adjusted R2	0.378	0.377	0.731	0.387	0.394	0.194
F Statistic (df = 44; 2020)	38.881***	38.768***	150.425***	40.180***	41.193***	19.563***

Note: *p<0.1; **p<0.05; ***p<0.01

Table A3.4a: Model 5: Cohesion Fund – no additional lag

	Dependent variable:					
	CF	INVQ	EMPL	GDP	INC	MIG
plm::lag(CF, 1)	0.803***	0.003	-0.0002	0.001	0.001	0.0002
	(0.050)	(0.006)	(0.001)	(0.002)	(0.002)	(0.0001)
plm::lag(INVQ, 1)	0.300	0.399***	0.017***	0.005	-0.010	0.003***
	(0.288)	(0.033)	(0.006)	(0.010)	(0.011)	(0.001)
plm::lag(EMPL, 1)	-0.341	0.123	0.622***	0.120**	0.036	0.005
	(1.541)	(0.179)	(0.034)	(0.052)	(0.057)	(0.004)
plm::lag(GDP, 1)	-0.153	-0.006	-0.025	0.328***	0.124***	0.001
	(1.283)	(0.149)	(0.028)	(0.044)	(0.048)	(0.003)
plm::lag(INC, 1)	-0.211	-0.015	-0.053**	0.033	0.206***	-0.006**
	(1.167)	(0.135)	(0.026)	(0.040)	(0.043)	(0.003)
plm::lag(MIG, 1)	13.959	4.538***	0.143	0.144	-0.182	0.488***
	(14.316)	(1.660)	(0.313)	(0.486)	(0.532)	(0.034)
plm::lag(sppol, 1)	0.061	-0.002	-0.001	-0.001	-0.002	-0.0002
	(0.058)	(0.007)	(0.001)	(0.002)	(0.002)	(0.0001)
plm::lag(spinv, 1)	0.098	0.074	0.018	0.006	0.023	-0.0005
	(0.527)	(0.061)	(0.012)	(0.018)	(0.020)	(0.001)
plm::lag(spemp, 1)	-5.770***	0.291	0.206***	-0.071	0.020	-0.006
	(2.140)	(0.248)	(0.047)	(0.073)	(0.080)	(0.005)
plm::lag(spgdp, 1)	-0.029	-0.159	0.013	-0.081	0.040	0.004
	(1.870)	(0.217)	(0.041)	(0.064)	(0.070)	(0.004)
plm::lag(spinc, 1)	0.918	0.062	-0.037**	0.029	0.032	-0.001
	(0.794)	(0.092)	(0.017)	(0.027)	(0.030)	(0.002)
plm::lag(spmig, 1)	59.446***	-5.868**	-1.633***	-0.793	-1.204	-0.0004
	(21.191)	(2.457)	(0.463)	(0.720)	(0.788)	(0.050)
g1_2008	0.372	0.149***	-0.022**	-0.030*	-0.029*	-0.002
	(0.468)	(0.054)	(0.010)	(0.016)	(0.017)	(0.001)
g2_2008	0.175	0.055	0.002	-0.005	0.009	-0.002
	(0.956)	(0.111)	(0.021)	(0.032)	(0.036)	(0.002)
g3_2008	-0.937***	0.202***	-0.038***	0.037***	0.041***	-0.001
	(0.310)	(0.036)	(0.007)	(0.011)	(0.012)	(0.001)
g4_2008	7.315***	-0.141	-0.004	-0.062	-0.022	-0.005
	(1.357)	(0.157)	(0.030)	(0.046)	(0.050)	(0.003)
g1_2009	0.801*	0.035	-0.053***	-0.069***	-0.057***	-0.003***
	(0.447)	(0.052)	(0.010)	(0.015)	(0.017)	(0.001)
g2_2009	1.461	-0.156	-0.047**	-0.058*	-0.064*	-0.005**
	(0.928)	(0.108)	(0.020)	(0.032)	(0.035)	(0.002)
g3_2009	-0.806**	0.058	-0.060***	-0.144***	-0.142***	-0.001
	(0.319)	(0.037)	(0.007)	(0.011)	(0.012)	(0.001)
g4_2009	3.766***	-0.263	-0.079***	-0.183***	-0.127**	-0.005
	(1.390)	(0.161)	(0.030)	(0.047)	(0.052)	(0.003)
g1_2010	0.008	0.006	-0.046***	-0.061***	-0.061***	-0.002*
	(0.417)	(0.048)	(0.009)	(0.014)	(0.015)	(0.001)
g2_2010	0.377	-0.022	-0.016	-0.047	-0.047	-0.004*
	(0.934)	(0.108)	(0.020)	(0.032)	(0.035)	(0.002)
g3_2010	-1.504***	0.065**	-0.065***	-0.057***	-0.052***	-0.002**
	(0.267)	(0.031)	(0.006)	(0.009)	(0.010)	(0.001)
g4_2010	-8.032***	-0.364**	-0.064**	-0.193***	-0.138***	-0.002
	(1.433)	(0.166)	(0.031)	(0.049)	(0.053)	(0.003)
g1_2011	0.388	-0.057	-0.069***	-0.093***	-0.088***	-0.003***
	(0.375)	(0.044)	(0.008)	(0.013)	(0.014)	(0.001)

g2_2011	0.074	-0.046	-0.017	-0.057*	-0.037	-0.003
	(0.907)	(0.105)	(0.020)	(0.031)	(0.034)	(0.002)
g3_2011	-0.599**	0.117***	-0.052***	-0.046***	-0.063***	-0.001
	(0.252)	(0.029)	(0.006)	(0.009)	(0.009)	(0.001)
g4_2011	0.538	-0.308*	-0.055*	-0.189***	-0.146***	-0.002
	(1.388)	(0.161)	(0.030)	(0.047)	(0.052)	(0.003)
g1_2012	0.446	-0.172***	-0.089***	-0.120***	-0.125***	-0.005***
	(0.355)	(0.041)	(0.008)	(0.012)	(0.013)	(0.001)
g2_2012	0.464	-0.030	-0.049**	-0.085***	-0.095***	-0.008***
	(0.877)	(0.102)	(0.019)	(0.030)	(0.033)	(0.002)
g3_2012	-0.566**	0.062**	-0.043***	-0.070***	-0.074***	-0.001
	(0.260)	(0.030)	(0.006)	(0.009)	(0.010)	(0.001)
g4_2012	0.530	-0.111	-0.045	-0.198***	-0.109**	-0.001
	(1.400)	(0.162)	(0.031)	(0.048)	(0.052)	(0.003)
g1_2013	0.702**	-0.148***	-0.073***	-0.112***	-0.120***	-0.004***
	(0.354)	(0.041)	(0.008)	(0.012)	(0.013)	(0.001)
g2_2013	1.539*	-0.027	-0.047**	-0.074**	-0.082**	-0.008***
	(0.873)	(0.101)	(0.019)	(0.030)	(0.032)	(0.002)
g3_2013	-0.687***	0.050*	-0.041***	-0.076***	-0.072***	-0.001**
	(0.236)	(0.027)	(0.005)	(0.008)	(0.009)	(0.001)
g4_2013	0.365	-0.245	-0.015	-0.222***	-0.107**	0.001
	(1.391)	(0.161)	(0.030)	(0.047)	(0.052)	(0.003)
g1_2014	0.410	-0.060	-0.034***	-0.085***	-0.081***	-0.002***
	(0.361)	(0.042)	(0.008)	(0.012)	(0.013)	(0.001)
g2_2014	1.763**	0.007	-0.017	-0.061**	-0.067**	-0.002
	(0.885)	(0.103)	(0.019)	(0.030)	(0.033)	(0.002)
g3_2014	-0.633***	0.087***	-0.021***	-0.070***	-0.075***	-0.0004
	(0.223)	(0.026)	(0.005)	(0.008)	(0.008)	(0.001)
g4_2014	0.373	-0.126	-0.012	-0.182***	-0.069	0.003
	(1.408)	(0.163)	(0.031)	(0.048)	(0.052)	(0.003)
g1_2015	-0.338	-0.064	-0.021***	-0.056***	-0.061***	-0.002***
	(0.351)	(0.041)	(0.008)	(0.012)	(0.013)	(0.001)
g2_2015	0.334	-0.009	-0.007	-0.032	-0.032	-0.001
	(0.887)	(0.103)	(0.019)	(0.030)	(0.033)	(0.002)
g3_2015	-0.839***	0.106***	-0.021***	-0.049***	-0.068***	-0.001
	(0.213)	(0.025)	(0.005)	(0.007)	(0.008)	(0.001)
g4_2015	0.244	-0.025	-0.001	0.051	-0.037	0.004
	(1.391)	(0.161)	(0.030)	(0.047)	(0.052)	(0.003)
g1_2016	-4.752***	-0.083**	-0.012	-0.039***	-0.045***	0.001
	(0.327)	(0.038)	(0.007)	(0.011)	(0.012)	(0.001)
g2_2016	-7.456***	-0.061	-0.004	-0.017	-0.018	-0.001
	(0.868)	(0.101)	(0.019)	(0.030)	(0.032)	(0.002)
g3_2016	-1.741***	-0.059**	-0.018***	-0.054***	-0.051***	-0.001**
	(0.211)	(0.024)	(0.005)	(0.007)	(0.008)	(0.001)
g4_2016	0.163	0.326**	0.011	-0.031	-0.046	0.004
	(1.344)	(0.156)	(0.029)	(0.046)	(0.050)	(0.003)
Observations	890	890	890	890	890	890
R2	0.807	0.690	0.877	0.699	0.667	0.587
Adjusted R2	0.772	0.634	0.855	0.645	0.607	0.513
F Statistic (df = 48; 753)	65.629***	34.925***	111.792***	36.506***	31.472***	22.314***

Note: *p<0.1; **p<0.05; ***p<0.01

Table A.3.4b: Model 6: Cohesion Fund – with additional lag

	Dependent variable:					
	CF(t-1)	INVQ	EMPL	GDP	INC	MIG
plm::lag(CF, 2)	0.676*** (0.056)	-0.010* (0.006)	-0.003** (0.001)	0.001 (0.003)	-0.003 (0.002)	-0.0004* (0.0002)
plm::lag(INVQ, 1)	0.525*** (0.178)	0.416*** (0.020)	0.004 (0.004)	-0.002 (0.008)	-0.005 (0.008)	0.002*** (0.001)
plm::lag(EMPL, 1)	0.169 (1.008)	0.100 (0.112)	0.549*** (0.023)	0.152*** (0.048)	0.083* (0.043)	0.006* (0.003)
plm::lag(GDP, 1)	0.172 (0.664)	0.092 (0.074)	-0.036** (0.015)	0.299*** (0.031)	0.058** (0.028)	0.006*** (0.002)
plm::lag(INC, 1)	-2.398*** (0.886)	0.003 (0.098)	0.0001 (0.020)	0.051 (0.042)	0.248*** (0.038)	-0.009*** (0.003)
plm::lag(MIG, 1)	-2.576 (8.039)	3.110*** (0.892)	0.133 (0.180)	-0.222 (0.380)	-0.260 (0.343)	0.345*** (0.028)
plm::lag(sppol, 1)	0.077 (0.050)	-0.005 (0.006)	0.001 (0.001)	-0.003 (0.002)	-0.0004 (0.002)	0.0001 (0.0002)
plm::lag(spinv, 1)	1.645*** (0.283)	0.113*** (0.031)	0.004 (0.006)	0.022 (0.013)	0.006 (0.012)	0.0001 (0.001)
plm::lag(spemp, 1)	-5.816*** (1.349)	0.040 (0.150)	0.234*** (0.030)	0.048 (0.064)	0.175*** (0.058)	0.006 (0.005)
plm::lag(spgdp, 1)	0.910 (0.957)	0.026 (0.106)	0.070*** (0.021)	-0.042 (0.045)	-0.007 (0.041)	0.010*** (0.003)
plm::lag(spinc, 1)	-0.105 (0.677)	-0.002 (0.075)	-0.039** (0.015)	0.024 (0.032)	0.020 (0.029)	-0.003 (0.002)
plm::lag(spmig, 1)	10.313 (10.303)	-1.351 (1.143)	-1.113*** (0.231)	-0.691 (0.487)	-0.712 (0.440)	-0.018 (0.036)
g1_2009	2.652*** (0.185)	0.024 (0.021)	-0.034*** (0.004)	-0.079*** (0.009)	-0.062*** (0.008)	-0.002*** (0.001)
g2_2009	0.148 (0.131)	-0.073*** (0.015)	-0.028*** (0.003)	-0.076*** (0.006)	-0.059*** (0.006)	-0.0005 (0.0005)
g3_2009	0.184 (0.178)	-0.007 (0.020)	-0.054*** (0.004)	-0.114*** (0.008)	-0.092*** (0.008)	-0.001* (0.001)
g4_2009	-0.010 (0.166)	-0.066*** (0.018)	-0.032*** (0.004)	-0.075*** (0.008)	-0.044*** (0.007)	-0.002*** (0.001)
g1_2010	2.853*** (0.177)	0.036* (0.020)	-0.029*** (0.004)	-0.056*** (0.008)	-0.050*** (0.008)	-0.001 (0.001)
g2_2010	0.156 (0.139)	-0.001 (0.015)	-0.019*** (0.003)	-0.016** (0.007)	-0.005 (0.006)	0.001* (0.0005)
g3_2010	0.272* (0.162)	0.038** (0.018)	-0.046*** (0.004)	-0.034*** (0.008)	-0.033*** (0.007)	-0.0003 (0.001)
g4_2010	-0.040 (0.167)	-0.044** (0.019)	-0.019*** (0.004)	-0.001 (0.008)	-0.007 (0.007)	-0.0002 (0.001)
g1_2011	2.438*** (0.172)	0.002 (0.019)	-0.038*** (0.004)	-0.064*** (0.008)	-0.057*** (0.007)	-0.001** (0.001)
g2_2011	0.105 (0.136)	-0.021 (0.015)	-0.015*** (0.003)	-0.012* (0.006)	-0.009 (0.006)	0.0002 (0.0005)
g3_2011	-0.205 (0.156)	0.074*** (0.017)	-0.039*** (0.004)	-0.024*** (0.007)	-0.032*** (0.007)	0.0002 (0.001)
g4_2011	-0.218 (0.162)	0.027 (0.018)	-0.007* (0.004)	0.009 (0.008)	0.010 (0.007)	-0.0001 (0.001)
g1_2012	2.613*** (0.167)	-0.080*** (0.019)	-0.054*** (0.004)	-0.078*** (0.008)	-0.079*** (0.007)	-0.002*** (0.001)

g2_2012	0.121	-0.027*	-0.015***	0.014**	0.012**	0.001*
	(0.134)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2012	0.357**	0.021	-0.036***	-0.047***	-0.041***	-0.0001
	(0.160)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g4_2012	-0.053	-0.015	-0.013***	-0.006	0.011	-0.0003
	(0.161)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2013	2.705***	-0.063***	-0.051***	-0.072***	-0.078***	0.001
	(0.165)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2013	0.202	-0.040***	-0.015***	-0.005	-0.012**	0.002***
	(0.131)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2013	0.559***	0.006	-0.033***	-0.052***	-0.044***	-0.0001
	(0.150)	(0.017)	(0.003)	(0.007)	(0.006)	(0.001)
g4_2013	-0.011	-0.045**	-0.012***	-0.014*	0.002	0.001
	(0.161)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2014	2.816***	-0.011	-0.019***	-0.042***	-0.043***	-0.001**
	(0.168)	(0.019)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2014	0.240*	-0.019	-0.006*	0.031***	0.028***	-0.0001
	(0.132)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2014	0.558***	0.049***	-0.017***	-0.046***	-0.048***	0.001*
	(0.143)	(0.016)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2014	0.054	-0.020	-0.010***	-0.013*	-0.001	0.001***
	(0.160)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2015	2.786***	-0.004	-0.011***	-0.021***	-0.027***	-0.001
	(0.165)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2015	0.323**	0.006	-0.006**	0.064***	0.070***	0.001**
	(0.129)	(0.014)	(0.003)	(0.006)	(0.006)	(0.0004)
g3_2015	0.583***	0.057***	-0.017***	-0.030***	-0.046***	0.002***
	(0.138)	(0.015)	(0.003)	(0.007)	(0.006)	(0.0005)
g4_2015	0.047	0.002	-0.006*	-0.003	-0.003	0.005***
	(0.160)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g1_2016	2.469***	-0.030*	-0.003	-0.025***	-0.026***	0.001
	(0.162)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
g2_2016	0.345***	-0.007	-0.002	0.005	0.005	0.0001
	(0.133)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g3_2016	0.377***	-0.058***	-0.010***	-0.038***	-0.034***	-0.001***
	(0.136)	(0.015)	(0.003)	(0.006)	(0.006)	(0.0005)
g4_2016	-0.028	0.002	0.0003	-0.002	-0.001	0.0001
	(0.161)	(0.018)	(0.004)	(0.008)	(0.007)	(0.001)
Observations	2,322	2,322	2,322	2,322	2,322	2,322
R2	0.381	0.459	0.767	0.454	0.457	0.300
Adjusted R2	0.289	0.379	0.732	0.373	0.376	0.196
F Statistic (df = 44; 2020)	28.240***	38.981***	151.178***	38.230***	38.687***	19.711***

Note: *p<0.1; **p<0.05; ***p<0.01

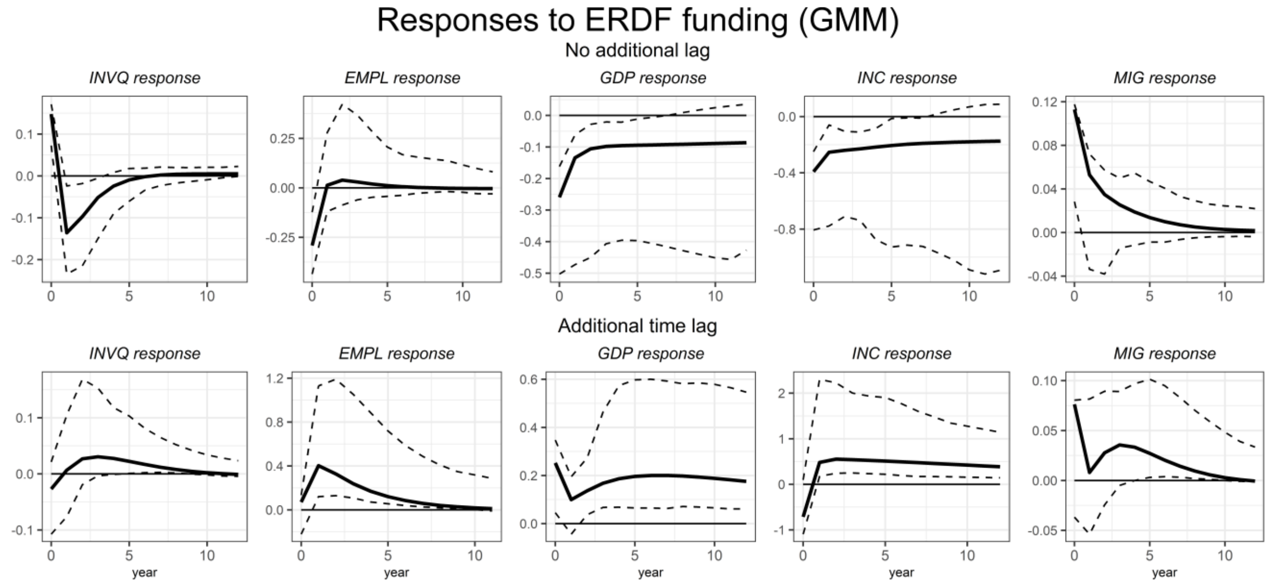

Figure A3.1: Responses to ERDF funding shocks with GMM estimations. Graph specifications equal Figure 3.4

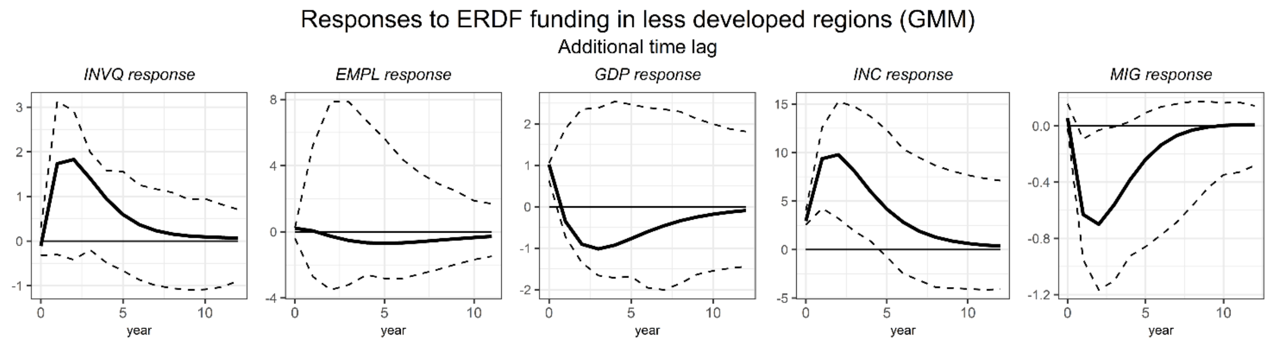

Figure A3.2: Responses to ERDF funding shocks in less developed regions with GMM estimation. Specifications and shock strength equal Figure A3.1

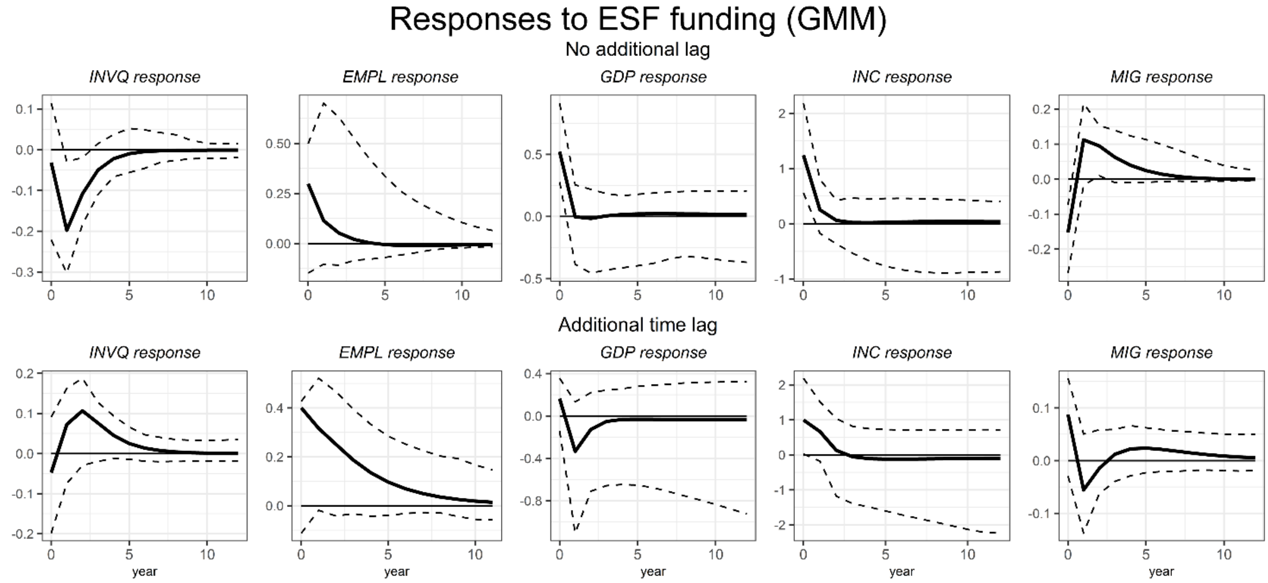

Figure A3.3: Responses to ESF funding shocks with GMM estimations. Specifications equal Figure 3.6.

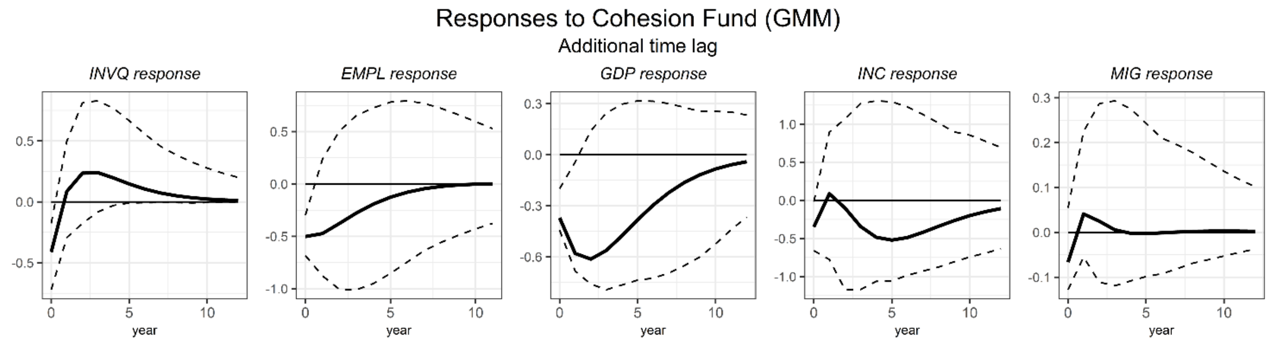

Figure A3.4: Responses to Cohesion Fund shocks with GMM estimations. Specifications equal Figure 3.8

4. Who benefits from Structural Investment Policy? An Empirical Analysis of the effects from the German Structural Fund GRW on Regional Wage Structures

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The paper is co-authored by Thomas Brenner.

Abstract: The German structural investment policy GRW provides financial subsidies to firms or providers of economic infrastructure in structurally weak regions in order to reduce regional economic disparities. The paper analyzes the effects of GRW grants on the wage development in funded regions at different quantiles of the wage distribution in order to answer the question to what extend additional productivity and income effects on firm level are transmitted to employees. We use a flexible spatial vector autoregressive panel model (SpVAR) that is able to estimate direct and indirect effects of GRW funding. We find that GRW industry subsidies have some positive effects on different stages of the wage distribution in East Germany, while effects in the West are limited to the top of the wage distribution. Infrastructure subsidies appear to be more efficient on wages than industry-firm subsidies, but are also limited to the East and to the service sector. This may indicate an upgrading of knowledge-intensive jobs due to infrastructure improvements.

Keywords: Regional policy, wages, income inequalities, spatial econometrics, impulse response functions

JEL Classification: C33, D31, J31, R15, R58

4.1 Introduction

Besides the European Cohesion Policy, the majority of member states offer national regional structural fund programs and investment subsidies to balance the spatial development and ensure equal opportunities as independent as possible from the place of residence (Criscuolo et al., 2019). The "Joint Federal/Länder task for the Improvement of Regional Economic Structures" (henceforth GRW) is the most important of these structural funds in the largest economy of Europe, Germany. Very similar investment funds for lagging areas at national level are provided by many other countries, for instance by Italy (Law 488/1992).

The GRW program redistributes financial resources to economically lagging regions by supporting capital investments and labor growth of private businesses as an incentive to locate in economically lagging regions and by subsidizing municipality projects bound to infrastructure that improve the regional conditions for economic actors in these regions. The program's main purpose is to procure primary and secondary effects on economic growth as a start for long-term endogenous and sustainable economic growth aiming for a more even spatial economic development under the objective of equivalent living conditions across regions that is postulated in the German constitution (Article 72).

This paper extends the scientific debate on the economic effects of structural GRW funds (e.g. Eberle et al. 2019; Brachert al. 2018; von Ehrlich & Seidel, 2015; Mitze et al., 2015), which focuses on productivity and employment effects, to the effects on the wage distribution in order to answer the question to what extend additional productivity and income effects on firm level are transmitted to employees. The effects of GRW funds and similar policies on wages and their intraregional inequalities are more or less neglected in previous studies (Cieślick & Rokicki, 2017). We analyze the effects on different quantiles of the wage distribution separately. This allows for examining the quality of jobs created as well as the impact on intraregional income inequalities, which have been increasing in recent years similar to cross-regional inequalities.

Figure 4.1 illustrates that inflation-adjusted real wages developed positive for high wages (75th and 90th percentile of the wage distribution) in Germany, while median wages and below have decreased on average over the period 2001 – 2010 based on the Employment History Dataset (BHP) from the German Institute for Employment Research (IAB) that is used in this study. Similar findings are made for example by Dustmann et al. (2009), Card et al. (2013) and Antonczyk et al. (2018). Several reasons are explaining this trend. Structural and technological change and associated demand for highly qualified workforce contributes to an increasing demand for workers at the top of the wage distribution. Contemporaneously there is a decreasing demand for low skilled workers due to the automation of routine and manual occupations on the bottom of the wage structure (Acemoglu & Autor, 2011). Afonso et al. (2013) find that this "skill biased technological change" has the strongest effect on intra-country inequalities in the European Union. Further explanations for rising income inequalities include the de-unionization and labor market liberalizations that took place in Germany under the name "Agenda 2010" (Biewen & Seckler, 2019), as well as financialization (Kohler et al., 2019; Lin & Tomaskovic-Devey, 2013) and consequences of globalization and free-trade (Afonso et al., 2013).

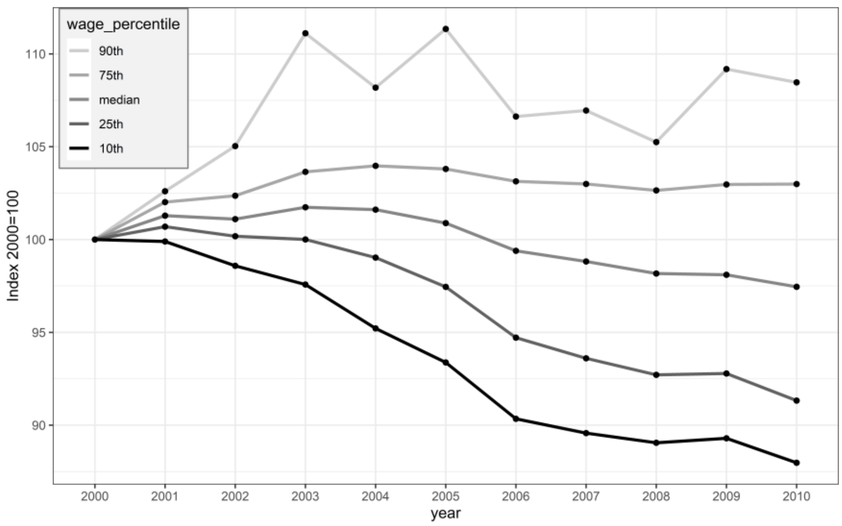


Figure 4.1: Inflation adjusted monthly gross wage percentile growth of full-time employed workers in Germany compared to year 2000. Weighted mean of all 401 administrative districts. Data origin: Institute for Employment Research, Nuremberg

It appears to be important to consider effects on wages, personal incomes and income inequalities in policy evaluation, as personal income is one of the most important determinants of individual material living standards, quality of life, well-being, participation in society and crucial for managing social balance and opportunities (e.g. Diener et al., 1985; Easterlin, 1974). Moreover, small personal income limits access to community goods, such as health care, education, housing, leisure opportunities and vacations (Ostry et al. 2014). Barca (2009) and Ferrara et al. (2020) clarify that improving the citizens well-being must be an important goal of regional policy. However, Schwellnus et al. (2017) illustrate that there is no linear relationship between regional or national economic growth and wages. The findings in Figure 4.1 support this, as Germany experienced a period of economic growth until 2008 that is not reflected in the wage development.

In addition, there is evidence that societies with higher income inequalities tend to reduce social mobility and have higher sensitivity for mental illness, crime and homicide rates (Wilkinson & Peckett, 2009). Moreover, Berg et al. (2012) find for multiple countries that low inequality levels lead to more sustainable growth in the long term, while on the other hand social inequalities and concentration of wealth are harming social cohesion and are found to be a cause for rising discontent (Dabla-Norris et al., 2015). Thus, the discussion on the geography of discontent emphasizes the role of inequalities in the recent rise of populist and right-wing parties in many countries (Dijkstra et al., 2020). This shows that income inequalities have become a central social and politic challenge and should be considered in policy evaluation. This objective of structural funds can be understood as regional instrumentation of the welfare state principle. Oates (1999) argues that a potential failure of regional redistribution policies occurs, if poor people in rich regions subsidize rich people in poor areas with their taxes.

To extract causal effects of GRW subsidies on regional wages, we use the advantages of a structural recursive spatial vector-autoregressive regression model (SpVAR) that attracts increasing attention in comparable research settings, since it is able to consider indirect effects between variables in the economic system over time. The approach contains simultaneous dynamic fixed effects panel estimations and controls for spatial spillover effects as well as for potential endogenous economic variables. To investigate GRW effect on wages, we use regional wage data from the IAB's employment history panel data for all 401 German administrative districts in the period 2001 – 2010. Finally, we test if there are conditional effects on GRW efficacy between the western and the structurally weaker eastern part of Germany.

The remainder of the paper succeeds in the following way. Section 4.2 concentrates on the GRW policy setup and related empirical research conducted so far. Section 4.3 presents our theoretical framework and research hypotheses. Data and variables are presented in section 4.4, the methodological approach is explained in section 4.5. Section 4.6 focuses on our empirical results. Finally, section 4.7 concludes.

4.2 GRW policy setup and empirical studies

As most important regional development policy in Germany, the GRW was implemented in 1969 to contribute to the aim of equivalent living conditions across the country and extended in the 1990s to foster the economic convergence of East Germany after the German reunification process (Deutscher Bundestag, 2014). The regional eligibility of funds depends on an indicator based on the regional unemployment rate, wage level, employment forecast and infrastructure and is limited to structurally lagging regions. In fact, 189 of 402 districts were supported by GRW funds in the period studied. The GRW program provides two separate investment schemes. The industrial scheme is dedicated to the production sector and directly subsidizes private firm investments in physical capital or labor costs, covering 35% to 50% of total costs with a focus on MSEs that manufacture products for (regional) export. The creation of additional jobs within the subsidized firm is obligatory in this scheme. The infrastructure scheme subsidizes economically relevant public infrastructure projects, such as transport or education and research centers up to 60% of the total costs. The co-financing approach aims to reduce windfall gains to a minimum, similar to other regional policy measures such as the European Cohesion Policy that is directly connected to GRW since part of the financial means result from the European Regional Development Fund (ERDF). GRW regulation details and subsidies are in the competence of the 16 federal states within a nationwide framework and payment is subdivided into federal and federal state grants, which causes a bit of fuzziness. In practice, the regulations differ only slightly and are comparable across federal states.

In our research period 2001 to 2010, the granted subsidies amounted to 20.51 billion euros. Of this amount, 14.29 billion were industry investment subsidies and 6.22 billion were infrastructure grants. 80% of the subsidies were spend on projects in the Eastern regions that formed the former GDR. The spatial distribution of funds is displayed in Figure 4.2.

Many studies have examined the efficacy of GRW funding subsidies. Eberle et al. (2019) offer

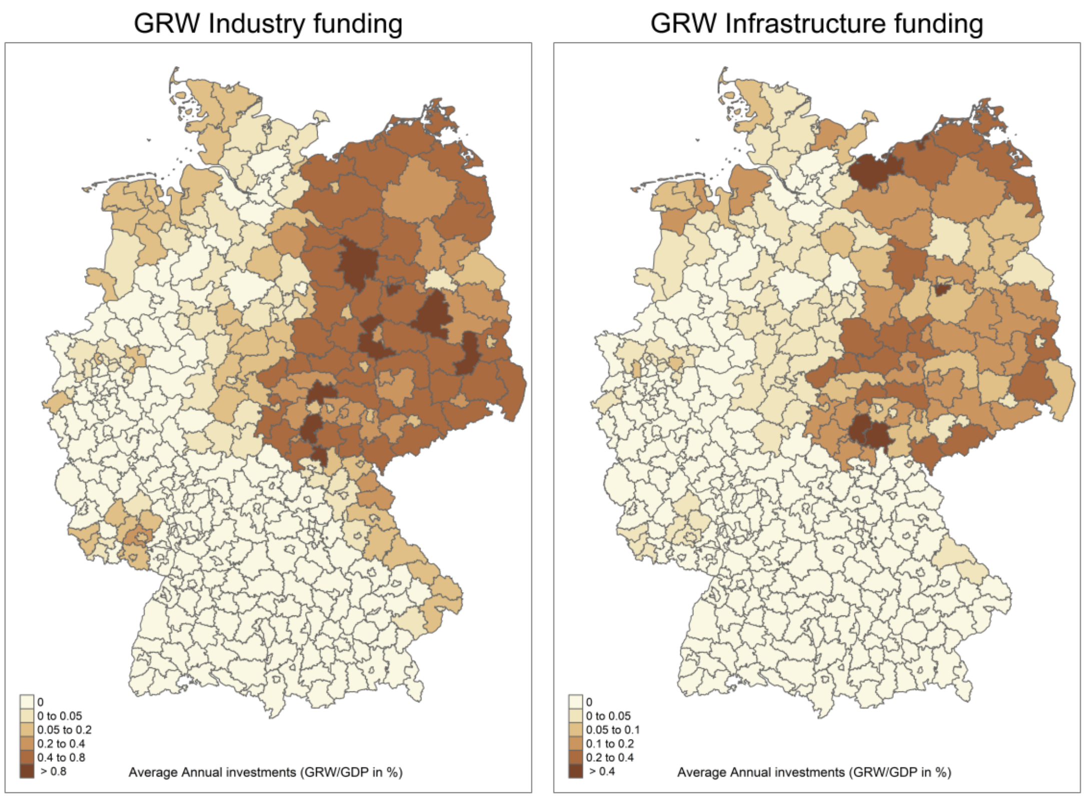


Figure 4.2: Average annual GRW intensity in % of GDP 2001 - 2010

a comprehensive summary with a focus on GRW effects on regional economic growth. Alecke and Unitiedt (2007), Röhl and von Speicher (2009), Alecke et al. (2013), Mitze et al. (2015), Rhoden (2016) find that GRW has positive effects on regional productivity. Regional employment growth is identified by Schalk and Untiedt (2000), von Ehrlich & Seidel (2015) and Dettmann et al. (2017). No or very limited effects are found by Eckey and Kosfeld (2005) and Egger et al. (2014).

Brachert et al. (2019) first mention wages in GRW evaluation in a study of effects in Western German regions in the program period 2000 - 2006. While they find evidence for regional productivity growth, they find no evidence for total gross wage growth. In similar policy setups, Busso et al. (2013) find positive effects on weekly wages of the US federal urban Empowerment Zones that do not correspond to increases in the local costs of living. Cieślick and Rokicki (2017) find a positive relationship between European structural funds and individual wages on NUTS-2 level for Polish regions.

4.3 Theoretical considerations

In order to obtain a theoretical framework that produces profound research hypothesis and allows for adequate model building, we consider the macroeconomic wage equation as established e.g. by Blanchard and Katz (1997), in which the change of log nominal wages w_t in a region i is defined as:

$$\Delta w_{it} = \alpha_{wi} + \Delta p_{t-1} - \beta u_{it} + \varepsilon_{wit,} \qquad (4.1)$$

where u is the unemployment rate, p the log price level, α_w a constant and ε_{wt} the error terms. The price level p_t, in turn, is constant across regions and depends on the constant, the wage level and the error term, so that price and wage inflation are mutually dependent. In the case of time-constant price inflation, real wages are a function of the unemployment rate. Decreasing unemployment should strengthen the bargaining power of workers, especially those on the lower end of the wage distribution, leading to the wage curve introduced by Blanchflower and Oswald (1994). Blanchard and Katz (1997) extend this by adding firm productivity to the wage equation:

$$\Delta w_{it} = \alpha_{wi} + \Delta p_{t-1} - \lambda(w_{i,t-1} - p_{t-1} - x_{t-1}) - \beta u_{it} + \varepsilon_{wit,} \quad (4.2)$$

where x_t denotes the log productivity level which has a positive impact on wages. The equation implies that productivity growth is constant over regions. However, we argue that this is insufficient, as individual regional factors lead to differences in firm and regional factor productivity levels and growth rates.

Mankiw et al. (1992) define the steady-state output X of an economy *i* at time *t* in their augmented Solow-Model (Solow, 1956) as:

$$X_i\,(t) = K_i(t)^{\alpha} H_i(t)^{ß} (A_i(t) L_i(t))^{1-\alpha-ß} \quad (4.3)$$

where K and H represent the physical and human capital in a region, while A represents the technological level in a region and L is the labor input with an exogenous growth rate equal to working-age population growth. The coefficients α and β display the decreasing returns to the different types of capital. Thus, region specific accumulation of physical and human capital as well as employment and technology input determine the growth of regional output.

We follow the extension by Eberle et al. (2019) who define L, in the spirit of Bräuninger and Pannenberg's (2002) endogenous augmentation of the production function, as:

$$L_{it} = \kappa_i(t) * Q_i(0) e^{n_i t}, \quad (4.4)$$

where Q_{it} is the population between 15 and 64 years with the exogenous growth rate n_i and $\kappa_i$is the share of Q_{it} that is actually employed ($L_i(t)$), which shows short-run variations, but is constant in the long-run.

Thus, the output per working-age population (labor productivity) is:

$$x_i(t) = k_i(t)^{\alpha} h_i(t)^{ß} (A_i(t)\kappa_i(t))^{1-\alpha-ß} \tag{4.5}$$

Considering another extension from Crihfield et al. (1995), who consider public capital Z_{it}, which has similar properties to K_{it}, but is non-excludable, equation (4.5) can be extended as follows (Eberle et al., 2019):

$$x_i(t) = k_i(t)^{\alpha} h_i(t)^{ß} z_i(t)^{\gamma} (A_i(t)\kappa_i(t))^{1-\alpha-ß-\gamma}, \tag{4.6}$$

where γ is the return to public capital. This term can be included into equation (4.2), which now takes into account differences in regional labor productivity. It becomes apparent that investing in regional production factors (physical, public & human capital, technology & employment) should have positive effects on regional wages. Therefore, we control for these factors in our model. By including public capital, we explicitly consider the effects of regional policy subsidies. Effective policy interventions either directly enhance the capital stock of (private) firms, stimulate further private capital investments through co-financing or support public infrastructure improvements. Hence, there should be a positive relationship between subsidies such as GRW funding and the regional steady state productivity and thus regional wages.

In addition, we should consider sector and firm heterogeneity across regions in the wage equation. Every sector or occupational group has its own wage market equilibrium and thus its own wage rate based on the specific factor productivity and adoption rate of technological innovation (Acemoglu & Autor, 2011). For example, wage rates in high productive and knowledge intensive services and particular industries (e.g. automotive) are higher than in most person-related services or agriculture. Hence, the regional average wage level strongly depends on the sectoral structure within the region. Moreover, Card et al. (2013) find evidence for rising firm heterogeneity in wage levels. Comparable employees are paid differently even between firms in the same industry, so that efficiency wages and individual payment policy have led to the development of high-wage-firms and low-wage firms. Economies of scale allow larger firms to pay higher wages than small firms. Therefore, we add a factor f_t to the augmented wage equation that reflects the regions observable firm characteristics (sectors, innovativeness, sizes, etc.):

$$\Delta w_{it} = \alpha_{wi} + \Delta p_{t-1} - \lambda(w_{i,t-1} - p_{t-1} - x_{it-1)} - \beta u_{it} + \Delta f_{it} + \varepsilon_{wit}. \quad (4.7)$$

In a next step, we assess cross-regional worker heterogeneity. Higher education and experience largely determines the access to high wages, employment opportunities and high-income careers. Especially the presence of the so-called creative class, is considered as a key factor for regional wage differentials, as creative and high-skilled employees are able to generate above-average wages (Hortas-Rico & Rios, 2019; Rodriguez-Pose & Tselios, 2009). Conversely, low education limits employment opportunities and income chances. Thus, the higher the average education level among employees, the higher the regional wage level. This is in line with the findings from Acemoglu & Autor (2011) and Afonso et al. (2013) that the skill-biased technological change is a key driver of the expanding wage distribution. Besides qualification, workforce heterogeneity can arise from age and gender of the local population. Wages are lower in the beginning of the professional career and increase with experience and productivity, but may decrease at the end of the career (Harris & Holmstrom, 1982). Aggregating these to the regional level we can add the factor b_t, which reflects the regions observable working age population characteristics (education, experience, age, gender), to eq (4.7), as follows:

$$\Delta w_{it} = \alpha_{wi} + \Delta p_{t-1} - \lambda(w_{i,t-1} - p_{t-1} - x_{it-1)} - \beta u_{it} + \Delta f_{it} + \Delta b_{it} + \varepsilon_{wit} \quad (4.8)$$

Migration can impact the strength of the human capital factor b_t by interregional and transnational migration dynamics. These bring several interesting dynamics to the model. Employees and jobseekers will look for jobs in another region, if they are unsatisfied with their local wages. The willingness to move or commute depends strongly on regional wages in those regions and individual costs, which increase with distance. If wages are higher within an acceptable distance, this brings bargaining power to the local workforce. Thus, the regional wages depend on wage developments in neighboring regions. Adding this into eq. (4.8), we get:

$$\Delta w_{it} = \alpha_{wi} + \Delta p_{t-1} - \lambda(w_{i,t-1} - p_{t-1} - x_{i,t-1)} - \beta u_{it} + \Delta f_{it} + \Delta b_{it} + \Delta H w_{it-1} + \varepsilon_{wit,} \quad (4.9)$$

where H is a spatial weight matrix, representing the decreasing likelihood to move with distance. The regional wage level thus depends not only on various regional economic factors, but on the same factors in neighboring regions. Figure 4.3 illustrates that median gross wages for full time employees in Germany definitely show spatial autocorrelated behavior. Moreover, we clearly see the presence of high wages in high-productive agglomerations.

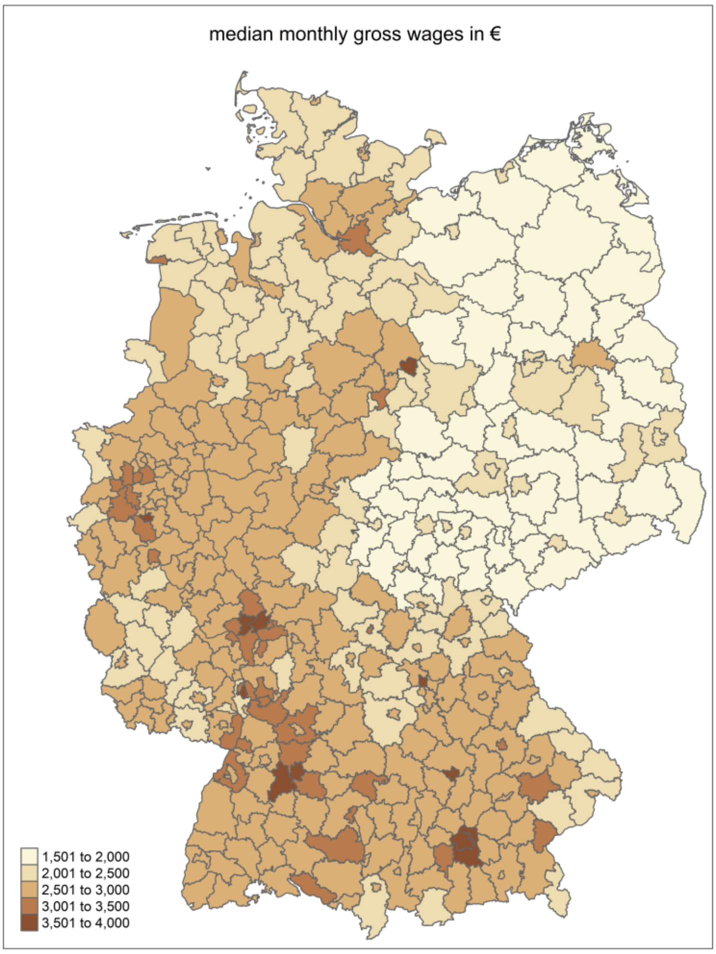


Figure 4.3: Median monthly gross wages 2010 in € in German administrative districts

In addition, numerous studies prove that foreign migration has a strong impact on the labor market. Immigrants are more likely to perform low-skilled jobs and to earn less than natives even if they have similar education and qualifications (e.g. Topel, 1994). In Germany, there is especially a share of immigrants from Eastern Europe earning very low wages for example in agriculture, in less skill-intensive services and in the manufacturing sector. On the other hand, foreign high-skilled workers are recruited for top-level positions in knowledge intensive services and global player companies (Afonso et al., 2013). This impact of foreign migration on the regional workforce should be already included in our model through factor b, as it manifests itself in the worker/population heterogeneity.

The interactions within (4.9) become more heterogeneous, as we are not only interested in average wages, but in different quantiles of the wage distribution. It is probable that not all factors have linear effects across the wage distribution. For example, technological progress in a region causes demand in high qualified workers, which means that wages on the top of the wage distribution rise faster than those on the bottom. On the other hand, a decline in unemployment should increase the wages of low-skilled workers, who are more at risk of unemployment than high-skilled workers are. Structural policy measures can therefore have different effects on the wage distribution depending on the regional factors affected.

4.4 Data and variables

For the analysis, we use a balanced panel data set with annual data for the 401 German administrative county districts and cities. The Employment History Dataset (BHP) from the German Institute for Labor Market Research (IAB) is as the central wage data. It contains regional percentiles of monthly gross wages of full-time employees in the private sector at the 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentile level. This data only includes wages of full-time employees, while wages and salaries of civil-servants that are determined by long-term collective agreements, as well as incomes of self-employed and part-time employees are excluded. This, leads to some shortcomings at the lower end of the wage distribution: In particular, the data does not show the development of diverse forms of contracts, such as mini- and part-time jobs. However, excluding this part of the labor market from the analysis means that we focus on the effects of the GRW funds on full-time employment, which is our intention. Wage research often has to struggle with the sensitivity of wage data. Especially data sources on inequalities are often lacking even for highly developed countries (Hortas-Rico & Rios, 2019). Although the administrative data source guarantees best data reliability, we face some minor difficulties. First, a continuous wage data set is limited to the years 2001 to 2010, as changes in the survey after that date prevent continuous panel data. Second, high incomes on the 90^{th} percentile are often censored at the level of the maximum income limit of the unemployment insurance system, which leads to missing values in 43 regions with peak incomes. All of these regions are cities or located in metropolitan areas and located in West-Germany (except Berlin). Their economic strength causes that these regions do not receive GRW funds, so that the missing data should not compromise the analysis (except Berlin, again). The GRW investment subsidies are measured in €, normalized to the regional GDP. This has the advantage that real subsidies are taken into account instead of treatment groups as done in most econometric policy evaluation studies. As Figure 4.2 shows, there are large differences in the funding intensity across regions that are eligible for funding. Moreover, it allows for distinguishing between industry and infrastructure subsidies.

We include further economic measures, as displayed in Table 4.1, in order to apply the augmented wage equation from eq. (4.9): In equilibrium, industry investments compensate the depreciation of physical capital and accounts for a fixed share of it, so it can be used as a measure for physical capital (k). The gross employment rate represents labor input (κ) in eq. (6). As a proxy for the regional technology level (A), we include the rate of employees in research and development. To represent human capital (h), we use the presence of high education (university degree) in the workforce. In addition, we use the share of employees without vocational training as a second proxy for human capital. Total productivity (GDP/working-age population) represents the productivity level in eq. (4.9). The workforce heterogeneity (*b*) in eq. (4.9) is represented by the share of foreign employees, the share of employees in their most productive career stage (age 30 – 55) and the share of male employees, which controls for the still existing gender pay gap. Firm heterogeneity (*f*) in eq. (4.9) is accounted for by including the firm sizes and the share of employees in the production sector, both of which are associated with higher wages. Table 4.1 presents all details on the used variables.

The use of spatial lags as control for spatial autocorrelation in wages as proposed in eq (4.9) is explained in section 4.5. All variables are transformed to their natural logarithm. Null values are replaced by very small numbers before transformation. As the SpVAR approach presented in section 4.5 is limited to stationary panel data sets, we apply the IPS-test (Im et al., 2005), which detects non-stationarity for the industry share, higher education, employment, GDP and higher wages (test results are given in Appendix Table A4.1). In order to use stationary data in the estimation, we subtracted linear time trends from those data together with their spatial lags, following Elhorst (2012). To ensure comparability, we de-trended every wage variable, also those who did not detect non-stationarity. Table 4.2 provides the data's summary statistics

Table 4.1: Variable descriptions and data sources

Acronym	Variable Description	Data Source
1a) GRW_IND **1b)GRW_INFRA**	GRW funding intensity (either total, industry, or infrastructure scheme) in relation to regional GDP *[GRW subsidies/GDP in €]*	GRW: Federal Office for Economic Affairs and Export Control (BAFA) GDP: Working Group „National Accounts oft he Federal States. - "Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder
2) INVQ	Private sector physical capital industry investment rate in the manufacturing, mining and quarrying sector in relation to regional GDP *[Industry Investments in € / GDP in €]*	German Federal Institute for Research on Building, Urban Affairs, and Spatial Development (BBSR), ongoing spatial monitoring, various issues
3) IND_S	Share of employees in the production sector on all employed workers *[Employed persons in production/Employed persons total]*	Institute for Employment Research (IAB)
4) EDU	Higher education – Workers with a university degree per economically active working population *[Employed persons with university degree/Population aged 15 to 64 years]*	German Federal Employment Agency Population data: German Federal Statistic Office
5) R&D	Share of employed persons in Research & Development *[Employed persons in R&D/Employed persons in total]*	Institute for Employment Research (IAB)
6) EMP	Gross employment rate *[Employed persons/Population aged 15 to 64 years]*	Institute for Employment Research (IAB)
7) GDP	Nominal GDP per economically active working population *[GDP in €/population aged 15 to 64 years]*	Working Group „National Accounts oft he Federal States. - "Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder
WAGE **8a) _M10** **8b) _M25** **8c) _M50** **8d) _M75** **8e) _M90**	Monthly gross wages of full-time employees as Mx^{th} *percentile* of the regional wage distribution among all full-time employed workers	Institute for Employment Research (IAB)
9) FSIZE	Weighted average firm size value *[(Employees * individual firm size dummy)/ all employees]* With dummies: Firms (<10 Employees =1, 10-49 employees = 2, 50 – 250 employees = 3 and > 250 employees = 4))	Institute for Employment Research (IAB)
10) FOR	Foreign employees *[Employees with German citizenship/total employees]*	German Federal Employment Agency
11) NDEG	Employees without vocational education per economically active working population *[Employees with vocational qualification/Population aged 15 to 64 years]*	German Federal Employment Agency
12) AGE	Share of Employees between 30 and 55 years *[Employees aged between 30 and 55 years/ total employee]*	German Federal Employment Agency
13) GEND	Share of male employees *[Male employees/all employees]*	German Federal Employment Agency

Table 4.2: Variable summary statistics

Nr	Acronym	Observations	Min	1.Quarter	Mean	3. Quarter	Max	Std. Dev.
1a	**GRW_IND**	4010	-18.421	-18.421	-13.776	-7.268	-2.854	5.740
1b	**GRW_INFRA**	4010	-18.421	-18.421	-15.640	-11.352	-3.392	4.816
2	**INVQ**	4010	-8.194	-4.356	-3.971	-3.542	-1.496	0.684
3	**IND_S**	4010	-3.261	-1.558	-1.329	-1.016	-0.377	0.413
3b	**IND_S_DET**	4010	-3.065	-1.525	-1.278	-0.961	-0.327	0.412
4	**EDU**	4010	-4.887	-3.649	-3.224	-2.872	-1.016	0.618
4b	**EDU_DET**	4010	-5.063	-3.937	-3.474	-3.111	-1.364	0.639
5	**R&D**	4010	-5.806	-4.594	-4.236	-3.883	-2.247	0.550
6	**EMP**	4010	-1.008	-0.748	-0.700	-0.643	-0.468	0.081
6b	**EMP_DET**	4010	-0.982	-0.779	-0.732	-0.679	-0535	0.074
7	**GDP**	4010	9.75	10.29	10.53	10.72	12.03	0.362
7b	**GDP_DET**	4010	9.68	10.16	10.39	10.58	11.77	0.372
8a	**WAGE_M10**	4010	6.772	7.041	7.134	7.222	7.519	0.130
8a2	**WAGE_M10_DET**	4010	6.791	7.020	7.123	7.220	7.523	0.135
8b	**WAGE _M25**	4010	7.077	7.428	7.501	7.606	7.933	0.158
8b2	**WAGE_M25_DET**	4010	7.045	7.408	7.477	7.581	7.914	0.156
8c	**WAGE _M50**	4010	7.334	7.723	7.792	7.888	8.270	0.161
8c2	**WAGE_M50_DET**	4010	7.311	7.679	7.733	7.818	8.122	0.149
8d	**WAGE_M75**	4010	7.613	7.955	8.052	8.151	8.688	0.167
8d2	**WAGE_M75_DET**	4010	7.587	7.886	7.963	8.051	8.431	0.153
8e	**WAGE _M90**	3580*	7.866	8.195	8.293	8.403	8.618	0.151
8e2	**WAGE_M90_DET**	3580	7.842	8.106	8.190	8.305	8.475	0.137
9	**FSIZE**	4010	0.688	0.888	0.958	1.025	1.271	0.093
10	**FOR**	4010	-0.190	-0.084	-0.057	-0.025	-0.002	0.040
11	**NDEG**	4010	-0.310	-0.094	-0.077	-0.054	-0.021	0.035
12	**AGE**	4010	-0.537	-0.446	-0.420	-0.394	-0.284	0.038
13	**GEND**	4010	-0.872	-0.656	-0.608	-0.559	-0.320	0.082

4.5 Econometric approach

Extracting the real effects of structural funds on wage development in the subsidized regions is not easy. The effects may occur directly and without time delay through new created jobs or with time-delay due to the rigidity of wages and indirect effects. For example, subsidies may trigger productivity or technology growth in the long-term that lead to wage growth in a later step.

Flexible vector autoregressive models have evolved as econometric method to analyze dynamic relationships between variables in time-series forecasts. Beyond that, the method allows for analyzing panel data with time-lagged variables, and the integration of spatial interdependencies, which explicitly considers the evolutionary nature of spatial economic systems and mutual interdependencies and indirect transmissions of effects between variables over time. Finally, it allows for visualizing the various estimated effects to local shocks in impulse response functions (IRFs).

The basic VAR approach by Sims (1980) has experienced two main advances that enable its application in regional economics. Holtz-Eakin et al. (1988) adapted the approach for panel data, Beenstock & Felsenstein (2007) and Di Giacinto (2010) developed methods to consider spatial autocorrelation and introduced the SpVAR model. Our model follows these approaches and is similar to the approaches of Mitze et al. (2018) and Eberle et al. (2019).

We estimate a dynamic SpVAR model to find the effects of GRW subsidies. Therefore, we specify a simultaneous equation system consisting of *M* simultaneous dynamic panel data equations in which every variable *m* appears as dependent variable. All variables are applied with a lag length of *t -1* year, since the variables need some time to react to "shocks" in other variables. This is particularly useful to take into account the stickiness of wages. The lag-length t-1 is chosen based on the Akaike Information Criterion.

Since the considered time period is influenced by trade cycle effects and in particular by the economic crisis from 2008 onwards, as well as cross-sectional heterogeneity, it is necessary to control for individual (μ) and time fixed effects(τ), which are able to control for exogenous global effects in the data set. The panel VAR equation system can be aggregated to the following reduced form (Rickman, 2010; Mitze et al., 2018):

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + \varepsilon_{\mathrm{it}}, \tag{4.10}$$

where i and t denote region and time, A is a $M*M$ coefficient matrix representing the relationships between dependent and independent time-lagged variables and ε denotes the error terms.

To limit the number of variables in the VAR, which has negative effects on the degrees of freedom, we make further assumptions about the endogeneity of variables in the system. We expect eight variables to interact directly and indirectly in a reciprocal manner (denoting them by y), while five variables control for dynamics in the regional labor market that directly affect the average wage development as given in equation (4.9), but do not interact with the other growth variables in a reciprocal way (denoting them by z). The former are the variables GRW input, investment rate, share of the manufacturing sector, higher education rate, employees in research & development, employment rate, GDP per economically active working population and the wage variable as displayed in Table 4.1. The latter are firm size, foreign employees, employees without vocational education and the employees average age and gender. Thus, we extend eq. (10) to differentiate between these groups of variables:

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + \mathrm{B}z_{it-1} + \varepsilon_{\mathrm{it}}, \quad (4.11)$$

where B is a $N*M$ coefficient matrix representing the relationship of dependent variables to time-lagged values of the control variables.

Furthermore, we consider the role of spatial dependency and spatial spillovers among variables, which is represented in the augmented wage equation. Since a Moran's I test confirms that spatial autocorrelation is present not only in wages but in all variables, we include spatial lags of all variables into the equations using a Spatial-Durbin model according to Beenstock & Felsenstein (2007) and Di Giacinto (2010). Hence, we can extend equation (11) as follows:

$$y_{it} = \mu_i + \tau_t + \mathrm{A}y_{it-1} + \mathrm{B}z_{it-1} + H_y W y_{it-1} + H_z W z_{it-1} + \varepsilon_{\mathrm{it}}, \quad (4.12)$$

where H_y represents a $M*M$ and H_z represents a $N*M$ coefficient matrix and W is a binary matrix of spatial weights in which W_{ij} = 1 when there is common border. However, the matrixes *B*, H_yW and H_zW are only integrated in order to calculate unbiased coefficients for matrix A, which is used in the IRF calculation.

In the empirical analysis the equations can be solved with different types of dynamic panel data estimators that have individual advantages and limitations. A detailed summary on this is given by Elhorst (2012). Dynamic linear fixed effect models are biased, especially if the time dimension is short. (Nickell, 1981). However, GMM estimators, that are the most popular alternative, provide reliable results if instruments are strong, but, as shown for example by Kiviet (1995) and Binder et al. (2005), the results can be strongly distorted if instruments are weak. As a third alternative dynamic quasi-maximum-likelihood estimators such as the QML-FE estimator (Hsiao et al., 2002) are developed to deal with the known problems. However, we observe problems to the indicator in the case of not completely exogenous independent variables, which cannot be avoided in the use of spatial lags as independent variables. Weighing the pros and cons, we estimate linear estimations, knowing that the Nickell-Bias, which causes downward biases in the lag dependent variables' estimates, is not significantly large for t=10. This makes robustness checks very important. Therefore, we additionally estimate the models as two-step system-GMM with collapsed instruments, using further lags of the dependent and independent variables as instruments. We will carefully refer to the robustness checks in the estimation section and present the GMM results in the Appendix.

Based on the results, we are able to calculate *M**M* impulse response functions (IRFs) that represent the reaction of all y-variables in region i to orthogonalized and uncorrelated exogenous shocks in these variables. To this end, the coefficient matrix $\mathrm{A}y_{it-1}$ is transformed into its moving-average representation, as proposed by Lütkepohl (2005).

Since all variables in A are treated as completely endogenous, we define a recursive variable order with ascending endogeneity and perform a triangular Choleski identification on the variance-covariance matrix of ε, following Mitze et al. (2018). This restricts the contemporaneous (same year) effects to one direction in order to avoid over-parametrization of the error terms that would lead to biased IRFs (Rickman, 2010). The causal ordering is based on a-priori theoretical assumptions on the endogeneity and results from Granger-Causality tests (*see Appendix A4.2*). The variable order corresponds to the order in Table 4.1. Finally, we are now able to calculate the moving-average-process over an infinite number of years, but all responses are based on the coefficient matrix calculated as in eq. (12).

In order to obtain 95% confidence intervals of the estimated IRFs, we conduct repeated simulations of the SpVAR with panel data sets of the same size that are randomly generated from the original data in a Monte Carlo simulation with 500 repetitions. Random regions are drawn (with recline) from the original data into the simulation data with all their attributes over time. Initial shocks are kept equal to the original SpVAR estimate.

4.6 Empirical results

We will present our empirical findings in three steps. In a first step, we present the responses of the investigated wage quantiles to shocks in the economic variables in the system to examine the differences in the factor's relevance for each wage quantile. This is relevant to understand indirect transmission channels from GRW funding to wage growth. In a second and more detailed step, we will present the effects of both GRW funding schemes on the wage quantiles to answer our primary research question. Finally, we split the dataset along the former inner-German border into West and East Germany to compare the responses to both GRW schemes. This is useful because the economies of both parts are still quite different. The East is structurally weaker than the West and is characterized by lower productivity and wages. Furthermore, unemployment is higher, but labor force participation rate, especially female participation rate, is higher. The results confirm that there is a different reaction to GRW funding in the subsamples *(Figure 4.6)*. Berlin is excluded from both subsamples because of its particular history. Additionally, we study if there is a difference in the response of wages in the production and service sector. This is reasonable as GRW is a policy measure that is mainly designed to support the production sector.

We find further results in the VAR estimation that are not in our focus, such as effects of GRW subsidies on variables other than wages. We observe, consistent with most similar studies presented in Sector 2, that GRW industry subsidies have significant positive effects on regional employment rates and GDP output per working population. The employment effect is immediately visible, and significantly positive up to 2 years after the actual subsidy. This was expected since job creation is mandatory for most funding cases in this scheme. We find significant GDP growth due to GRW industry subsidies from one year after the subsidy, but persisting longer term than employment growth.

Effects of GRW infrastructure subsidies on the local economy differ from those of industry funding. We do not observe employment or GDP growth, but significant growth of the share of employees in R&D starting one year after funding, which could result from the fact that research centers are explicitly part of the funded projects in this investment scheme. It further implies that firms engaged in R&D in particular can benefit from infrastructural improvements. However, this is not reflected in the growth of other variables. The full sets of IRFs are given in the Appendix (*Figures A4.1 and A4.2*).

4.6.1 Responses of wages to economic shocks

In the next step, we take a closer look on the responses of wages to general economic shocks. The results are shown in figure 4.4. The IRFs positioned in the same line are responses from a given wage quantile to non-policy variables estimated within one SpVAR model. These effects are not substantially affected by the policy scheme used in the applied model. This proves the reliability and stability of our econometric method. The estimated impulse responses using GMM estimations are presented in the appendix *(Figures A4.3-A4.8).* As expected, GMM's estimate larger coefficients of the autoregressive term, resulting in longer-lasting responses. In order to ensure the stability of the system, the R&D variable had to be detrended in the robustness tests. This should affect the estimated wage responses to R&D shocks, but not have large impact on the estimated wage responses to GRW shocks.

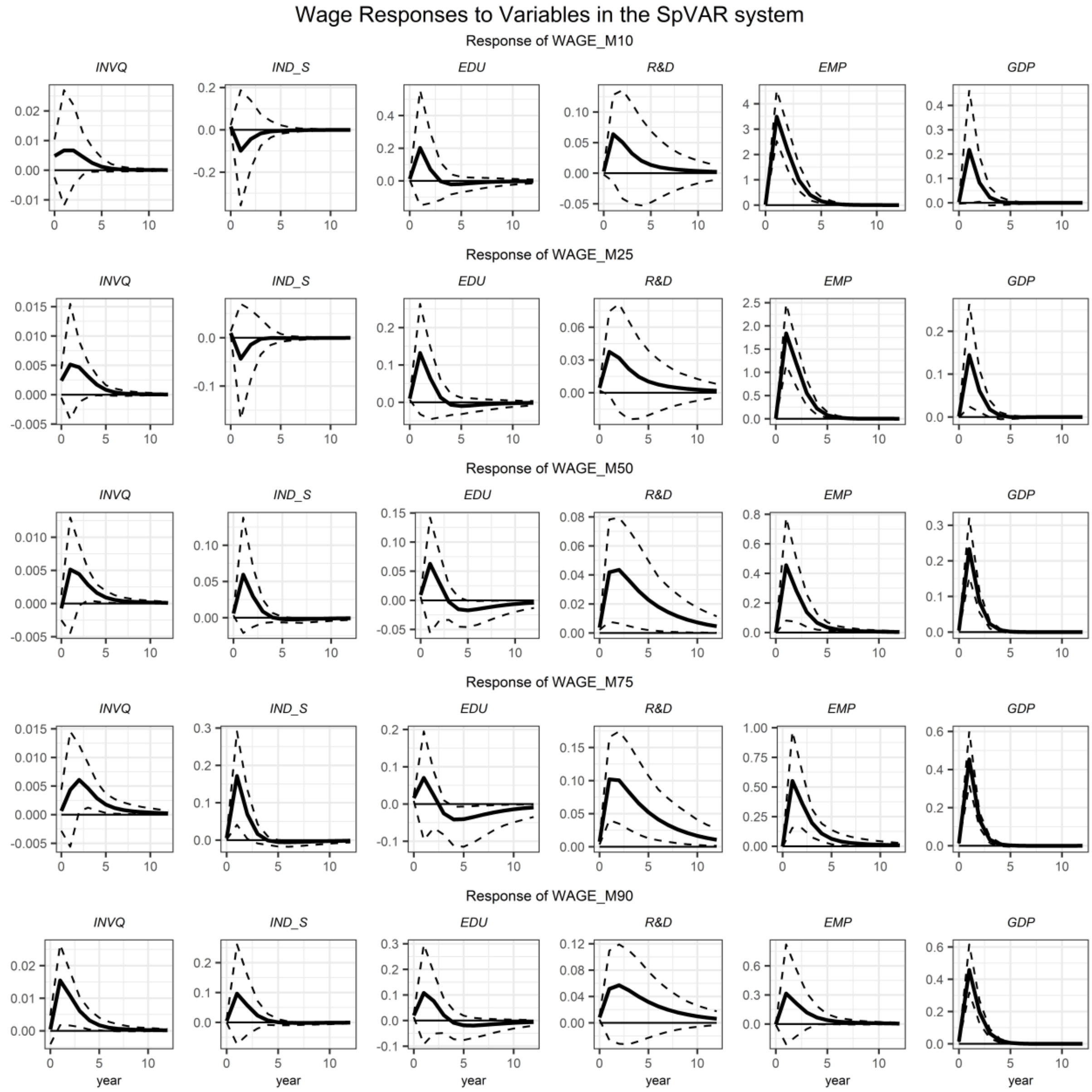


Figure 4.4: Impulse Response Functions (IRFs) of Wage variables to isolated shocks in other variables in the SpVAR systems. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %.

We find evidence that wages above the median respond significantly positive to shocks in the private sector investment rates in the linear equation models *(Figure 4.4)*. However, these significances are not robust in GMM estimation *(Figure A4.3)*. Contrary to the theoretical considerations, higher education shares do not affect wages according to the linear equation models. However, GMM estimates suggest a positive relationship between higher education and wages in the long run. In contrast, we find evidence that shocks in the number of R&D employees have positive effects on median wages and the 75th percentile of the wage distribution. This is a very robust result. In GMM estimation (with detrended R&D variable) all wage quantiles respond positively to R&D employment shocks. This proves the general impact of an increasingly technology and innovation-oriented economy on the upgrading of jobs, but according to the linear model also on increasing regional inequalities, supporting the findings from Hortas-Rico & Rios (2019).

In contrast, shocks in the overall employment rate trigger most positive effects for lowest wages at the 10th and 25th percentile, smaller effects on the median and the 75th percentile and not significant effects for top wages at the 90th percentile. This is confirmed by the GMM estimation. Hence, as expected, low wages are more sensitive to the regional employment dynamics, especially the number of unemployed persons. Finally, GDP shocks have very positive effects on wages all over the wage distribution, which again is very robust.

4.6.2 Responses of wages to GRW industry funding

We find evidence that GRW subsidies can have positive effects on wages in the total sample of 401 German counties and independent cities, but we do not find general validity of this statement (*Figure 4.5*). The estimated effects of GRW industry subsidies on lowest wages (10th percentile) initially suggest a positive contemporaneous relationship between GRW and lowest wage, but these effects are not robust to GMM estimation and contemporaneous effects are not

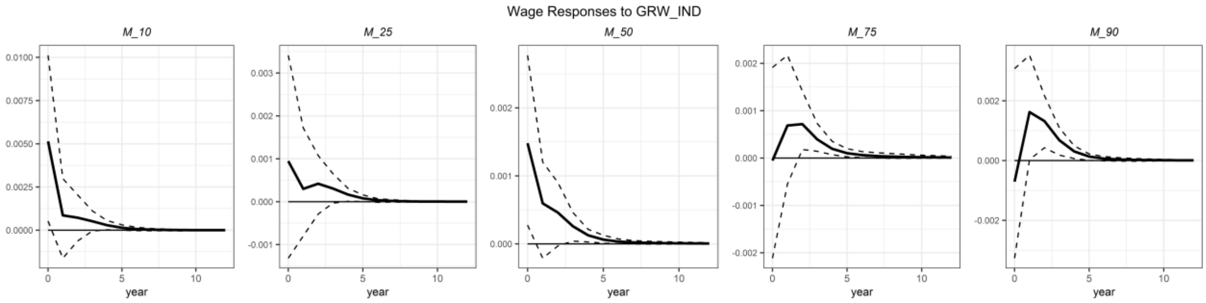


Figure 4.5: Impulse responses of wages to GRW Industry shocks. Each response represents individual model estimation, thus shock strength is not comparable. Model specifications remain constant except for the wage variable. Graph specifications equal Figure 4.4

automatically associated with the subsidies, as they may occur at a point in the year when the subsidies have not yet been paid. We cannot differentiate this with our panel data. However, later effects can be claimed as time-causal relationships due to the estimated lag-structure. We find the same picture for median wages. Again, the result is not robust. Top wages (75th and 90th percentile) respond positively to GRW industry subsidies in the medium term (approx. 3 years after funding). As shown in *A4.6*, these results remain robust to GMM estimates. These medium-term effects appear to be indirect effects to some extent, as subsidies cause GDP growth that causes rising wages in the medium term *(see Figure 4.4)*

We conclude that the impact of GRW industry funding on wages is limited to high wages. Thus, GRW subsidies appear to increase wage inequalities within funded regions. At this point Oates' (1999) argument is not met, since mainly affluent employees seem to benefit from public redistributive policies.

Splitting up the sample into western and eastern regions, we observe that GRW effects on wages are much more often positive and several times higher in the eastern part than in the West (*Figure 4.6*). Since shocks are hold constant over both versions, the y-scales are comparable, although real GRW subsidies are much higher in the East. In the Western part of Germany significant medium-run effects can be found for top wages (90th percentile) (robust for GMM

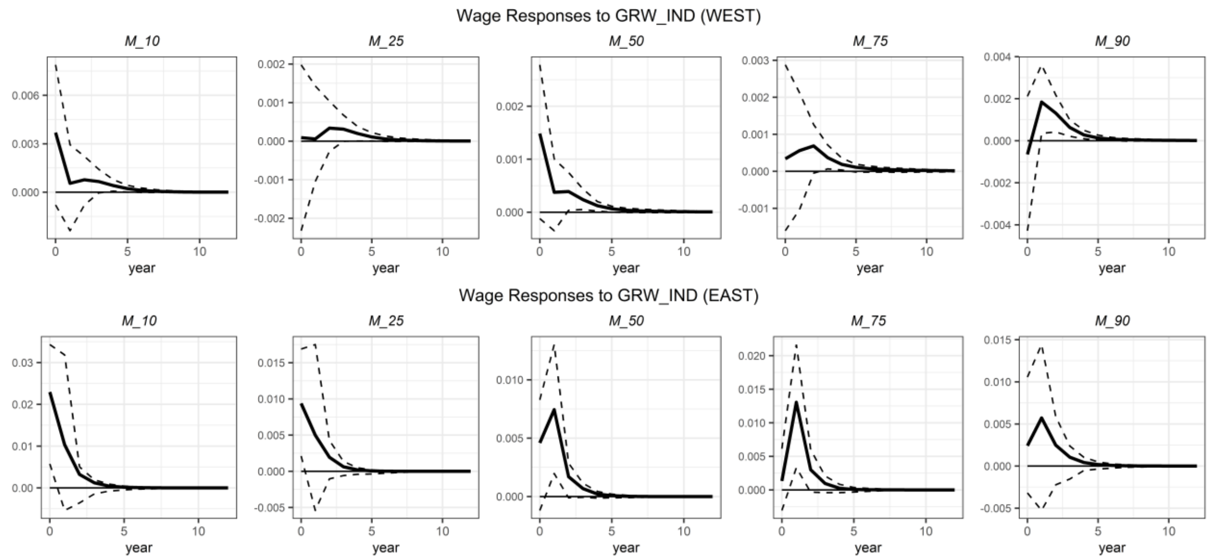


Figure 4.6: Impulse Responses of wage variables to GRW industry shocks in the Western and the Eastern subsample. Shock strength are hold constant to estimation with total sample. Specifications equal Figure 4.5

(A4.5)). However, the immediate effects are volatile, so that both are not necessarily significantly positive in total.

In contrast, we find significantly positive effects on all estimated quantiles except for top wages in the East, using both estimation techniques. It shows that wage responses to subsidies differ substantially between the East and the West. The effects on lower wages may be due to employment and productivity effects. Thus, GRW industry subsidies in the East have several positive effects on wages, indicating sustainable improvements in the labor market that do not occur in the subsidized Western regions. Surprisingly, we find no substantial differences between wage responses in the industry and the service sector, although this scheme aims at supporting firms in the industrial sector.

These results do not allow us to draw conclusions about the development of intraregional inequalities in the East. While short-term job creation due to GRW subsidies appears to support low-income jobs, GRW induced regional growth effects appear to support high-wages in a longer horizon. Thus, GRW industry subsidies do not reduce medium-term inequality growth.

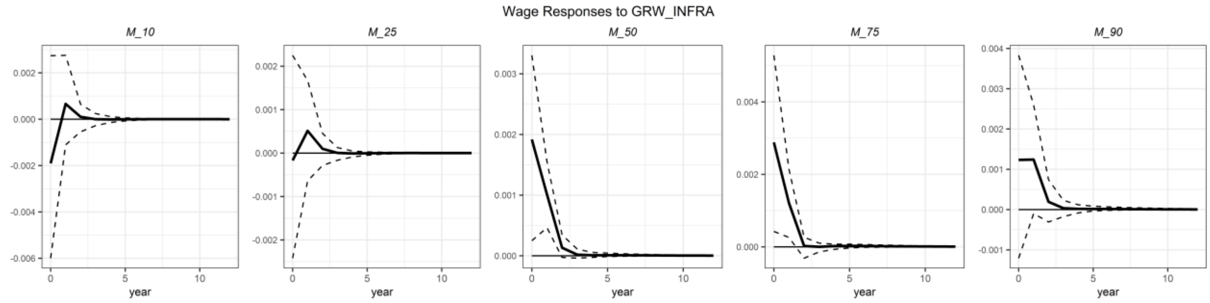


Figure 4.7: Impulse responses of wages to GRW Infrastructure shocks. Each response represents individual model estimations, thus shock. Model specifications remain constant except for the wage variable. Graph specifications equal Figure 4.4

4.6.3 Responses of wages to GRW infrastructure funding

As expected, wage responses to infrastructure subsidies differ from those to industry subsidies (Figure 4.7). There are no significant effects on wages below the median. Median wages and 75th percentile wages show a significant response to infrastructure subsidies, which also holds for GMM estimation (Figure A4.6, without significance for t=0). Top wages at the 90th do not respond significantly These effects could be explained by the observed growth in R&D employment, since we find neither employment nor productivity growth. Thus, the effects may indicate an upgrading of jobs towards more skill intensive positions, but not management positions.

Again, the wage effects of GRW infrastructure subsidies in the West differ substantially from those in the East (*Figure 4.8*). Wage responses to infrastructure subsidies in the West are not significant at all in the linear model, while wages at the 25th and 50th and 75th percentile in the East immediately respond significantly positive to GRW. Again the GMM check points to more volatile immediate relationships, but confirms a positive reaction to GRW subsidies in the East (also for the 10th percentile) *(Figure A4.7).*

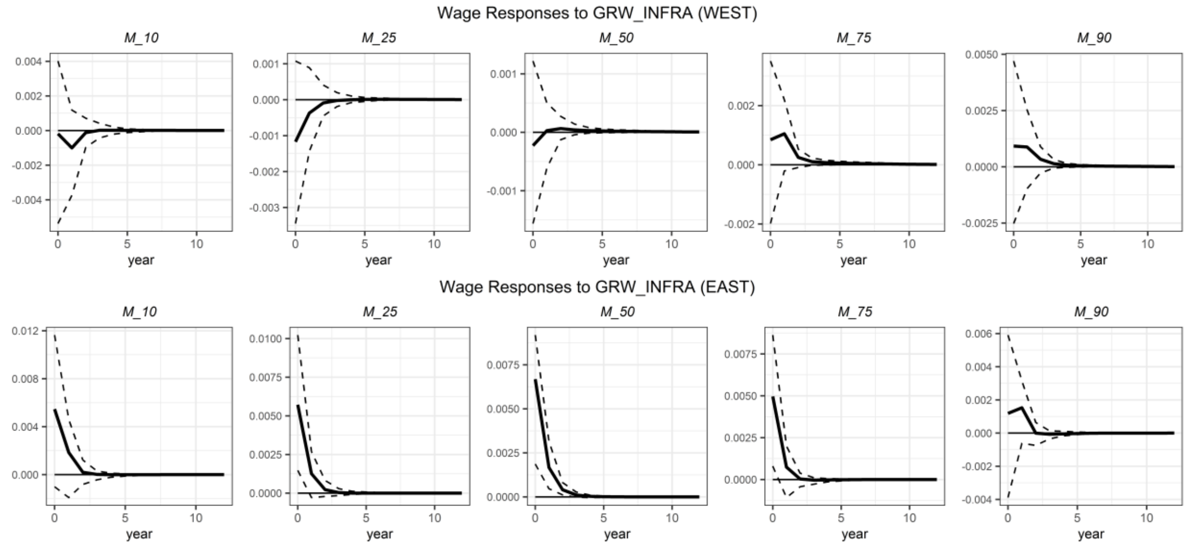


Figure 4.8: Impulse Responses of wage variables to GRW infrastructure shocks in the Western and the Eastern subsample. Shock strength are hold constant to estimation with total sample. Specifications equal Figure 4.4

Unlike for industrial funding, we find differences in wage responses between the production and service sector for infrastructure subsidies. For the production sector, we find no significant wage effects at all, neither in total, in the West, nor in the East. In contrast, we find that wage growth in the service sector due to GRW infrastructure subsidies seems to drive the observed effects *(Figure 4.9).* These results are robust in the GMM estimation *(A4.8).* We can conclude that infrastructure subsidies mainly affect wages in the service sector. This supports the hypothesis that growth due to GRW subsidies is mainly driven by R&D subsidies. Since these are wages around the median, we find that Oates' (1999) argument is neither met nor rejected in the case of infrastructure subsidies. However, as the effects are not accompanied by total GRW-induced productivity growth, it is not likely that these effects trickle-down to low-income workers over time.

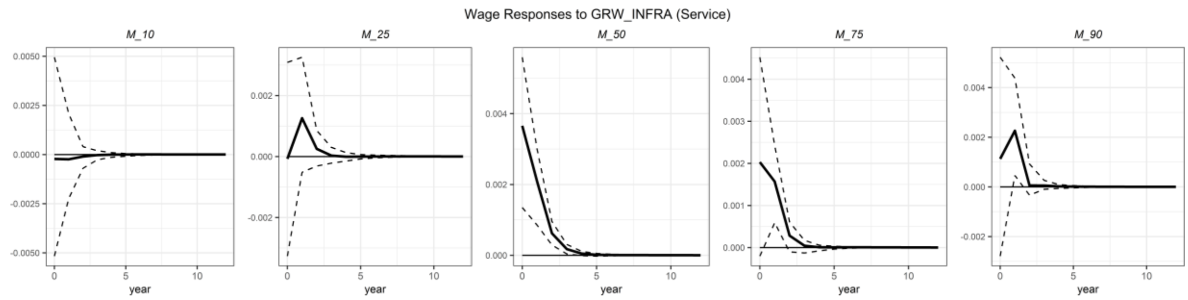


Figure 4.9: Impulse responses of Service sector wages to GRW infrastructure shocks. Shock strength are hold constant to estimation with total sample. Specifications equal Figure 4.5

4.7 Conclusion

The paper contributes to the evaluation of the economic effects of structural investment policies by drawing attention to wage responses to structural funds (GRW) in Germany. A SpVAR simultaneous equation model is applied to regional panel data for the 401 German county districts and independent cities in the period 2001- 2010 to examine causal effects of GRW subsidies. The model incorporates advanced theoretical representations of regional wage growth based on the wage equation from Blanchard and Katz (1997). Mutual responses to orthogonal shocks to variables in the regional economic system are illustrated in impulse response functions. This method allows the simultaneous estimation of multiple effects on the regional economies and the inclusion of indirect effects and interdependencies between variables. For instance, consistent with studies by Schalk and Untiedt (2003), von Ehrlich and Seidel (2015) and Dettmann et al. (2017), we find employment growth as a consequence from subsidies in the GRW industry subsidies, which may result from mandatory job creation within the funding scheme.

We find, however, that these growth effects do not lead to significant overall wage growth, but to wage growth that is limited to certain quantiles of the wage distribution, to specific funding schemes, and to certain regions and sectors. While industry subsidies appear to support more affluent employees especially in the wealthier West, effects of the infrastructure subsidies are limited to East Germany, mainly in the medium range of the wage distribution. We find that skill-intensive services in particular seem to benefit from infrastructure subsidies, although GRW has a general focus on the industrial sector. Thus, infrastructure subsidies seem to contribute to structural change in industrially dominated regions that face structural difficulties. Moreover, these findings somehow contradict the growth and employment effects that are found by many studies (and also true for the infrastructure scheme in this study). This could be due to wage rigidities, as wages are not as volatile as economic growth and are fixed by contracts, which decouples their short-term development from single funding or productivity enhancing events and may only appear due to long-term stable productivity growth on firm level, which would require a more advanced lag-strucure in the estimation system to be identified. Extending the model to better capture long-term effects would make it even more complex, but could be an interesting further research on this topic. To gain more detailed insights into this dynamics, future research could also compare wage effects in different economic sectors to explain the found relationship between infrastructure funding and wages in the service sector, or focus on other inequality measures such as the Gini coefficient.

While this study concentrates on economic effects in Germany, it seems reasonable that its results provide a relevant contribution to the general discussion of effects from similar regional investment policies such as the closely related European Regional Development Fund, even though a generalization is inadmissible without examination on the European level.

4.8 References

Acemoglu, D. & Autor, D. (2011). Skills, Tasks and Technologies: Implications for Employment and Earnings. In: Ashenfelter, O. and Card, D. (eds.), *Handbook of Labor Economics*. Elsevier, pp. 1043-1171.

Afonso, O., Albuquerque, A. & Almeida, A. (2013). Wage inequality determinants in European Union countries. *Applied Economics Letters*, 20, 1170-1173. DOI: 10.1080/13504851.2013.797551.

Alecke, B., Mitze, T. & Untiedt, G. (2013). Growth effects of regional policy in Germany: Results from a spatially augmented multiplicative interaction model. *The Annals of Regional Science*, 50, 535–554, DOI: 10.1007/s00168-012-0503-7.

Alecke, B. & Untiedt, G. (2007). Makroökonometrische Untersuchungen zu den Wirkungen für die Ausgleichs- und Wachstumsregionen. In: Institut für Wirtschaftsforschung Halle (Ed.), *Interregionale Ausgleichspolitik in Deutschland: Untersuchungen zu den Effekten ausgewählter Systeme zur Herstellung von "gleichwertigen Lebensverhältnissen"*, Halle (Saale), pp. 82-99.

Antonczyk, D., DeLeire, T. & Fitzenberger, B. (2018). Polarization and Rising Wage Inequality: Comparing the U.S. and Germany. *Econometrics, MDPI,* 2018, 6, 1-33. DOI: 10.3390/econometrics6020020.

Barca F. (2009). An agenda for a reformed Cohesion Policy. Independent report prepared at the request of Danuta Hübner, the Commissioner for Regional Policy, April 2009.

Beenstock, M. & Felsenstein, D. (2007). Spatial vector autoregressions. Spatial Economic Analysis, 2, 167-196. DOI: 10.1080/17421770701346689.

Berg, A., Ostry, J. & Zettelmeyer, J. (2012), What makes growth sustained? *Journal of Development Economics,* 98, 149-166. DOI: 10.1016/j.jdeveco.2011.08.002.

Biewen; M. & Seckler, M. (2019). Unions, Internationalization, Tasks, Firms, and Worker Characteristics: A Detailed Decomposition Analysis of Rising Wage Inequality in Germany. *The Journal of Economic Inequality*, 17, 461-498. DOI: 10.1007/s10888-019-09422.

Binder, M., Hsiao, C. & Pesaran, M. (2005). Estimation and Inference in Short Panel Vector Autoregressions with Unit Roots and Cointegration. *Econometric Theory*, 21,795-837.

Blanchard, O. & Katz, L. (1997). What We Know and Do Not Know about the Natural Rate of Unemployment. *Journal of Economic Perspectives,* 11, 51-72. DOI: 10.1257/jep.11.1.51.

Blanchflower, D. & Oswald, A. (1994). Estimating a Wage Curve for Britain 1973 - 1990. *The Economic Journal,* 104, 1025-1043. DOI: 10.2307/2235062.

Binder, A. & Choi, D. (1990). A Shred of Evidence on Theories of Wage Stickiness. *The Quarterly Journal of Economics*, 4, 1003-1015.

Brachert, M., Dettmann, E. & Titze, M. (2019). The regional effects of a place-based policy – Causal evidence from Germany. *Regional Science and Urban Economics*, 79, 1-17. DOI: 10.1016/j.regsciurbeco.2019.103483.

Brachert, M., Dettmann, E. & Titze, M. (2018), Public Investment Subsidies and Firm Performance – Evidence from Germany. *Journal of Economics and Statistics*, 238, 103-124. DOI: 10.1515/jbnst-2017-0131.

Bräuninger, M. & Pannenberg, M. (2002). Unemployment and productivity growth: An empirical analysis within an augmented Solow model. *Economic Modelling*, 19, 105-120. DOI: 10.1016/S0264-9993(00)00065-1.

Busso, M., Gregory, J. & Kline, P. (2013). Assessing the Incidence and Efficiency of a Prominent Place Based Policy. *American Economic Review*, 103, 897-947. DOI: 10.1257/aer.103.2.897.

Card, D., Heining, J. & Kline, P. (2013). Workplace Heterogeneity and the Rise of West German Wage Inequality. *The Quarterly Journal of Economics*, 128, 967-1015. DOI: 10.1093/qje/qjt006.

Cieślick, A. & Rokicki, B. (2017). EU structural interventions and individual wages in Poland: Empirical evidence for 2004–2006 financial framework. *Regional Science Policy & Practice,* 9, 202-217. DOI:10.1111/rsp3.12100

Crihfield, J. B., Giertz, J. F. & Mehta, S. (1995). Economic growth in the American states: The End of convergence? *The Quarterly Review of Economics and Finance*, 35, 551-577. DOI: 10.1016/1062-9769(95)90054-3.

Criscuolo, C. Martin, R., Overman, H. & van Reenen, J. (2018). Some Causal Effects of an Industrial Policy. *American Economic Review,* 109, 48-85. DOI: 10.1257/aer.20160034.

Dabla-Norris, E., Kochhar, K., Suphaphiphat, N., Ricka, F. & Tsounta, E. (2015). Causes and Consequences of Income Inequality: A Global Perspective. *IMF Staff Discussion Note*, Strategy, Policy, and Review Departement, IMF, Washington, DC.

Dettmann, E., Titze, M. & Weyh, A. (2017). Who Benefits from GRW? Heterogeneous Employment Effects of Investment Subsidies in Saxony Anhalt. *IWH Discussion Papers*, 27/2017, Halle/Saale.

Deutscher Bundestag (2014). Koordinierungsrahme der Gemeinschaftsaufgabe „Verbesserung der regionalen Wirtschaftsstruktur“ ab 1. Juli 2014. Deutscher Bundestag, 18. Wahlperiode, Drucksache 18/2200, Berlin.

Di Giacinto, V. (2010). On vector autoregressive modelling in space and time. *Journal of Geographical Systems*. 12, 125–154. DOI: 10.1007/s10109-010-0116-6.

Diener, E., Emmons, R. A., Larsen, R. J. & Griffin, S. (1985). The Satisfaction With Life Scale. *Journal of Personality Assessment*, 49, 71-75. DOI: 10.1207/s15327752jpa4901_13.

Dijkstra, L., Poelman, H. & Rodríguez-Pose, A. (2020). The geography of EU discontent, *Regional Studies*, 54, 737-753. DOI: 10.1080/00343404.2019.1654603.

Dustmann, C., Ludsteck, J. & Schönberg, U. (2009). Revisiting the German Wage Structure, *The Quarterly Journal of Economics*, 124, 843–881, DOI: 10.1162/qjec.2009.124.2.843.

Easterlin, R. (1974). Does Economic Growth Improve the Human Lot? in: P. David & M. Reder, (Ed.). *Nations and Households in Economic* Growth: Essays in Honor of Moses Abramovitz. Academic Press, New York, pp. 89-126.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98: 701-735. DOI: 10.1111/pirs.12373.

Eckey, H.-F. & Kosfeld, R. (2005). Regionaler Wirkungsgrad und räumliche Ausstrahlungseffekte der Investitionsförderung. *Jahrbuch für Regionalwissenschaft*, 25, 149-173.

Egger, P., Eggert, W. & Larch, M. (2014). Structural Operation and Net Migration Across European Union Member Countries. *Review of International Economics*, 22, 352-378, DOI:10.1111/roie.12112.

Elhorst, J. P. (2012). Dynamic Spatial Panels: Models, Methods, and Inferences. *Journal of Geographical Systems,* 14, 5-28. DOI: 10.1007/s10109-011-0158-4.

Ferrara, A., Dijkstra, L., McCann, P. & Nisticò, R. (2020). The Response of Regional Well-Being to EU Cohesion Policy Interventions. *SSRN Working Paper*. DOI: 10.2139/ssrn.

Harris, M. & Holmstrom, B. (1982). A Theory of Wage Dynamics. *The Review of Economic Studies,* 49, 315-333.

Holtz-Eakin, D., Newey, W. & Rosen, H.S. (1988). Estimating Vector Autoregressions with Panel Data. Econometrica, 56, 16371-1395.

Hortas-Rico, M. & Rios, V. (2019). The drivers of local income inequality: a spatial Bayesian model-averaging approach. *Regional Studies,* 53, 1207-1220, DOI: 10.1080/00343404.2019.1566698.

Hsiao C., Pesaran, M. & Tahmiscioglu, A. (2002). Maximum likelihood estimation of fixed effects dynamic panel data models covering short time periods. *Journal of Econometrics*, 109, 107–150. DOI: 10.1016/S0304-4076(01)00143-9.

Im, K. S., Pesaran, M. H. & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics,* 115, 53–74. DOI: 10.1016/S0304-4076(03)00092-7.

Kiviet, J. F. (1995). On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. *Journal of Econometrics,* 68, 53-78. DOI: 10.1016/0304-4076(94)01643-E.

Kohler, K., Guchanski, A. & Stockhammer, E. (2019). The impact of financialisation on the wage share: a theoretical clarification and empirical test. *Cambridge Journal of Economics*, 43, 937-974.

Lin, K. & Tomaskovic-Devey, D. (2013). Financialization and U.S. Income Inequality 1970–2008. *American Journal of Sociology*, 118, 1284-1329. DOI: 10.1086/669499.

Lütkepohl, H. (2005). *New introduction to multiple time series analysis.* Berlin: Springer.

Mankiw, N. G., Romer, D. & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107, 407-437. DOI: 10.2307/2118477.

Mitze, T., Paloyo, A. R. & Alecke, B. (2015). Is there a purchase limit on regional growth? A quasi-experimental evaluation of investment grants using matching techniques. *International Regional Science Review,* 38, 388-412. DOI: 10.1177/0160017613505200.

Mitze, T., Schmidt, T. D., Rauhut, D. & Kangasharju, A. (2018). Ageing shocks and short-run regional labour market dynamic in a spatial panel VAR approach. *Applied Economics*, 50, 870-890. DOI: 10.1080/00036846.2017.1346360.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica* 49, 1417-1426. DOI: 10.2307/1911408.

Oates, W. (1999). An Essay on Fiscal Federalism. Journal of Economic Literature, 37, 1120-1149. DOI: 10.1257/jel.37.3.1120.

Ostry, J., Berg, A. & Tsangarides, C. (2014). Redistribution, Inequality and Growth. *IMF Staff Discussion Note,* International Monetary Fund, Washington DC.

Rhoden I. (2016*). Econometric Analysis of Regional Productivity Convergence in Germany from 2000 to 2012.* Bochum: Universitätsverlag Brockmeyer, Ruhr-Forschungsinstitut für Innovations- und Strukturpolitik e.V. (RUFIS) Nr. 2/2016.

Rickman, D. S. (2010). Modern macroeconomics and regional economic modeling. *Journal of Regional Science*, 50, 23-41. DOI: 10.1111/j.1467-9787.2009.00647.x..

Rodriguez-Pose, A. & Tselios, V. (2009). Education and income inequality in the regions of the European Union. Journal of Regional Science, 49, 411–437. DOI: 10.1111/j.1467-9787.2008.00602.x..

Röhl, K.-H. & von Speicher, P. (2009). Ostdeutschland 20 Jahre nach dem Mauerfall: Ist die Investitionsförderung Triebfeder von Industriewachstum und regionaler Entwicklung? Köln: *IW–Positionen – Beiträge zur Ordnungspolitik aus dem Institut der deutschen Wirtschaft Köln Nr 41.*

Schalk, H. J. & Untiedt, G. (2000). Regional investment incentives in Germany: Impacts on factor demand and growth. *The Annals of Regional Science*, 34, 173-195. DOI: 10.1007/s001689900008.

Schwellnus, C., Kappeler, A. & Pionnier, P. (2017). The Decoupling of Median Wages from Productivity in OECD Countries. *International Productivity Monitor*, 32, 44-60.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica,* 48, 1-48.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70, 65–94. DOI:/10.2307/1884513.

Topel, R. (1994). Regional Labor Markets and the Determinants of Wage Inequality. *American Economic Review*, 84, 17-22.

von Ehrlich, M. & Seidel, T. (2015). The persistent effects of place-based policy: Evidence from the West-German Zonenrandgebiet. *CESifo Working Paper No. 5373.*

Wilkinson, R. & Pickett, K. (2009). Income Inequality and Social Dysfunction. *Annual Review of Sociology,* 35, 493-511. DOI: 10.1146/annurev-soc-070308-115926.

A4. Appendix

Table A4.1: Test results for Im-Pesaran-Shin Unit-Root Test

Acronym	Test-statistic (Wtbar)	p-value
GRW_IND	-18.847	0.000
GRW_INFRA	-13.535	0.000
INVQ	-24.54	0.000
IND_S	-11.61	1.000
IND_S_DET	-29.19	0.000
EDU	37.33	1.000
EDU_DET	-30.95	0.000
R&D	-5.87	0.000
EMPL	4.31	1.000
EMPL_DET	-26.27	0.000
GDP	14.30	1.000
GDP_DET	-34.05	0.000
WAGE_M10	-5.68	0.000
WAGE_M10_DET	-27.82	0.000
WAGE_M25	-5.67	0.000
WAGE_M25_DET	-39.38	0.000
WAGE_M50	10.16	1.000
WAGE_M50_DET	-40.16	0.000
WAGE_M75	19.05	1.000
WAGE_M75_DET	-39.13	0.000
WAGE_M90	24.93	1.000
WAGE_M90_DET	-36.86	0.000

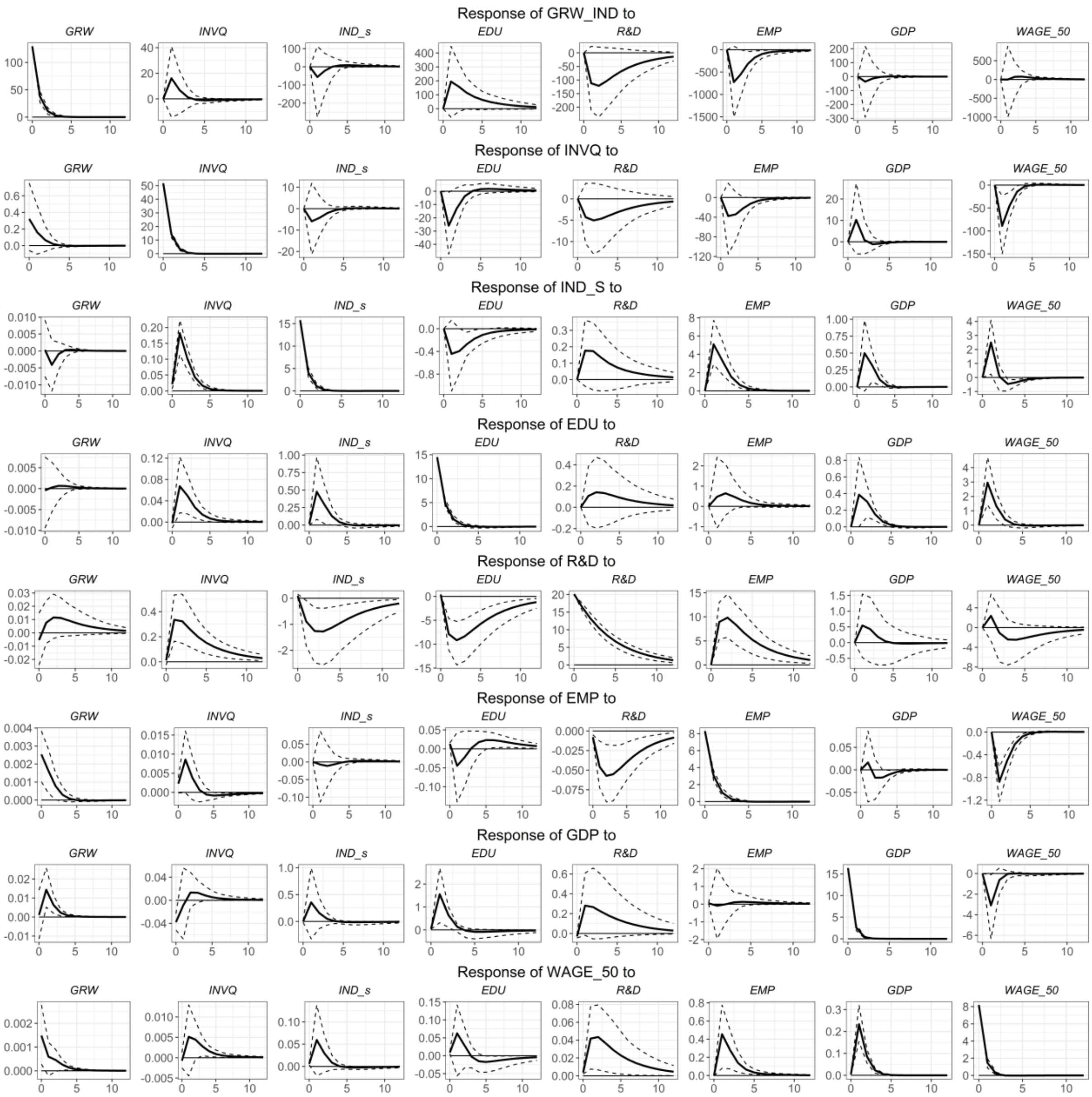
Notes: Im-Pesaran-Shin-Test for unit roots in Panel data as in Im, Pesaran, Shin (2005). Alternative hypothesis: Stationarity. For GRW_IND amd GRW_INFRA: Only regions that received GRW subsidies are tested.

***Table A4.**2: Panel Granger Causality Test (lag =1)*

:COLUMN: GRANGER CAUSES :ROW:	GRW_IND		GRW_INFRA		INVQ		IND_S_DET		EDU_DET		R&D		EMPL_DET		GDP_DET		WAGE_M50	
	value	p-value	*value*	*p-value*	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value	value	p-value
GRW_IND	x	x	-	-	0.97	0.33	1.77	0.08	-1.13	0.26	1.93	0.05	0.38	0.70	-0.38	0.70	-0.09	0.93
GRW_INFRA	-	-	x	x	0.22	0.83	-0.89	0.37	-0.40	0.68	0.83	0.41	-0.27	0.78	-0.58	0.56	-0.57	0.57
INVQ	-0.81	0.42	3.46	0.00	x	x	1.81	0.07	1.86	0.06	2.55	0.01	3.34	0.00	4.12	0.00	4.35	0.00
IND_S_DET	0.14	0.89	0.29	0.77	3.33	0.00	x	x	5.40	0.00	1.97	0.00	9.99	0.00	11.27	0.00	5.63	0.00
EDU_DET	0.52	0.60	-0.03	0.97	6.63	0.00	6.14	0.00	x	x	7.59	0.00	14.98	0.00	5.46	0.00	9.95	0.00
R&D	-0.09	0.92	0.18	0.86	1.86	0.06	2.03	0.04	2.23	0.02	x	x	6.35	0.00	3.25	0.00	3.22	0.00
EMPL_DET	1.77	0.07	0.86	0.39	5.42	0.00	4.71	0.00	4.52	0.00	15.95	0.00	x	x	-.04	0.96	13.91	0.00
GDP_DET	-0.18	0.86	1.97	0.04	3.91	0.00	9.74	0.00	7.10	0.00	-0.90	0.37	9.63	0.00	x	x	24.51	0.00
WAGE_M50_DET	1.08	0.28	-0.10	0.92	1.07	0.28	9.16	0.00	14.06	0.00	0.94	0.34	24.33	0.00	3.81	0.00	x	x

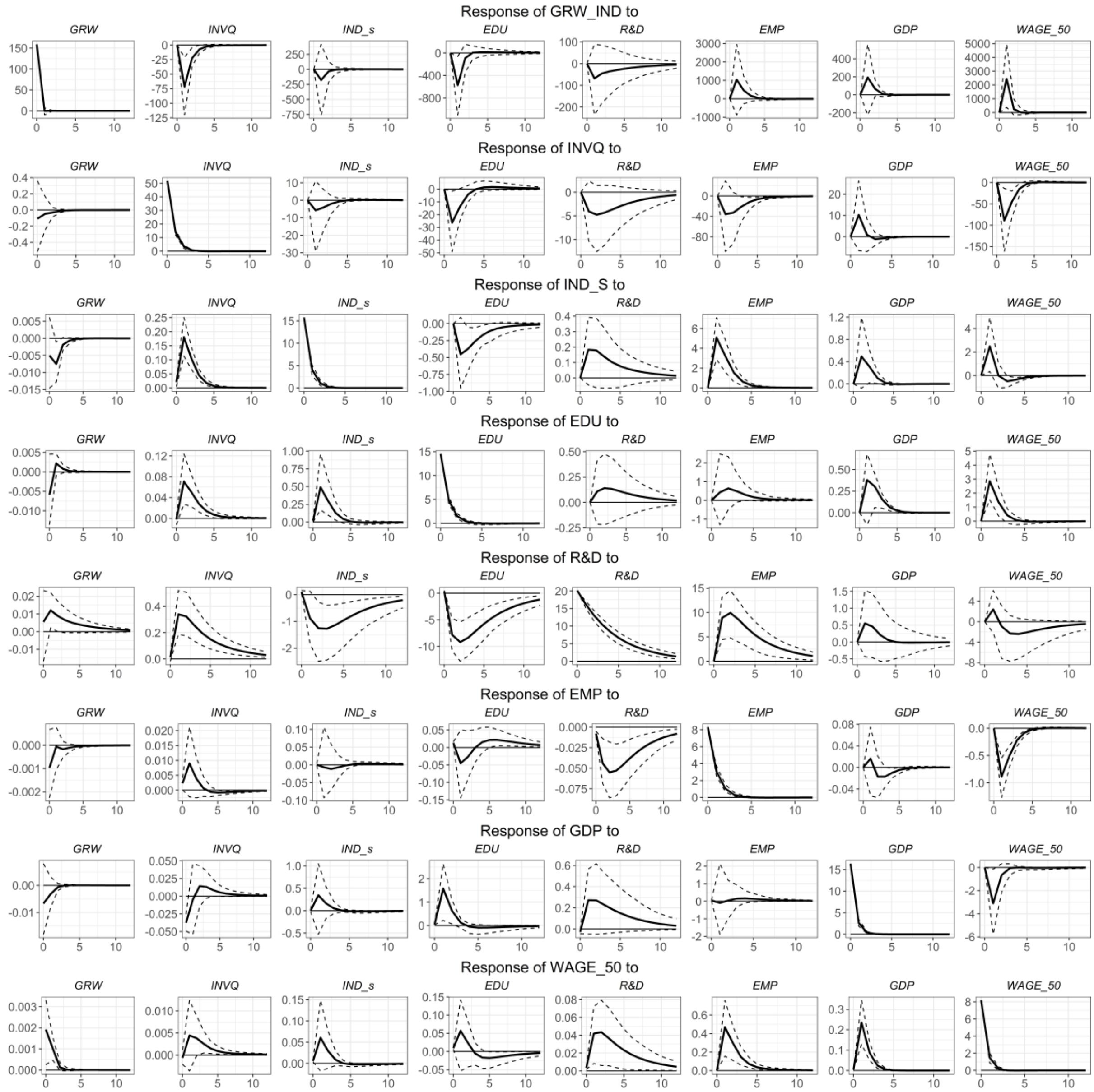
Note: Granger Causality Test is performed for every region, test as given in Dumitrescu &Hurlin (2012)
Alternative hypothesis = Granger causality given for at least one region
For GRW_IND amd GRW_INFRA: Only regions that received GRW subsidies are tested.

Figure A4.1: Full set of IRFs with GRW Industry subsidies (GRW_IND) and median wages (WAGES_M_50).



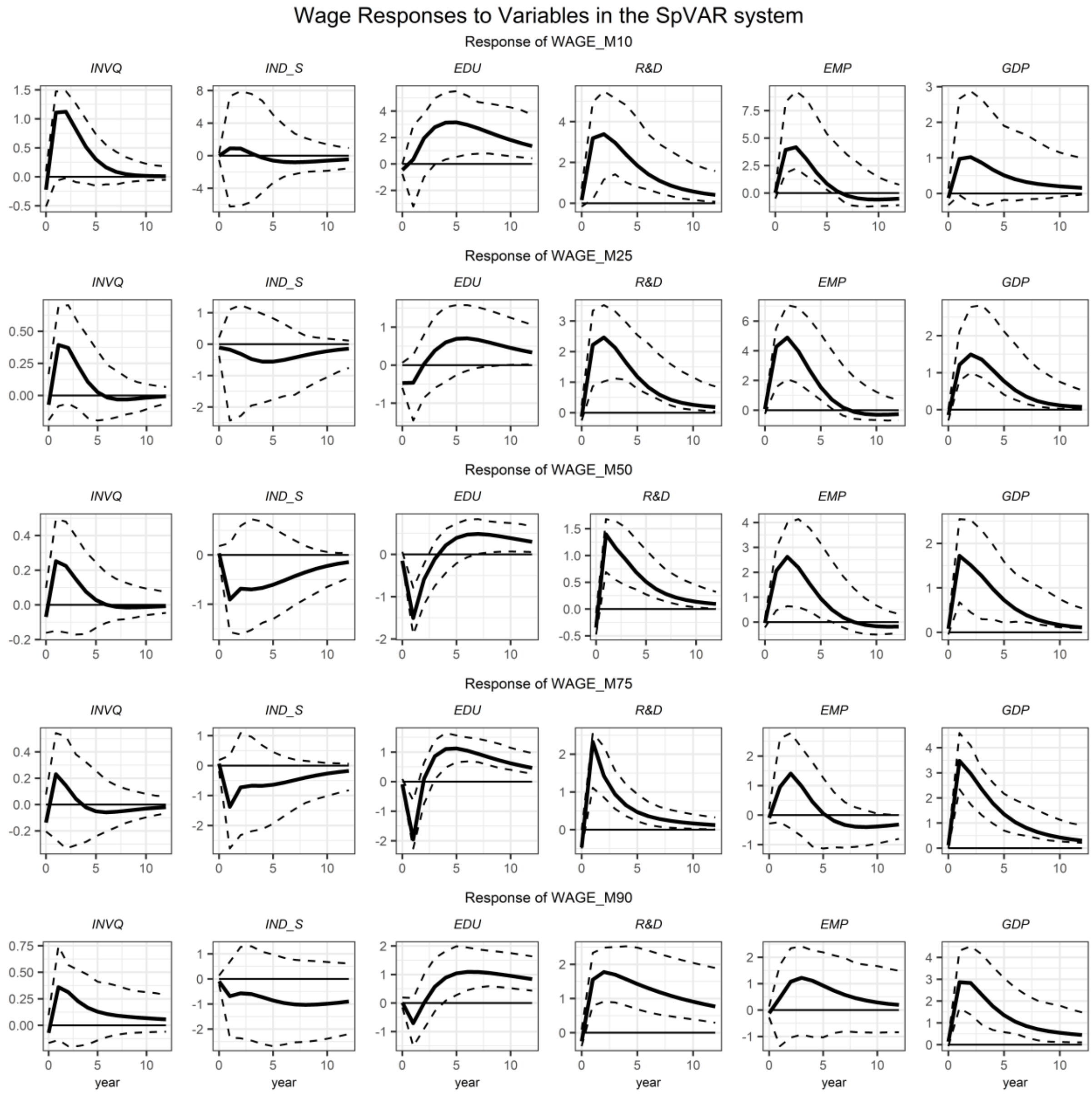
Notes: Impulse response Functions (IRFs) of Wage variables to isolated shocks in other variables in the SpVAR systems with linear fixed effects estimations. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %.

Figure A4.2: Full set of IRFs with GRW Infrastructure inputs (GRW_INFRA) and median wages (WAGES_M_50).



Note: Graph specifications equal Figure A4.1

Figure A4.3: Wage responses to variables in the SpVAR system with GMM estimations

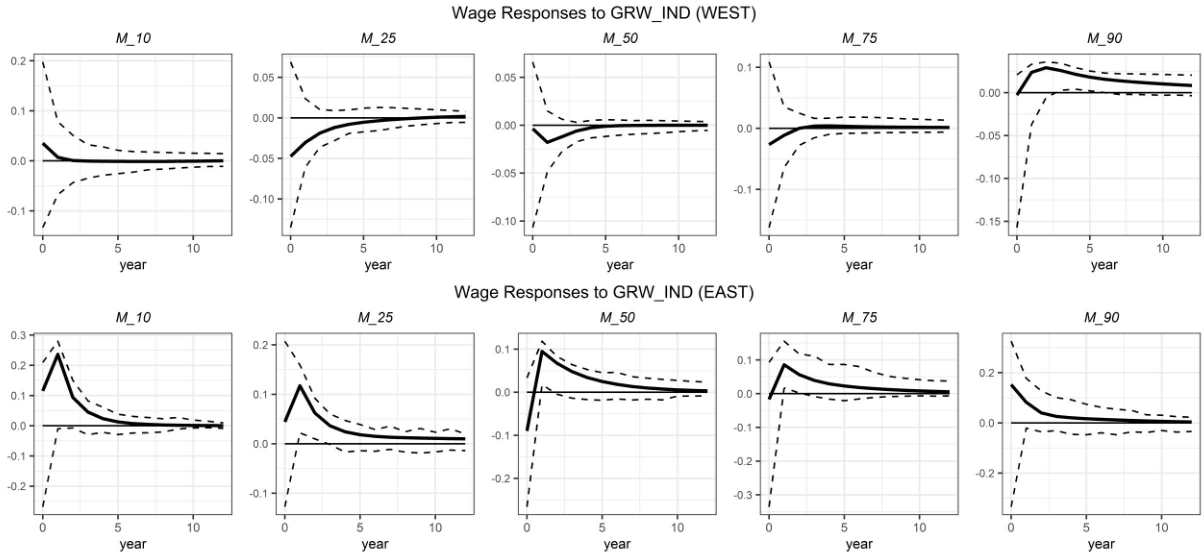


Note: This Figure is the robustness check to Figure 4.4, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.4.

Figure A4.4: Wage responses to GRW Industry subsidies with GMM estimations

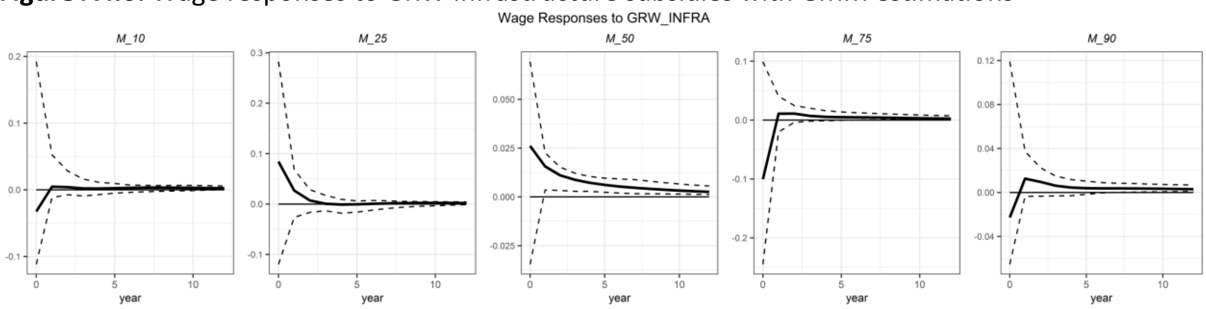
Note: This Figure is the robustness check to Figure 4.5, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.5.

Figure A4.5: Wage responses to GRW Industry subsidies in Eastern and Western subsample with GMM estimations



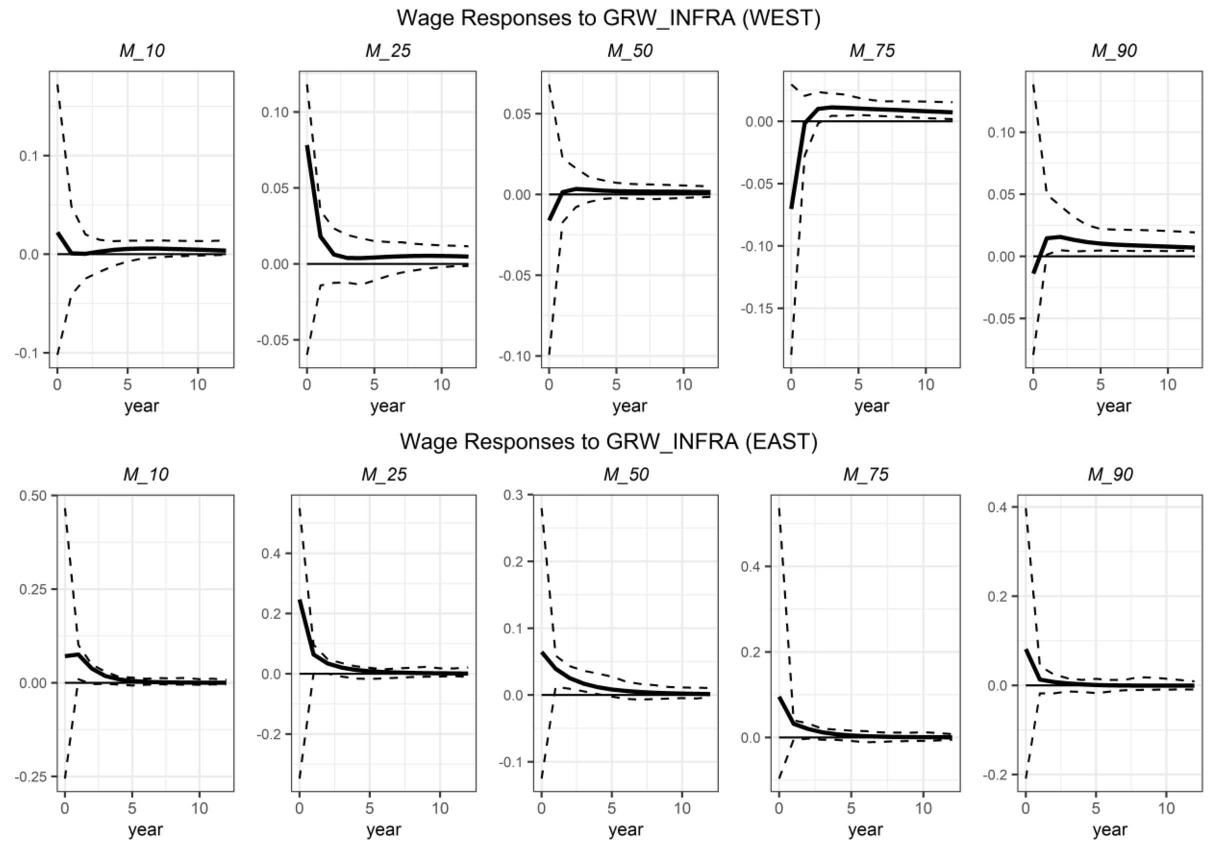
Note: This Figure is the robustness check to Figure 4.6, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.6.

Figure A4.6: Wage responses to GRW Infrastructure subsidies with GMM estimations



Note: This Figure is the robustness check to Figure 4.7, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.7.

Figure A4.7: Wage responses to GRW Infrastructure subsidies in the Western and Eastern subsample with GMM estimations



Note: This Figure is the robustness check to Figure 4.8, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.8.

Figure A4.8: Wage responses in the service sector to GRW Infrastructure subsidies with GMM estimations

Note: This Figure is the robustness check to Figure 4.9, using GMM estimations as given in Section 4.5. Specifications equal Figure 4.8.

5. Analyzing the spatio-temporal diffusion of economic change – advanced statistical approach and exemplary application

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Notes: This paper was submitted for publication in Spatial Economic Analysis (22.12.2020). The paper is co-authored by Thomas Brenner.

Abstract: This article presents a spatio-temporal panel vector-autoregressive approach (SptpVAR) as an extended spatial econometric method for analyzing spillover effects of regional economic change in time and space. The approach aims to extend the spatial dimension of SpVAR models by capturing the overall cross-regional spillover dynamics over time through additional estimations of effects into neighboring regions and backward spillover to the source region. By showing how local economic dynamics trigger spillover dynamics in economically linked regions, the results are of particular interest to policy makers. To demonstrate the functioning of the SptpVAR approach, it is applied to 361 German regions using a regional growth model and a regional panel data set in the time-period 2000-2017 in an exemplary application.

Keywords: Economic dynamics, Spatial spillover, Spatial econometrics, SpVAR

JEL classification: C33, O40, R12, R23

5.1. Introduction

Regional sciences face growing interest in applied spatial econometrics and interest in spatial data analysis tools. Especially the analysis of economic spillover and externalities across regional units is an important topic to understand the spatial dynamics of economic systems. Simultaneously, dynamic flexible vector-autoregressive panel models (pVARs), as one of many methods, have become an essential tool in the empirical analysis of economic systems with interrelated variables and estimation of responses to exogenous shocks, such as economic policy interventions. Although cutting-edge pVAR models are referred to as spatial panel VARs (SpVAR), these models provide scope for improvement in the integration of cross-regional interdependencies among variables and the spatial dissemination of economic effects in neighboring or economically linked regions (e.g. the models of Beenstock & Felsenstein 2007, Mitze et al.; 2018, Eberle et al., 2019). Local economic growth shocks cause spatial externalities in economically linked regions due to various transmission channels that affect the mobility of production factors, such as technology and knowledge diffusion, commuting, or cross-border trade. Thus, effects from a single economic shock can disseminate in space by causing multiplicative effects.

The used SpVAR approaches fall short to capture the complete spatiotemporal dynamics for two reasons: First, only direct spatial effects from neighboring regions to the analyzed region are considered (so-called in-spillover), neglecting economic linkages with larger geographic distance. Second, in most of these cases spatial effects are only used to avoid statistical biases caused by spatially autocorrelated error terms. Further spatial effects over time are usually not analyzed (an exception is Wardenburg & Brenner, 2020). This is somewhat inconsistent, because the SpVAR approaches considers indirect effects among the variables included, meaning the effects from one variable to another and from this variable to a third variable and from there back to the first variable are included in the analysis, while effects to the neighboring region and feedback effects into the initial region are not examined. The reason for this shortcoming in the literature can be found in the complexity of spatial spillover. On the one hand, the spatial structure allows for a large variety of third-order and higher spillover effects. On the other hand, the spillover effects strongly depend on the type of regions involved. In principle, a complete analysis of spatial spillover would require to consider each region with its specific characteristics and neighbors separately, which would imply separate regressions for each region, which usually is not statistically possible without increasing the number of observations.

The purpose of this paper is to develop an approach that is able to capture and analyze spatial spillover processes as far as possible within a rather general statistical approach, integrate them into the resulting impulse response functions (IRFs) and estimate the spatial expansion of regional economic shocks over neighboring and economically linked regions. To this end the SpVAR approach is extended to include the spatial dissemination of local economic shocks over time while considering regional heterogeneity in region types and economic structure. To demonstrate the functioning of the approach, it is applied to the economic development in German regions. The assessment of spatial effects is of particular importance for regional policy makers, since it is important to know how economic policy measures for one region affect other regions.

Using German regional panel data in the time-period 2000 to 2017, we use our recursive SptpVAR to analyze the spatio-temporal dissemination of economic changes, especially local labor demand shocks and productivity growth. The study focusses on the extent to which both variables affect economic development in economically connected regions. A specific interest in this paper is in supra-regional labor market migration in reaction to local economic shocks, that has an intrinsic spatial dimension.

The remainder of the paper succeeds as follows. Section 2 presents the theory on spatial interdependent growth models and cross-regional spillover dynamics as well as spatial VAR models. Section 3 introduces our SptpVAR framework strategy and exemplary data and variables. The empirical results are presented in section 4. Section 5 concludes with a summary.

5.2. Theoretical background

As it is widely shown in theoretical and empirical works, the economic development of countries, regions or cities depends to a certain extend on economic processes within nearby regions or countries due to growth spillover and cross-regional interdependencies (e.g. Ertur & Koch, 2007; Grossmann & Helpman, 1991; Howitt, 2000; Rey & Janikas, 2005; Rey & Montouri, 1999). From an observer's perspective this can be seen in historical examples such as the spatiotemporal dissemination of the industrial revolution across England and Europe, but also in the present co-movement in business cycles of neighboring and economically linked regions (Montoya & de Haan, 2008).

Multi-country growth models explaining spatially interdependent growth by considering cross-unit spillover have been developed in endogenous as well as neoclassical settings. Endogenous growth models that emphasize the role of knowledge and innovation spillover as source of spatially interdependent technological progress are more common (Coe & Helpman, 1995; Ertur & Koch, 2011; Grossmann & Helpman, 1991; Howitt, 2000; Howitt & Mayer-Foulkes, 2005). Basile and Usai (2015) provide a summary on these models. Nevertheless, for the basic mechanisms in our application we build on a neoclassic model that considers the spatial effects of technology and knowledge diffusion and the mobility of further production factors, such as workers that contribute to spatial interdependencies between regions.

5.2.1. Spatial growth models

Neoclassic regional growth models build on the Solow-Modell, which explains regional growth of a closed market as a function of Capital (K), Labor (L) and Technology (A) (Solow, 1956). Borts and Stein (1964) advanced this model to the first regional growth model allowing for spatial spillover.

Following Lopez-Bazo et al. (2004) who extend the common neoclassical growth model from Mankiw et al. (1992) by including cross-regional spatial spillover that are mainly caused by technological diffusion, we start with formulating the labor productivity in a simple regional economy *i* in period *t* as:

$$y_{it} = A_{it} k_{it}^{\tau_k} h_{it}^{\tau_h}, \tag{5.1}$$

where k and h are physical and human capital per labor unit and τ_k and τ_h are internal returns to both factors, determined by population growth, technology growth and depreciation rate (Lopez-Bazo et al., 2004). The spatial dimension is integrated trough spatial technology and knowledge diffusion. Thus, A_{it} depends on the technological level of neighboring regions, which, in turn, depends on physical and human capital intensity in this regions. So A_{it} is defined as:

$$A_{it} = \Delta_t (k_{\rho it}^{\tau_k} h_{\rho it}^{\tau_h})^{\gamma}, \tag{5.2}$$

with the exogenous component Δ_t that is assumed to be constant over regions and $k_{\rho it}$ and $h_{\rho it}$ denoting the physical and human capital ratios in neighbor regions while γ measures the strength of externalities across regions (Lopez-Bazo et al., 2004). Combining (5.1) and (5.2), it becomes clear that a region's steady state labor productivity and growth rate depend on capital investments within the region and in its neighbors. Thus, labor productivity in a region profits from investments in neighboring regions, even without own investments. In consequence, regional growth systems cannot be analyzed without incorporating spatial interdependencies. Similar to Mankiw et al. (1992), physical and human capital growth within a region is a function of regional capital accumulation, population and technology growth and depreciation rate. Additionally, due to decreasing returns to capital, investment rates are a decreasing function of capital stocks, while it is an increasing function of capital stocks in neighboring regions due to externalities across economies, which makes investments more profitable in regions surrounded by regions with high capital intensity (Lopez-Bazo et al. 2004). The authors conclude, that the initial conditions for regional growth within a region equal the ones in Mankiw et al (1992), while externalities across regions cause that growth to depend on the initial productivity and growth rates in their neighbors. As a consequence, the growth rates of two identical economies with identical preconditions may differ if preconditions in their neighbors differ (Lopez-Bazo et al., 2004). The authors argue that spillover do not accelerate the convergence rate across regions as they are a function of parameters within each economy, while persistent inequalities are intensified by more intensive knowledge diffusion among neighboring strong economies (Lopez-Bazo et al., 2004). In addition, Pfaffermayr (2009) points out, that knowledge and innovation advantages affect neighboring regions first, but become global within time due to spatial diffusion.

Ertur and Koch (2007) develop a similar spatially augmented growth model based on the Solow-Model (Solow, 1956) with technological interdependence with similar theoretical assumptions as Lopez-Bazo et al. (2004). In their model, a region's steady state real income per worker depends positively on the region's saving rate and negatively on population growth. The same applies for savings and population growth in neighboring regions due to spatial externalities and technological interdependence.

5.2.2. Factor mobility spillover effects

Both the models of Lopez-Bazo et al. (2004) and Ertur and Koch (2007) focus on knowledge and technological spillover as the only factors that are able to cross regional borders. Pecuniary production factors are still handled as closed economies, ignoring capital and labor mobility and other spillover that have direct impact on the regional steady state by affecting physical and human capital intensity as well as regional population growth (Pfaffermayr, 2012). We argue, that this should also be considered in analyzing spatial growth systems.

Capello (2009) identifies three major categories of spatial spillover: Knowledge spillover, industry spillover and growth spillover, pointing out that cross-regional interdependencies are not limited to knowledge spillover. Industry spillover, that may include knowledge spillover, occur on firm level within related industries, if linked firms benefit from value or productivity gains of dynamic, usually large firms without direct compensation through input or output linkages (Barrios et al. 2003). Growth spillover in the most general form summarize all types of growth transmissions between related regions, including knowledge and industry spillover (Capello, 2009; Arora & Vamvakidis, 2005; Cheshire, 1995). Spatial externalities result from the openness and spatial as well as economical limitation of regional economic systems, which are not self-sufficient, but necessarily interact, inter alia, in supply and demand of goods, production factors and common supply chains (Capello, 2009). Thus, local economic volatility that affects the demand and supply of goods and production factors has a direct transmission channel into other regions by increasing the needs for imports from other regions, as additional demand cannot be fully absorbed by local supply. These pecuniary externalities may lead to income and GDP growth in trade-linked regions and further multiplicative effects in those regions as developed in the Export-Growth-Theory (North, 1955). Moreover, regions directly interact via commuting that cause spatial externalities (Shearmur & Motte, 2009). Spending capacities and consumption demands at the place of residence directly depend on the workplace income per worker.

5.2.3. Labor market mobility

Migration between regions is modelled as exogenous in the presented neoclassical growth models. However, labor productivity, income per worker and labor market migration are strongly interwoven and migration has large impact on population growth. Therefore, Pfaffermayr (2012) presents an augmented Solow growth model including net-migration, based on the works of Barro and Sala-I-Martin (2004), Sung (2010) and Braun (1993). These postulate (average) income differentials per worker as main driver of migration across regions, whereby individuals migrate towards regions with higher income and job opportunities (Barro & Sala-I-Martin, 2004). Pfaffermayr (2012) models net immigration ξ for a set of regions y_N as:

$$\xi(y_1 \dots, y_N) \approx \kappa\left[(y_i - y_i^*) - \sum_{j=1}^{N} m_{ij}(y_j - y_j^*)\right], \quad (5.3)$$

where, m_{ij} denotes the exogenous spatial weights, representing that relocations spanning smaller distances are more likely than large distance moves, due to financial and social migration costs and frictions, y* denotes steady state regional income and κ is a parameter reflecting the sensitivity of willingness to migrate at a given spatially weighted average differential income per worker (Pfaffermayr, 2012). Thus, κ is a factor of the individual weighting of locational utilities that result from economic incentives, natural amenities and cultural (manmade) residential amenities (Rodriguez-Pose & Ketterer, 2012; Wardenburg & Brenner, 2020).

The question whether labor market migration has positive or negative effects on regional growth and convergence across regions is answered differently in the literature (Ozgen et al., 2010; Huber & Tondl, 2012; Fratesi & Percoco, 2014). From a neoclassical perspective immigration enhances population growth and therefore reduces economic growth by decreasing the capital-labor ratio and vice versa for emigration. On the other hand, emigration potentially decreases a regions human capital, with negative effects on output and labor productivity. Hence, Pfaffermayr and Fischer (2018) argue that migration accelerates convergence between high and low income regions if human capital of immigrants is not higher than that of natives. Given, that the income differentials result inter alia from higher average human capital in the immigration region, this should apply on average. However, assuming that migrants are particularly high-skilled seeking for additional income rewards brain-drain dynamics reduce the human capital of the sending region and decelerate convergence.

Given these dependencies, an econometric model for analyzing the spatial effects in economic growth should consider physical and human capital growth, innovation, labor as well as income and migration. While the possibility of negative spatial externalities is not considered in the mentioned spatial growth literature, their presence in reality is likely due to brain-drain effects and competition between firms in neighboring regions causing productivity increases in one region negatively affecting other regions.

5.2.4. Spatial VAR-models

Flexible VAR models have their origin in Sims (1980) approach for vector-autoregressive time-series forecasting. Their main advantage is that flexible models are able to estimate mutual time-lagged interaction across dynamic regional variables without making too many a priori restrictions. Holtz-Eakin, Newey and Rosen (1988) adapted Sims approach for panel data VAR (pVAR) estimations. pVARs model economic interdependencies by estimating simultaneous dynamic regression models in which each variable in the system is a dependent variable, depending on lagged values of all variables in the system. Therefore, our starting point is a reduced form simultaneous dynamic first-order panel VAR estimation system in its aggregated form with M estimations, where M equals the number of variables in the system and i and t represent region and time (Rickman, 2010):

$$y_{it} = \mu_i + \tau_t + Ay_{it-1} + \varepsilon_{it}. \quad (5.4)$$

In this basic form A represents an M*M coefficient matrix. Its values describe the relationship of y_{it} to time-lagged endogenous variables in the system, while μ_i and τ_t represent individual and time-fixed effects to control for cross-sectional heterogeneity and global economic dynamics and trade-cycle effects (such as economic crisis) within the panel data set.

This unrestricted model has serious shortcomings as it treats all variables as fully endogenous, which results in over-parametrization and biased impulse response functions (Rickman, 2010). To overcome this problem, the structural VAR model is used. An a-priori causal variable ordering that represents the causal economic structure of variables based on their assumed degree of endogeneity is done (Bernanke, 1986). A subsequent decomposition of the variance-covariance matrix prevents that contemporaneous relations across variables are captured by the instantaneous covariance of the error term (Mitze et al., 2018). The detailed procedure is described in section 3.

Since the presented structural VAR model ignores potential spatial spillover effects, it does not fit regional panel datasets. Beenstock and Felsenstein (2007) and Di Giacinto (2010) proposed ways to calculate coefficients for A that are not biased by spatial autocorrelation by including spatial lag variables as additional independent variables to equation (5.4):

$$y_{it} = \mu_i + \tau_t + A_1 y_{it-1} + H_1 W y_{it-1} + \varepsilon_{it}, \quad (5.5)$$

where H is an additional M*M matrix of spatial lag coefficients and W is a spatial weight matrix, constant over the M-estimations and over time. In general, further past times (t-2, t-3, …) can be included in Equation (5.5) implying the use of further coefficient matrices A_2, H_2, A_3, H_3 and so on. To keep the presentation of our methodological extension simple and since only one past time is relevant in our application example, we consider only dependencies on time *t-1*. Various analyzes of the effects of local economic shocks have used this kind of model (e.g. Eberle et al., 2019). Although, these models are able to correct for exogenous push-in spillover effects, where economic growth results from developments in related regions, they still do not quantify these effects or integrate push-out spillover effects, since the values of H are ignored in the further examination. Wardenburg and Brenner (2020) present an extended spatial indirect SpVAR model and calculate push-in spillover effects by estimating additional impulse responses representing the effects of a shock in a neighboring region, based on a one-time growth spillover into the estimated region, however, still ignoring possible later second-order spillover.

Canova and Cicarelli (2009) model a multi-country VAR for multiple time-series based on a global vector-autoregression (GVAR) approach. This approach allows for time variation in the estimated coefficients, but does not explicitly focus on spatial interdependencies. In a restricted GVAR approach Dewachter, Houssa and Torffamo (2012) model a European cross-country VAR which models push-out spillover for Germany under the assumption of a homogenous spatial lag structure. Ramajo, Marquez and Hewings (2017) follow a multiREG-SpVAR that is also based on GVAR methods for seventeen Spanish regions. The model estimates push-in and push-out spillover and explicitly allows for heterogeneity in spillover intensity across regions and allows to identify regions as growth generators with large outward growth spillover. However, this estimation technique ignores effects over time and needs to estimate individual regression systems for every regional unit. Thus, it is not appropriate for data sets with a large number of regions.

In general, within a SpVAR approach all estimation techniques that are used in panel data analysis can be applied. Elhorst (2012) provides an overview of adequate estimators and their limitations for dynamic panel models pointing out that least-squares models including individual fixed effects and lagged dependent variables (OLS-FE) are biased due to the known Nickell-Bias, especially if t is rather small (<10) (Nickell, 1981). Generalized methods of moments (GMM) estimators have become the most popular alternative, providing consistent estimators under the assumption of strong instrumental variables. However, Kiviet (1995), Hsiao et al. (2002) and Binder et al. (2005) show that GMMs produce noteworthy biases if instruments are weak. Alternatively, transformed likelihood based estimators such as the quasi-maximum likelihood estimator including fixed effects (QML-FE) proposed by Hsiao et al. (2002), and the orthogonal reparametrization approach (OPM) by Lancaster (2002) have been developed considering the incidental parameter problem resulting from maximum-likelihood estimations in dynamic panel models (see Neyman & Scott, 1948). Binder et al. (2005) and Pickup and Hopkins (2020) show, that this estimator outperforms classic OLS-FE, GMMs and the QML-FE estimators especially for small t. However, we find that these estimators face serious problems, if independent variables are not completely exogenous to the lagged dependent variables, what automatically is the case for time-lagged spatial lags of the dependent variable and if partially multicollinearity among independent variables is present. For the sake of simplicity in our application example we use OLS-FE techniques, arguing that the known bias is small with t=17, which is rather preferable against the unknown biases of the other techniques. Furthermore, our focus is not on the estimation technique but on the way in which push-in and push-out spillover can be considered. Our approach for dealing with spillover - presented in Section 3 - can be combined with all kinds of estimators.

5.2.5. Impulse response functions

Based on the coefficients of $\mathrm{A}y_{it-1}$ from (5) it is now possible to model impulse response functions (IRFs) that illustrate the response of a particular variable to an isolated uncorrelated shock in another variable in the system that includes indirect effects between variables in the system over time. In a non-spatial VAR this is expressed by transforming $\mathrm{A}y_{it-1}$ to its moving-average form, in which A_T represents the dependence on the variable values T time steps before, considering p past time steps (Lütkepohl 2005):

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t. \quad (5.6)$$

Considering the above-mentioned problems with over-parametrization a Choleski decomposition of the covariance matrix is performed following Lütkepohl (2005). This decomposition leads to a matrix A that is premultiplied to eq. (6):

$$Ay_t = A_1^* y_{t-1} + \cdots + A_p^* y_{t-p} + \varepsilon_t. \quad (5.7)$$

Considering now the shock element I_k which is a diagonal matrix with unit variance of the input variables, adding $(I_k - \mathbf{A})y_t$ to (4) gives

$$y_t = A_0^* y_t + A_1^* y_{t-1} + \ldots + A_p^* y_{t-p} + \varepsilon_t, \quad (5.8)$$

where A_0^* equals $I_k - \mathbf{A}$ and is a lower triangular matrix (Lütkepohl, 2005). Thus, this estimation is recursive and does not allow for instantaneous circular effects, but may contains mutual effects beginning from y_{t+1}.

5.3. Econometric advancement

In this section we present our technique for extending the presented SpVAR models to a flexible recursive SptpVAR that enables to estimate push-in and push-out spillover corrected impulse responses for a specific location and its economically connected neighbors over time.

Taking equation (5.5) as a starting point, we follow the reasoning of Wardenburg and Brenner (2020) that inward spillover intensity per time step is given by the matrix of spatial lag coefficients (HWy_{it-1}). This enables to calculate spatial spillover into a region *i* by assuming a shock within a neighboring region i_w and multiplying it with the spatial lag matrix to get inward effects from an external shock into the calculated region at the next time step of the IRF estimation. In case of two identical economies in terms of size and structure, one could argue, that inward spillover effects from i_w to *i* equal the outward spillover from *i* to i_w, which would allow to use the spatial lag matrix to also estimate outward spillover effects. However, allowing for differences in size, the inward spillover effect into i is a multiple of the outward spillover to i_w, where the multiplier is not known. It could be argued that the multiplier is equal to the size ratio of both economies. However, this relies on the assumption that spillover depend linearly on size. Moreover, the assumption of structural homogeneity in space would be necessary, which is rather unlikely to hold in reality. Economic and geographical characteristics bring strong heterogeneity in the ability to produce and absorb spatial externalities. For example, the more a country's or region's firms and institutions are integrated in cross-border cooperation, innovation systems, commuting and trade, the more is its economic development influenced by the development of other regions. Thus, for example, landlocked regions experience more spatial spillover than coastal regions or islands (Roberts & Deichmann, 2009). Moreover, the infrastructure and accessibility of other regions determine the ability to absorb economic growth and defines the amount of spillover (Durlauf & Johnson, 1995). For example, central regions usually possess a strong linkage to their neighboring regions. In consequence, the spatial dissemination of shocks strongly depends on the spatial and economic structure of the neighbors and is strongly heterogeneous in space, meaning that a region might be more affected by a shock in a neighboring region than the other way round, even if both regions are of same size. As a consequence, we argue that calculating outward spillover from a region as equal to inward spillover using spatial lag coefficients from (5.5) is not correct, although it provides a way to calculate a rough estimation.

To explicitly take into account spatial heterogeneity, we model push-in and push-out spillover effects over time, not only for the regional unit in which the computed shock occurs, but also for spatio-economically linked regions. In order to keep the following calculable, we assume that the spatial weight matrix W contains only values of 0 and 1, meaning that we only distinguish between neighbors and non-neighbors, as done in most studies. Furthermore, it is too complicated to consider the exact structure of the neighbors of one region, so that we treat all direct neighbor regions as a hypothetical single region i_w, which influences the developments in the considered region i and is influenced by the shock in region i due to economic spillover. Assuming that this neighborhood region i_w surrounds region i, we can define a second neighborhood region i_{ww} (with $i \not\subseteq i_{ww}$) consisting of all neighbors to region i_w (with $i \not\subseteq i_{ww}$). So, i_{ww} can be called the second order neighborhood of *i*. In the same way further orders of neighborhood could be build, but in our application further orders do not matter. That might be different in other applications. Figure 5.1 shows an exemplary neighborhood structure and the theoretical dissemination of economic shocks in space.

The neighborhoods i_w and i_{ww} of each region i are combinations of original regions and have to be constructed in the dataset. The number of these units equals the number of regions in the dataset for each neighborhood *,* i_w, i_{ww},(…) since every region has one neighborhood region at each order of neighboring. The identification of spatially and economically linked regions is presented in section 5.3.2. As mentioned above, using summed neighborhood regions represents a simplification. However, the only more exact version would require to treat all regions separately, implying single regressions for each of them. Using summed neighborhood regions allows distinguishing regions with different surrounding settlement structure, e.g. big

Figure 5.1: Dissemination of economic shocks from region I to neighboring region and higher order neighbors over time.

cities with their surrounding and rural regions in the periphery. By this part of the spatial structure and type of neighboring regions is considered. However, it means that some information on individual regional spillover get lost in summing up neighborhood regions.

By calculating accurate neighborhoods instead of calculating spatially weighted lags, we can rewrite equation (5.5) to:

$$y_{it} = \mu_i + \tau_t + A_1 y_{it-1} + H_1 y_{i_w t-1} + \varepsilon_{it}, \tag{5.9}$$

where the coefficient matrix H defines the spillover intensity from the combined neighborhood region i_w into *i*. Again, as in the following, we include only the dependence on the former time step. Of course, further past times could be included in the same way.

We now extend the approach and estimate the autoregressive dynamic effects within the combined regions i_w by formulating an additional M*M autoregressive process congruent to equation (5.9):

$$y_{i_w t} = \mu_{i_w} + \tau_t + C_1 y_{i_w t-1} + G_1 y_{it-1,} + J_1 y_{i_{ww} t-1} + \varepsilon_{i_w t}, \tag{5.10}$$

where C is a M*M matrix of coefficients representing the autoregressive dependence within i_w, $G_,$ is an additional same-size matrix with spatial coefficients representing that the values of $y_{i_w t}$ depend on time-lagged push-out spillover from region i, while the matrix J represents analogously push-in spillover from the remaining neighbors i_{ww}. A regression equation for $y_{i_{ww} t}$ and even more distant neighbors can be set up similar to (5.10), dependent on their own lagged values and lagged values of inner and outer neighbors, with corresponding coefficient matrices. The resulting coefficient matrices can be used to calculate spillover corrected IRFs for *i,* i_w and i_{ww}. This system can, in theory, be extended without spatial limits. The number of observations is constant over the estimation systems.

Of course, this technique has some difficulties. The most obvious is that individual regions are represented multiple times in the calculated dependent variables of (10), although in different combinations. Thus, regions that have identified neighborhood relations to many regions have a stronger impact on the calculated dependent variables than those that have only one identified neighbor, which affects the estimation results. Of course, this depends strongly on the chosen definition of neighborhood. If, e.g., neighborhood is defined based on commuting, metropolitan cities are linked to many regions, due to size effects and due to the higher amount of weekend-commuter, which means that large cities impact the results of the new developed estimation systems stronger than other regions. However, we believe that this representation of highly connected regions reflects the real spatial spillover structure, because, as argued above, these are drivers of spatial interdependent growth due their high economic integration.

5.3.1. Spatio-temporal IRFs

The information provided by the coefficient matrices from the additional regression systems is used to extend the moving average calculation by including spatial spillover, considering that an initial shock at time t_0 leads to spatial spillover not only once, but at every time step in which the effect persists. In principle the IRF values y_{t0} to $y_{t\infty}$ can be calculated by using the moving-average representation as described above in Equation (5.8), but including the additional spillover terms from Equation (5.9) and adding similar calculations for the neighboring regions. For simplicity, we again only consider one past time step (*p=1*) and obtain after the Choleski decomposition analogous to Equation (5.8) for the considered region:

$$y_{it} = A_0^* y_{it} + A_1^* y_{it-1} + H_1 y_{i_w t-1} + \varepsilon_t. \tag{5.11}$$

The IRFs for the neighboring regions are given by

$$y_{i_w t} == C_0^* y_{i_w t} + C_1^* y_{i_w t-1} + G_1 y_{it-1} + J_1 y_{i_{ww} t-1} + \varepsilon_t \tag{5.12}$$

and

$$y_{i_{ww}t} = D_0^* y_{i_{ww}t} + D_1^* y_{i_{ww}t-1} + K_1 y_{i_w t-1} + L_1 y_{i_{www}t-1} + \varepsilon_t. \tag{5.13}$$

Further neighborhoods could be considered in a similar way.

As each IRF needs the estimation results of the next neighbors, all IRFs must be calculated simultaneously. Thus, we practically need to limit the spatial expansion, because otherwise an infinite dimension of estimations would result. Since effect strength will decrease while fuzziness increases with distance, we decided to consider complete estimations up to $y_{i_{ww}t}$, including simplified spatial spillover from i_{www}, that are restricted to spatially depend on its inner neighbors, but not its outer neighbors.

In order to show how this effects the IRFs of the considered region *i*, let us consider a shock (change) y_{i0} in this region at time *t=0* and check how this spreads through the equations (assuming all other values to be zero at time *t=0*, as done in IRF calculation). Then, at time *t=1* the values are given by (only presenting the deterministic part, to each value a stochastically determined value has to be added):

$$y_{i1} = A_1 A_0^* y_{i0} \ , \qquad y_{i_w 1} = G_1 A_0^* y_{i0} \qquad \text{and} \quad y_{i_{ww}1} = 0. \tag{5.14}$$

At time *t=2* spillovers come back from the neighboring regions:

$$\begin{gathered} y_{i2} = (A_1^2 + H_1 G_1) A_0^* y_{i0}, \\ y_{i_w 2} = (C_1 G_1 + G_1 A_1) A_0^* y_{i0} \quad \text{and} \quad y_{i_{ww}2} = K_1 G_1 A_0^* y_{i0}. \end{gathered} \tag{5.15}$$

While after two time steps the development in region *i* is only influence by spillover that come back from the neighboring regions, after four time steps additional spillover coming back from second-order neighbors as well as spillover from the developments that have been triggered in the neighboring regions add to the developments within the region. The effects of the original shock on region *i* are then given by:

$$y_{i4} = (A_1^4 + H_1G_1A_1^2 + H_1C_1G_1A_1 + A_1H_1G_1A_1 + A_1^2H_1G_1 + A_1H_1C_1G_1 + H_1C_1^2G_1 + H_1G_1H_1G_1 + H_1J_1K_1G_1) * A_0^*y_{i0}, \tag{5.16}$$

This shows that multiple spillover effects occur that play a role for the reaction of a region to shocks (changes) especially in the medium run. All these effects are ignored in the approach that is so far used in the literature.

In order to assess the statistical significance of the estimation results, we conduct a Monte Carlo simulation, in which we draw regions with all their attributed regional and neighborhood values over years from the original data set until the dataset reaches the same size. Regions can be drawn multiple times. We then estimate the developments after the shock for 500 randomly drawn datasets while holding the initial shock constant and calculate 95% confidence of the IRF values.

We should mention that, despite being sensitive for regional heterogeneity, size effects limit the comparability of effects between the IRFs for i, i_w and i_{ww}. IRFs indicate responses in %. Thus, the total effects depend on the size and can be approximated by comparing the mean size of the accumulated economies.

5.3.2. Neighborhood and spatial lags

By explicitly modelling also the neighboring regions, the definitions of regional units and economically linked neighborhood regions become crucial for the estimation results and the identification of spillover. Like most regional data analysis, we are limited to the use of administrative regions due to data availability. These are mere containers and the spatial expansion of local shocks does not follow local boundaries.

The first problem is the identification of relevant neighbors. Most spatial VARs use a binary Spatial-Durbin model, identifying physically bordering regions as neighbors to calculate spatial-lag variables (e.g. Eberle et al., 2019). As mentioned before, economic interactions are not necessarily based on geographic proximity. However, based on the identified transmission channels, proximity seems to be an important condition for strong market relatedness and spatial connectivity. Moreover, it is important to identify economic linkages that lead to spatial spillover without immediate geographic proximity. In a metropolitan area, for example, regions share economic interactions with the regions core city, even without sharing an administrative border. Furthermore, it must be considered that economic interactions are not evenly distributed across neighbors and not necessarily symmetric. A shock in a large city like Berlin may generate larger impacts on a smaller surrounding city or region than vice versa due to size effects and the accompanying commuting and trade patterns. However, asymmetric spillover are imaginable even for regions of equal size. To identify economic linkages, the economic distance seems to be as relevant as the physical distance.

In order to develop appropriate spatial-weights, we generate a binary spatial weight matrix W in two steps. The first step is to identify spatial proximity using a binary spatial contiguity matrix with W_{ij} = 1 if regions share a border, assuming that physical neighbors automatically share economic externalities. Various instruments can be used to identify further economic linkages. Ramajo et al. (2017) identify economic distance via cross-regional trade linkages. Since we do not have the corresponding data, we consider commuting patterns. We focus on outward-bound commuters, since y_{it} depends on the economic situation at the person's workplace (job-losses, wage gains), whereas economic shocks at the place of residence should not have impact on the workplace. To identify cross-region commuters, we use federal data, that display individuals that are not registered in the regions they life in. These are not necessarily daily commuters, but may be weekend-commuters or people that are registered and work in different places for other reasons. In order to take into account linkages between regions due to commuting, we assign to every region the commuters' target regions, and order these by the share of commuters. Then, we regard all regions at the top of this list as linked regions until a share of more than 80% of the commuters is considered. These regions are added to the neighborhood matrix, whereby double-counts are excluded to maintain the binary matrix structure.

To limit the before mentioned overrepresentation of metropolitan cities and restrict the number of neighbors, we use another neighborhood matrix that represents the population-weighted travel distance by car. If this is higher than 90 minutes, regions are not counted as economic neighbors. Obviously substantial economic spillover with greater distance cannot be ruled out, but are, in our opinion, negligible.

The 2nd order neighborhood matrix V is identified by identifying all regions which are connected to a direct neighbor but are not neighbors of the region itself. A $M*M$ matrix results that contains values of 1 for all 2nd order neighbors and values of 0 for all other pairs of regions. The same procedure is done for the 3rd order spatial weights. We further encounter problems with the spatial limitation of datasets here, for example country borders or coasts. In our analysis, non-German regions are not included as neighbors in the dataset due to different information bases and administrative region definition. This limits the number of neighbors (and higher order neighbors), but is not an essential problem for the estimation.

Another issue is the choice of a suitable spatial scale. The smaller the chosen regional unit, the larger the spillover should be compared to the region size. The smaller the economy, the higher the need to import production factors from other regions which extends the need for spatial externalities. While a main concern of former studies was to lose spillover information by using a small regional scale, this is solved by our new approach. Furthermore, in larger regional scales, such as country level analysis, the within-country externalities are not recognized as such. In the case of negative cross-regional (but not cross-country) externalities, these would decrease the estimated responses and would cancel each other out on country level. Hence, choosing rather small regions seems to be advantageous for this method.

5.3.3. Exemplary data and variables

The paper's exemplary empirical analysis is based on a balanced panel dataset set including annual data in the spatial unit of all 361 German administrative county regions in the time period 2000 to 2017. County regions are identical to the 401 administrative counties and cities, but district-free cities with a population <100.000 are combined with a neighborhood region. With few exceptions, these cities are surrounded by just one region with which they are strongly connected, which could distort the results.

The variables utilized in the SptpVAR model are based on the theoretical frameworks in Section 2. Hence, we use the private sector investment rate as a measure of physical capital investments and higher education as measure for human capital. Moreover, we integrate the employment rate and GDP as proxy for the output (labor productivity). As in all similar studies, measuring the technology rate is an essential problem for adequately considering growth models in econometric analysis. We argue, that there is no well-suited measure, since patents – the commonly used indicator with its known advantages and disadvantages – do not have adequate autoregressive characteristics due to high fluctuations and time delays in patent recognition. We argue that regional technology growth should be included in the GDP measure by directly influencing labor productivity. Additionally, the migration rate is included as well as the household income to control for income as the main reason for migration. Spatial lags for every variable are computed as given in Section 3. All variables are used in their natural logarithm form. Table 5.1 outlines the use of variables and data sources.

To verify the actual presence of spatial autocorrelation, we perform a Morans-I test on our database given the spatial weight matrix presented in section 3.2. The results confirm the existence of spatial autocorrelation among all six variables. Another necessary check for pVAR estimation is testing the stationarity condition.

Table 5.1: Variable descriptions and data sources

Acronym	Variable Description	Data Source
INVQ	Private sector physical capital industry investment rate in the manufacturing, mining and quarrying sector as share of the GDP* *[Industry Investments in € / GDP in €]*	German Federal Statistical Office. GDP: Working Group 'National Accounts of the Federal States. - 'Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder
EMP	Gross employment rate *[Employed persons/Population aged 15 to 64 years]*	Institute for Employment Research (IAB) Population data: German Federal Statistic Office
EMP_UNI	Higher education – Workers with a university degree per economically active working population *[Employed persons with university degree/Population aged 15 to 64 years]*	German Federal Statistical Office Population data: German Federal Statistic Office
INC	Mean disposable household income *[Disposable income of private households/population]*	National Accounts of the Federal States ('Volkswirtschaftliche Gesamtrechnungen der Länder') Population data: German Federal Statistic Office
MIG	Regional net migration rate *[(net migration – population$_{t-1}$)/population$_{t-1}$]*	Migration statistic of the federal government and the federal states Population data: German Federal Statistic Office
GDP	Nominal GDP per economically active working population *[GDP in €/population aged 15 to 64 years]*	Working Group 'National Accounts of the Federal States. - 'Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder' Population data: German Federal Statistic Office

*Remarks: *Only investments of firms with >=20 working persons are gathered. The missing investments in relation to measured values should not be correlated in space and time, and therefore not produce structural errors.*

The results suggest that unit roots are present in four of six variables, namely employment rate, higher education rate, GDP and income. Hence, we follow Ellhorst (2012) and subtract a time trend from each individual unit in the panel data for the concerned variables. Morans- I and IPS test results are given in the Appendix (*Table A5.1 and A5.2*). The summary of the used variables is given in table 5.2.

Table 5.2: Variable summary statistics

Nr	Acronym	Observations	Min	1.Quarter	Mean	3. Quarter	Max	Std. Dev.
1	**INVQ**	3610	-8.194	-4.335	-3.967	-3.560	-1.496	0.651
2	**EMP**	3610	-1.464	-0.8845	-0.723	-0.587	0.411	0.256
2.1	**EMP_DET**	3610	-1.485	-0.987	-0.830	-0.703	0.095	0.262
3	**EMP_UNI**	3610	-4.710	-3.521	-3.116	-2.813	-0.948	0.595
3.1	**EMP_UNI_DET**	3610	-4.773	-3.866	-3.442	-3.127	-1.253	0.595
4	**INC**	3610	6.903	7.230	7.345	7.460	8.090	0.163
4.1	**INC_DET**	3610	6.884	7.080	7.167	7.253	7.792	0.134
5	**MIG**	3610	-.0405	-.0011	.0026	.0061	.0592	.0060
6	**GDP**	3610	9.762	10.394	10.619	10.807	12.545	0.354
6.1	**GDP_DET**	3610	9.656	10.164	10.372	10.535	11.784	0.352

Note: _DET denotes detrended version of the variable.

As outlined above we need some a priori restrictions towards the causal variable ordering to be able to perform the choleski decomposition of the variance-covariance matrix. The chosen order is as presented in Table 5.1, based on a Granger-Causality test and additional theoretical assumptions. Test results are given in Appendix-Table A5.3. It is assumed that the investment rate is the most exogenous variable and cannot be affected by other variables in the same year (but in the following years), while GDP is most endogenous and is contemporaneously affected by all other variables.

5.4. Empirical results

The empirical results demonstrate the functioning of our SptpVAR approach and bring some new empirical insights. In this section we present a brief selection of results. The approach provides individual impulse response functions for every pair of variables and regional neighborhood level (i, i_w and i_{ww}). All resulting IRFs are listed in the appendix *(Figure A5.1).*

Focusing on effects of shocks in the local employment rate, we find that a single shock in the number of jobs within a region has significant positive effects on the local net migration rates in the following years (*Figure 5.2*). This suggests that at least some of this additional jobs are

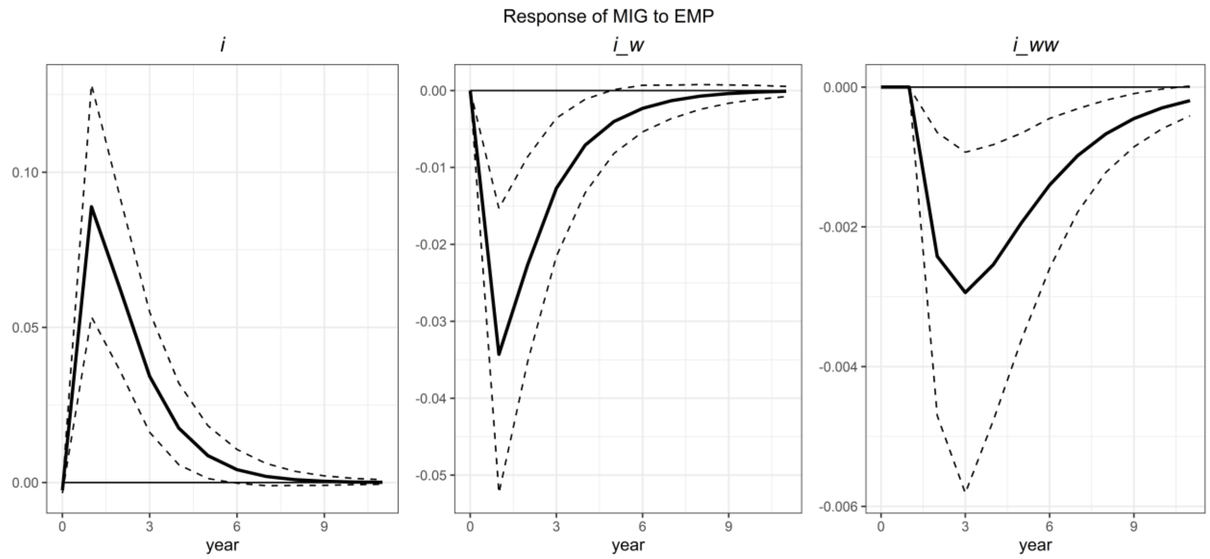

Figure 5.2: Responses of migration to GDP shock. Note: Estimated impulse response functions are solid lines. Dashed lines represent 95% coefficient intervals from Monte Carlo simulations with 500 repetitions. IRFs display responses to orthogonal shocks in the amount of the standard deviations of the impulse variables. Responses are given in %

filled by external workers that move to the region. The results for 1st order and 2nd order neighbors indicate a significant negative development of net migration rates. We therefore see that these neighbors' loose a share of their population to region *i*. Assuming that these were already gainfully employed before or are at least qualified enough to take on a job, these regions forfeit potential growth capital. This finding supports the theoretical assumptions of equation (5.3), that personal income is a main driver of migration. Furthermore, spatial proximity has an effect, most immigrants into *i* seem to move from neighboring or economically linked regions. This is an important finding for the assessment of economic policies. Secondly, we focus on output (GDP) responses to employment shocks, examining the validity of the spatial growth theories presented. In support of the Mankiw growth model (*Equation (5.1)*), we find that local labor growth has significant positive effects on the total output within the same region. However, this local shock has no significant effect on neighboring regions *(Figure 5.3).* Thus, based on our results, labor growth does not cause spatial externalities that impacts the neighbors total output in a significant way. The same applies for other variables' responses to employment shocks, were we do not find significant spatial effects.

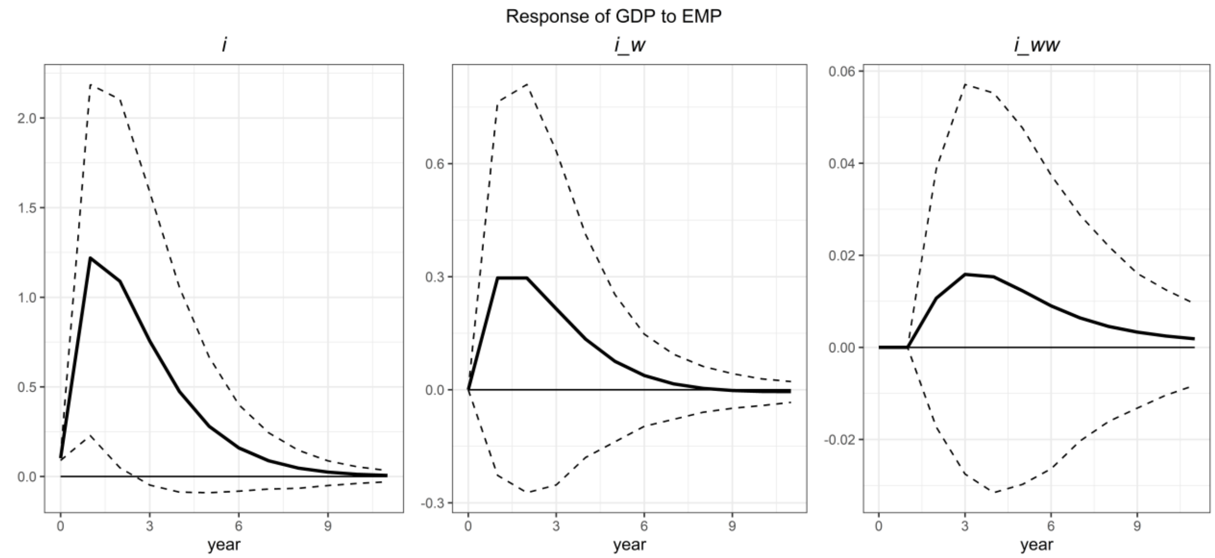

Figure 5.3: Responses of GDP to employment shock. Specifications equal Figure 5.2

We also note that output per working-age population is negatively affected by migration within the same region *(Figure 5.4).* This indicates that population growth has negative effects on the regions productivity. Based on the presented considerations by Pfaffermayr and Fischer (2018), it means that the average migrant is not as productive as the existing population one year after moving. This explains negative effects on productivity, at least in short term. In consequence, the effects shown in Figure 5.4 should lead to convergence in productivity across regions. We do not find spatial output effects on local GDP growth.

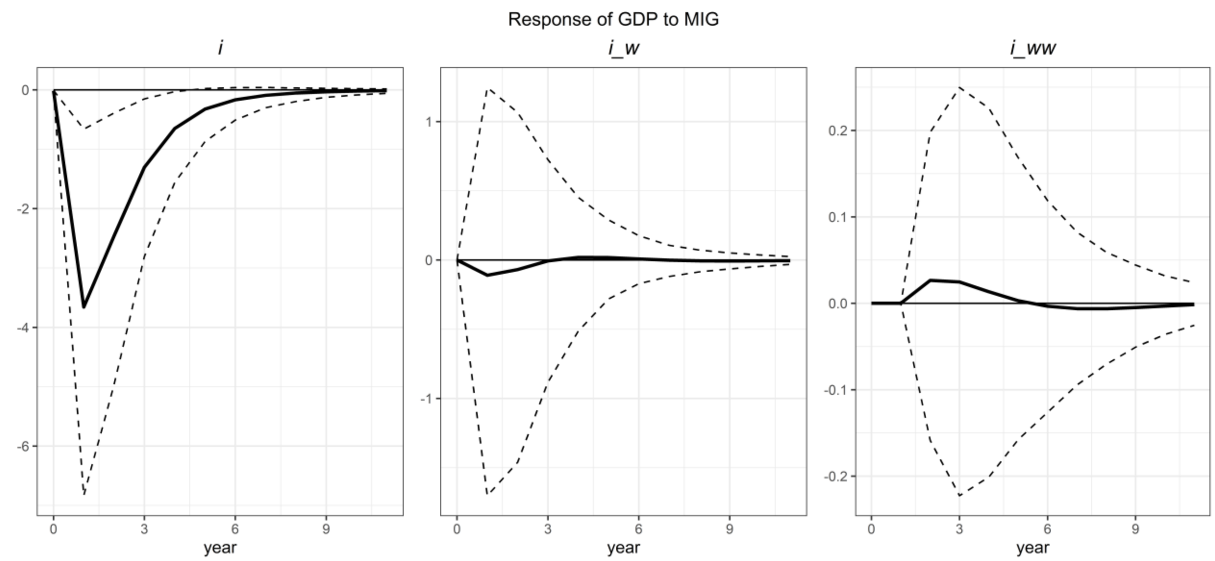

Figure 5.4: Responses of GDP to migration shock. Specifications equal Figure 5.2

Additionally, we are interested in the spatial dissemination of output shocks. We find that GDP growth has on average positive, but not significant effects on its neighbors and no clear impact on 2nd order neighbors *(Figure 5.5).* Thus, we do not find clear evidence for spatial economic externalities within the economic output, against the hypothesis that knowledge driven output growth should spillover into its neighboring regions causing output growth. It appears that the spatial effects of output growth depend on the nature of the shocks. Assuming that knowledge or technology level spillover cause growth in neighboring regions, this may not be the case for other growth sources, explaining average positive but not significant growth spillover.

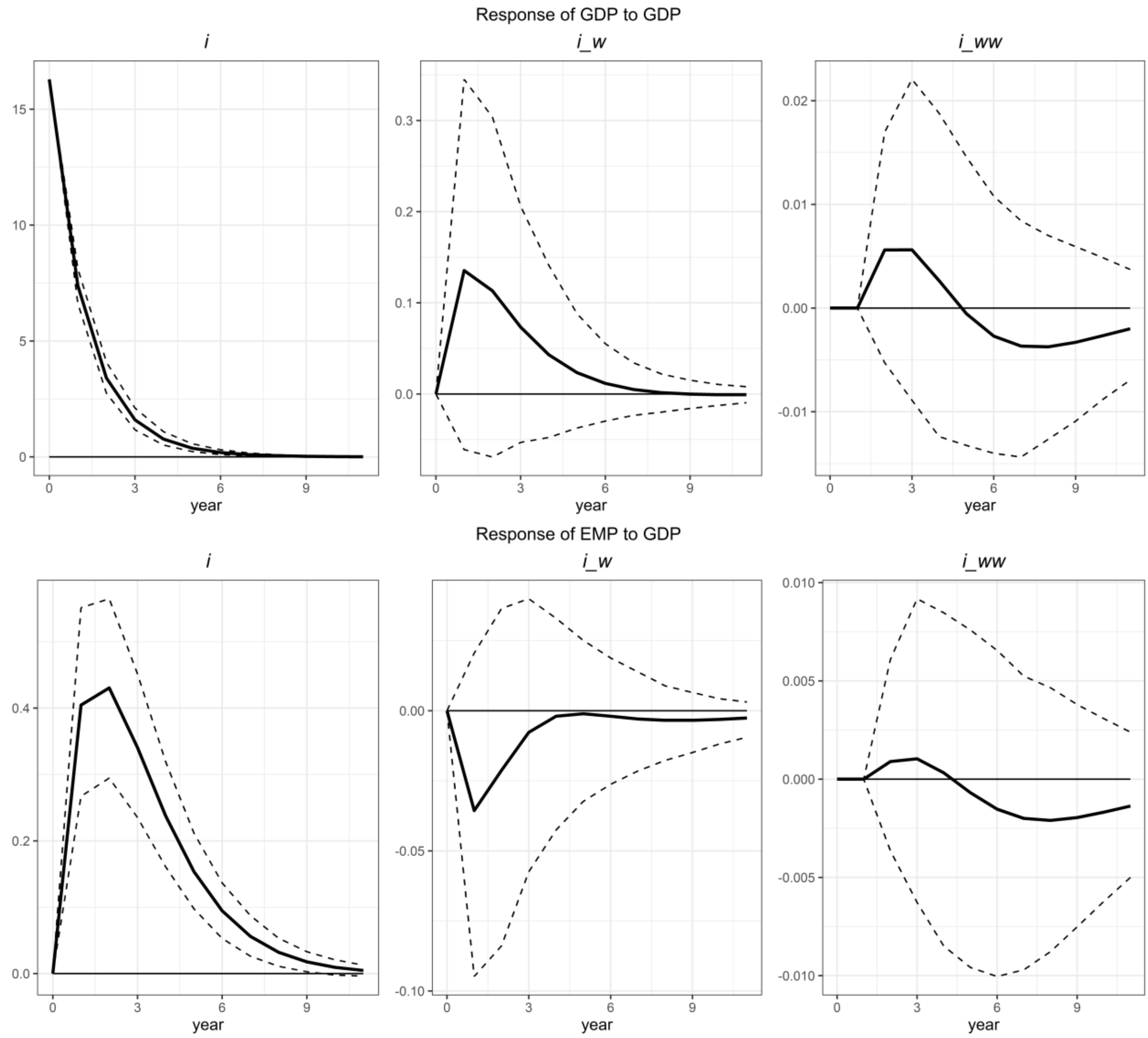

Figure 5.5: Responses of GDP to GDP and employment shocks. Specifications equal Figure 5.2

Further research using the SptpVAR approach concentrating on this issue could clarify this. Secondly, we find significant employment growth as a result of GDP shocks (*Figure 5.5*). The effects are not causing employment growth in neighboring regions.

Nevertheless, GDP growth shows spatial impact in the form of significantly positive migration responses within the region and in both types of neighboring regions (*Figure 5.6*). While it is obvious that economically growing regions are attractive for immigrants from other regions, the spatial results somehow seem to contradict the findings from Figure 5.2.

We detect a clear difference between spillover from employment and from GDP growth. Employment growth in a region seems to attract people from surrounding regions into the region, meaning that it leads to quite local migration. In contrast, GDP growth seems to attract people from outside the wider neighborhood (including second order neighboring regions) into this neighborhood, implying long-distance migration. Both effects seem to be connected to suburbanism dynamics, but the latter effect (including second-order neighbors) even goes beyond that.

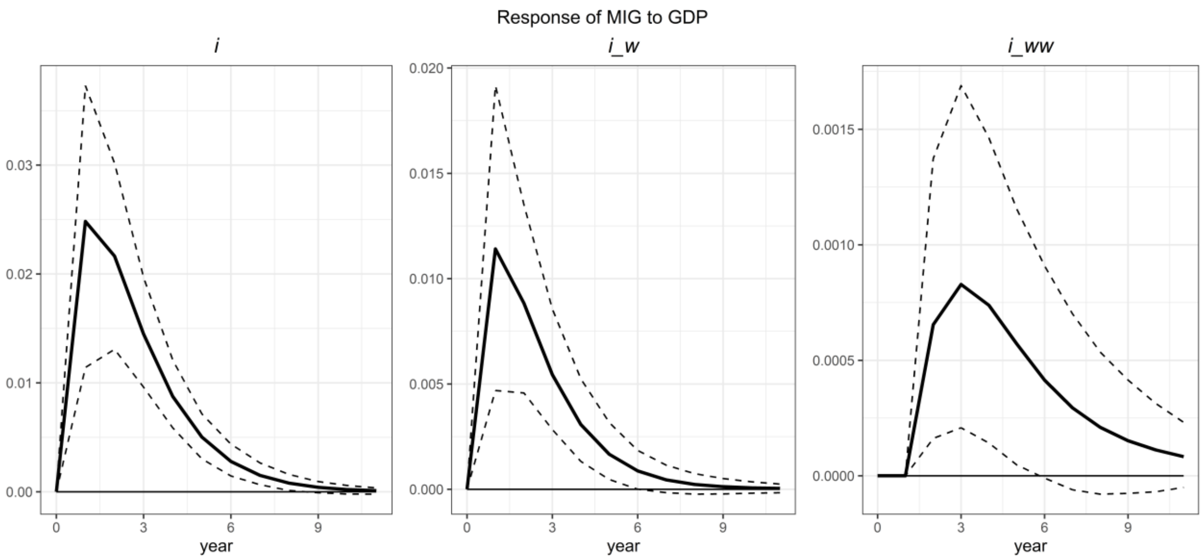

Figure 5.6: Responses of migration to GDP shocks. Specifications equal Figure 5.2

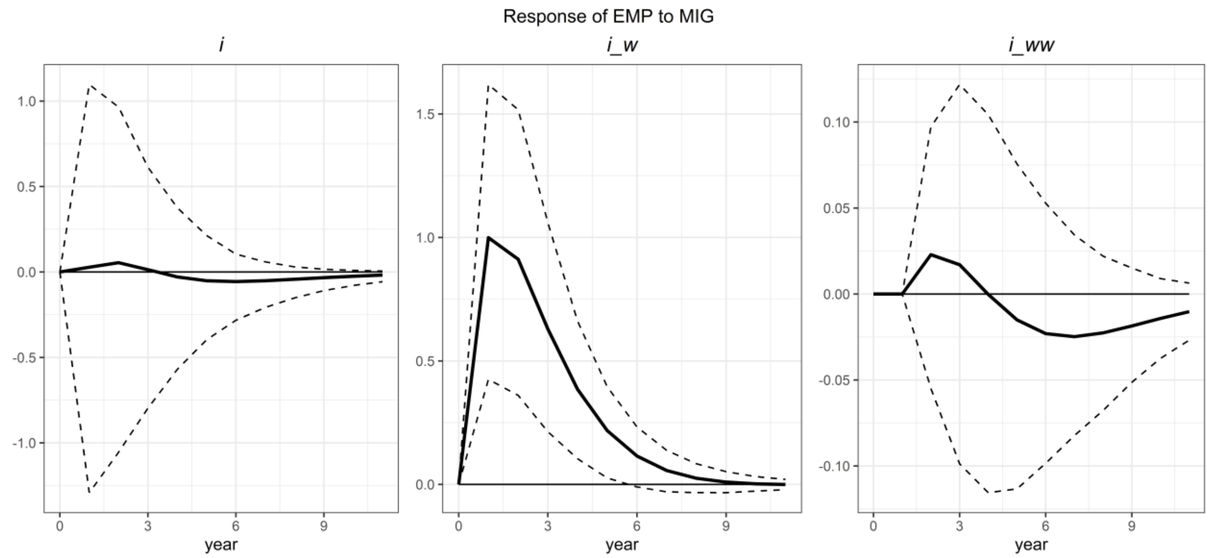

Figure 5.7: Responses of employment to Migration shock. Specifications equal Figure 5.2

Finally, our estimation reveals that significant effects in neighboring regions are possible, even if there are no significant local effects. *Figure 5.7* illustrates that there is no within region reaction of the local employment rate to migration. However, in the direct neighborhood, the employment rate increases per working age population, although there is no local shock. We believe, that the effect is provoked by emigrants into i. If their average employment rate before migration was lower than those of the remaining population in i_w, the employment rate within the region increases without new jobs being created.

5.5. Conclusion

The paper aimed to develop a theoretical SpVAR model that extends former approaches by integrating spatial externalities of local economic shocks into the analysis and overcome problems in dealing with spatial effects in regional panel data. We presented an SptpVAR model that does this in a rather general approach that allows to track the spatio-temporal diffusion of local economic change in space as well as in time and incorporates indirect effects not only between variables, but also in space in the resulting IRFs. Furthermore, the proposed approach allows to examine spatial heterogeneity by building subsamples: e.g. studying the subsample of larger cities would imply that the spillover between these cities and their surrounding regions is examined. The functioning of the approach is shown by applying it to a spatial dataset for 361 German regions.

The main advantages of the new approach are that spatial spillover effects resulting from a shock in one region on the surrounding or connected regions and indirect feedback spillover from these regions to the origin region are no longer neglected. Hence, the new approach also provides additional information on spatial spillover structures that are very interesting, for example for the evaluation of regional policy measures. However, the approach brings some limitations. It still relies on the use of administrative regions as spatial containers, faces problems at the spatial end of the data set (e.g. country borders) and generates rather large regions when calculating higher order neighborhoods. Nevertheless, the approach allows for some new interesting empirical insights. We find that positive effects in one region can cause positive or negative spillover in neighbors and linked regions and therefore increase or mitigate the total effects. Our exemplary application shows that spatial spillover are most relevant if migration dynamics are included in the analysis.

We conclude that the SptpVAR has versatile application possibilities in the empirical analysis of dynamic economic systems.

5.6. References

Angeriz, A., McCombie, J. & Roberts, M. (2008). New Estimates of Returns to Scale and Spatial Spillover for EU Regional Manufacturing, 1986- 2002. *International Regional Science Review*, 31(1), 62-87. https://doi.org/10.1177/0160017607306750.

Arora, V. & Vamvakidis, A. (2005). Economic spillover. Exploring the impact trading partners have on each other's growth, *Finance and Development*, 42(3), 48-50.

Audretsch, D. B. & Feldman, M. P. (2004). Knowledge spillover and the geography of innovation, in: Henderson, J & Thisse, J (Eds) *Handbook of Regional and Urban Economics vol. 4*, (pp. 2713-2739). North-Holland.

Barrios, S., Bertinelli, L. & Strobl, E. (2003). Multinationals and Local Indigenous Development. *CORE Discussion Paper 2003/05*, Belgium, UCL, Center for Operations Research and Econometrics.

Barro, R. & Sala i-Martin, X. (2004). *Economic Growth, edn. 2.* MIT-Press.

Basile, R. & Usai, S. (2015): Analysis of regional endogenous growth. In: *Handbook of research methods and applications in economic geography*, (pp. 234-258) Edward Elgar Publishing Limited.

Beenstock, M. & Felsenstein, D. (2007). Spatial vector autoregressions. *Spatial Economic Analysis*, 2, 167–196, DOI: 10.1080/17421770701346689.

Bernanke, B. S. (1986). Alternative Explanations of the Money-Income Correlation, *Carnegie-Rochester Conference Series on Public Policy*, 25, 49-99.

Binder, M., Hsiao, C. & Pesaran, M. (2005). Estimation and Inference in Short Panel Vector Autoregressions with Unit Roots and Cointegration. *Econometric Theory,* 21, 795-837

Borts, G. & Stein, J. (1964). Economic Growth in a Free Market. *Columbia University Press*, New York

Bosker, M. (2007). Growth, agglomeration and convergence, a space-time analysis for European regions, *Spatial Economic Analysis*, 2, 91-100.

Braun, J. (1993). *Essays on Economic Growth and Migration.* PhD Thesis, Harvard University.

Canova, F. & Ciccarelli, M. (2009). Estimating Multicountry VAR Models. *International Economic Review,* 50, 929-959.

Capello, R. (2009). Spatial Spillover and Regional Growth: A Cognitive Approach. *European Planning Studies,* 17, 639-658.

Cheshire, P. (1995). A new phase of urban development in Western Europe? The evidence for the 1980s. *Urban Studies*, 32, 1045-1063.

Coe, D. & Helpman, E. (1995). International R&D spillover. *European Economic Review,* 39, 859-897.

Dewachter, H., Houssa, R. & Toffano, P. (2012). Spatial Propagation of Macroeconomic Shocks in Europe. *Review of World Economics,* 148, 377-402.

Di Giacinto, V. (2010). On vector autoregressive modelling in space and time. *Journal of Geographical Systems*, 12, 125-154, DOI: 10.1007/s10109-010-0116-6.

Durlauf, S., & Johnson, P. (1995). Multiple regimes and cross-country growth behavior. *Journal of Applied Econometrics,* 10, 365-384.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98, 701-735, DOI: 10.1111/pirs.12373.

Elhorst, J. P. (2012). Dynamic Spatial Panels: Models, Methods, and Inferences. *Journal of Geographical Systems* 14, 5-28.

Ertur, C. & Koch, W. (2007). Growth, Technological Interdependence and Spatial Externalities: Theory and Evidence. *Journal of Applied Econometrics*, 22, 1033-1062.

Ertur, C. & Koch, W. (2011). A contribution to the theory and empirics of Schumpetrian growth with worldwide interactions. *Journal of Economic Growth*, 16, 215-255.

Fingleton, B. & McCombie, J. (1998). Increasing returns and economic growth: Some evidence for manufacturing from the European Union regions, *Oxford Economic Papers*, 50, 89-105.

Fratesi, U. & Percoco, M. (2014). Selective migration, regional growth and convergence: Evidence from Italy. *Regional Studies,* 48, 1650-1668.

Grossman, G. & Helpman, E. (1991). *Innovation and Growth in the Global Economy*, MIT Press.

Holtz-Eakin, D., Newey, W. & Rosen, H.S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica*, 56, 16371-1395.

Howitt, P. (2000). Endogenous growth and cross-country income differences. *American Economic Review*, 90, 829-846.

Howitt, P. & Mayer-Foulkes, D. (2005). R&D, Implementation and stagnation: A Schumpeterian theory of convergence clubs. *Journal of Money, Credit and Banking*, 37, 147-177.

Hsiao C., Pesaran M. & Tahmiscioglu, A. (2002). Maximum likelihood estimation of fixed effects dynamic panel data models covering short time periods. *Journal of Econometrics,* 109, 107-150.

Huber, P. & Tondl, G. (2012). Migration and regional convergence in the European Union. *Empirica,* 39, 439-460.

Im, K. S., Pesaran, M. H. & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115, 53-74.

Kiviet, J. F. (1995). On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. *Journal of Econometrics,* 68: 53-78.

Lancaster, T. (2002). Orthogonal Parameters and Panel data. *Review of Economic Studies,* 69, 647-666

Lopez-Bazo, E., Vaya, E. & Artis, M. (2004). Regional Externalities and Growth: Evidence from European Regions. *Journal of Regional Science*, 44, 43-73.

Lütkepohl, H. (2005*). New introduction to multiple time series analysis*. Springer.

Mankiw, G., Romer, D. & Weil, D. (1992). A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics*, 107, 40-437.

Mathur, V. & Song, F. (2000). A labor market based theory of economic development. *The Annals of Regional Science,* 34, 131-145

Mitze, T., Schmidt, T.D., Rauhut, D. & Kangasharju, A. (2018). Ageing shocks and short-run regional labor market dynamics in a spatial panel VAR approach. *Applied Economics*, 50, 870-890, DOI: 10.1080/00036846.2017.1346360.

Montoya, L.A. & de Haan, J. (2008). Regional Business Cycle Synchronization in Europe? *International Economics and Economic Policy* 5, 123–37.

Neyman, J. & Scott, E. (1948). Consistent estimation from partially consistent observations. *Econometrica*, 16, 1-32.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica*, 49, 1417-1426.

North, D. (1955). Location Theory and Regional Economic Growth. *Journal of Political economy*, 63, 243-258.

Ozgen, C., Nijkamp, P. & Poot, J. (2010). The effect of migration on income growth and convergence: Meta-analytic evidence. *Papers in Regional Science,* 89, 537-561.

Pfaffermayr, M & Fischer, L. (2018). The more the merrier? Migration and convergence among European regions. *Regional Science & Urban Economics, 72,* 103-114.

Pfaffermayr, M. (2012). Spatial convergence of regions revisited: A spatial maximum likelihhod approach. *Journal of Regional Science,* 52, 857-873

Pfaffermayr, M. (2009). Conditional β- and σ-convergence in space: A maximum likelihood approach. *Regional Science & Urban Economics*, 39, 63-78.

Pickup, M. & Hopkins, V. (2020). Transformed-likelihood estimators for dynamic panel models with a very small T. *Political Science Research and Methods*. Advance online publication. DOI:10.1017/psrm.2020.30.

Ramajo, J., Marquez, M. & Hewings, G. (2017). Spatiotemporal Analysis of Regional Systems: A Multiregional Spatial Vector Autoregressive Model for Spain. *International Regional Science Review*, 40, 75-96.

Rey, S. J. & Janikas, M. V. (2005). Regional convergence, inequality, and space. *Journal of Economic Geography*, 5,155–176. DOI: 10.1093/jnlecg/lbh044.

Rey, S. J. & Montouri, B. D. (1999). US regional income convergence: a spatial econometrics perspective, *Regional Studies*, 33, 143-156.

Rickman, D S. (2010). Modern macroeconomics and regional economic modeling. *Journal of Regional Science*, 50, 23-41.

Roberts, M. & Deichmann, U. (2009). International Growth Spillover, Geography and Infrastructure. *Policy Research Working Paper*. The World Bank, Development Research Group.

Rodriguez-Pose, A. & Ketterer, D. (2012). Do Local Amenities Affect the Appeal of Regions in Europe for Migrants? *Journal of Regional Science,* 52, 535-561.

Romer, P. M. (1990). Endogenous technical change. *Journal of Political Economics,* 98, 71-102.

Shearmur, R. & Motte, B. (2009). Weak Ties that Bind: Do Commutes Bind Montreal's Central and Suburban Economies? *Urban Affairs Review,* 44, 490-524.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48, 1-48.

Solow, R. (1956). A Contribution to the Theory of Economic Growth, *The Quarterly Journal of Economics*, 70, 65-94, https://doi.org/10.2307/1884513.

Sung, L., Hong, E. & Li, T. (2010). Incorporating Technology Diffusion, Factor Mobility and Structural Change into Cross-Section Growth Regressions. *Journal of Regional Science*, 50, 734-755.

Wardenburg, S. & Brenner, T. (2020). How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany. *Journal of Regional Science,* 60, 1047-1073. DOI: 10.1111/jors.12500.

Zabel, J. (2012). Migration, housing market, and labor market responses to employment shocks. *Journal of Urban Economics* 72, 267-284.

A5 Appendix

Table A5.2: Moran's I test of spatial autocorrelation

Variable	INVQ		EMP		EMP_UNI		INC		MIG		GDP	
Year	Morans-I	p-value	Morans-I	p-value	Morans-I	p-value	Morans-I	p-value	Morans-I	p-value	Morans-I	p-value
2000	0.099	0.000	0.055	0.011	0.232	0.000	0.659	0.000	0.432	0.000	0.329	0.000
2001	0.108	0.000	0.066	0.003	0.228	0.000	0.665	0.000	0.560	0.000	0.334	0.000
2002	0.119	0.000	0.072	0.002	0.224	0.000	0.661	0.000	0.502	0.000	0.335	0.000
2003	0.137	0.000	0.075	0.001	0.217	0.000	0.660	0.000	0.283	0.000	0.338	0.000
2004	0.134	0.000	0.077	0.001	0.216	0.000	0.656	0.000	0.316	0.000	0.336	0.000
2005	0.122	0.000	0.085	0.000	0.213	0.000	0.651	0.000	0.231	0.000	0.348	0.000
2006	0.143	0.000	0.077	0.000	0.216	0.000	0.635	0.000	0.251	0.000	0.339	0.000
2007	0.151	0.000	0.074	0.001	0.216	0.000	0.633	0.000	0.422	0.000	0.338	0.000
2008	0.173	0.000	0.069	0.002	0.217	0.000	0.635	0.000	0.315	0.000	0.345	0.000
2009	0.142	0.000	0.063	0.005	0.219	0.000	0.593	0.000	0.232	0.000	0.335	0.000
2010	0.164	0.000	0.060	0.007	0.220	0.000	0.620	0.000	0.290	0.000	0.328	0.000
2011	0.196	0.000	0.062	0.005	0.213	0.000	0.629	0.000	0.277	0.000	0.332	0.000
2012	0.220	0.000	0.064	0.004	0.219	0.000	0.652	0.000	0.380	0.000	0.331	0.000
2013	0.149	0.000	0.063	0.005	0.225	0.000	0.652	0.000	0.410	0.000	0.332	0.000
2014	0.128	0.000	0.065	0.004	0.225	0.000	0.672	0.000	0.257	0.000	0.335	0.000
2015	0.130	0.000	0.069	0.002	0.224	0.000	0.668	0.000	0.091	0.000	0.345	0.000
2016	0.133	0.000	0.072	0.002	0.223	0.000	0.660	0.000	0.162	0.000	0.335	0.000
2017	0.143	0.000	0.076	0.001	0.225	0.000	0.649	0.000	0.223	0.000	0.340	0.000

Table A5.2: IPS unit-root test statistics

Variable	IPS-test statistic	p-value
INVQ	-31.711	0.000
EMP	39.812	1
EMP_DET	-17.622	0.000
EMP_UNI	24.398	1
EMP_UNI_DET	-25.224	0.000
INC	27.116	1
INC_DET	-31.393	0.000
MIG	-13.440	0.000
GDP	32.813	1
GDP_DET	-33.162	0.000

Note: Number of regions = 361, t= 10, test based on Im Pesaran & Shin (2003):

H0: presence of unit roots. _DET donates detrended version of the variable.

Table A5.3: Panel Granger Causality Test (lag=1)

↓ GRANGER → CAUSES	INVQ		EMP_DET		EMP_UNI_DET		INC_DET		MIG		GDP_DET	
	value	*p-value*	*value*	*p-value*	*value*	*p-value*	*value*	*p-value*	*value*	*p-value*	*value*	*p-value*
INVQ	x	x	9.94	0.00	4.03	0.00	0.09	0.926	1.23	0.219	1.66	0.097
EMP_DET	1.08	0.284	x	x	9.29	0.00	18.43	0.000	8.29	0.000	8.48	0.000
EMP_UNI_DET	1.06	*0.288*	-1.17	0.243	x	x	7.76	0.000	4.00	0.000	2.95	0.003
INC_DET	0.39	0.696	3.76	0.000	22.90	0.000	x	x	2.74	0.006	2.819	0.005
MIG	1.11	0.266	9.04	0.000	-1.21	0.225	1.77	0.075	x	x	6.04	0.000
GDP_DET	4.12	0.000	0.57	0.568	3.89	0.000	6.71	0.000	-3.11	0.756	x	x

Note: Test as given in Dumitrescu & Hurlin (2012).
Granger Causality Test is performed for every region; Alternative hypothesis = Granger causality given for at least one region

Table A5.4: Core-Model regression results

	Dependent variable:					
	INVQ	EMP	EMPL_UNI	INC	MIG	GDP
plm::lag(invq, 1)	0.412***	.003***	0.007***	-0.001	-0.00003	0.002
	(0.012)	(0.001)	(0.001)	(0.001)	(0.0001)	(0.001)
plm::lag(emp, 1)	-0.864***	0.565***	-0.049*	-0.011	0.014***	0.128***
	(0.255)	(0.012)	(0.026)	(0.011)	(0.003)	(0.027)
plm::lag(empl_uni, 1)	-0.111	-0.015***	0.664***	-0.011**	-0.001	0.020*
	(0.109)	(0.005)	(0.011)	(0.005)	(0.001)	(0.012)
plm::lag(inc, 1)	0.469**	0.047***	0.070***	0.701***	0.021***	0.008
	(0.224)	(0.010)	(0.023)	(0.010)	(0.003)	(0.024)
plm::lag(mig, 1)	-0.832	0.085*	0.034	-0.005	0.153***	-0.164
	(1.050)	(0.048)	(0.105)	(0.047)	(0.013)	(0.113)
plm::lag(gdp, 1)	0.124	0.030***	0.019*	-0.006	0.005***	0.462***
	(0.111)	(0.005)	(0.011)	(0.005)	(0.001)	(0.012)
plm::lag(spinvq, 1)	0.048*	-0.0004	0.004	-0.001	0.0001	-0.005**
	(0.025)	(0.001)	0.002)	(0.001)	(0.0003)	(0.003)
plm::lag(spemp, 1)	1.121**	0.097***	0.199***	0.010	-0.024***	-0.198***
	(0.498)	(0.023)	(0.050)	(0.022)	(0.006)	(0.053)
plm::lag(spempl_uni, 1)	-1.036***	-0.106***	-0.111***	0.036***	-0.003	0.046*
	(0.242)	(0.011)	(0.024)	(0.011)	(0.003)	(0.026)
plm::lag(spinc, 1)	0.411	0.024	-0.108***	-0.143***	-0.010**	-0.124***
	(0.381)	(0.018)	(0.038)	(0.017)	(0.005)	(0.041)
plm::lag(spmig, 1)	-3.801**	0.420***	0.917***	0.013	0.189***	-0.156
	(1.762)	(0.081)	(0.177)	(0.079)	(0.022)	(0.189)
plm::lag(spgdp, 1)	0.110	0.014	0.012	-0.003	0.010***	0.059**
	(0.230)	(0.011)	(0.023)	(0.010)	(0.003)	(0.025)
Observations	6,137	6,137	6,137	6,137	6,137	6,137
R2	0.181	0.432	0.468	0.469	0.073	0.254
Adjusted R2	0.125	0.394	0.432	0.433	0.011	0.204
F Statistic (df = 12; 5748)	105.676***	364.648***	421.142***	423.546***	37.761***	163.402***

Notes: Dependent variables within region i
*p<0.1; **p<0.05; ***p<0.01

Table A 5.5: 1st neighbor regression models

	Dependent variable:					
	SPINVQ	SPEMP	SPEMPL_UNI	SPINC	SPMIG	SPGDP
plm::lag(invq, 1)	0.017***	0.001**	0.002***	-0.0001	0.00003	0.002**
	(0.006)	(0.0003)	(0.001)	(0.0004)	(0.0001)	(0.001)
plm::lag(emp, 1)	-0.164	0.001	0.031**	-0.018**	-0.007***	0.009
	(0.124)	(0.006)	(0.012)	(0.008)	(0.002)	(0.014)
plm::lag(empl_uni, 1)	-0.058	-0.008***	-0.009*	0.002	0.003***	-0.004
	(0.052)	(0.003)	(0.005)	(0.003)	(0.001)	(0.006)
plm::lag(inc, 1)	-0.025	-0.011**	-0.023**	0.010	0.001	0.00001
	(0.107)	(0.005)	(0.011)	(0.007)	(0.002)	(0.012)
plm::lag(mig, 1)	0.167	0.066**	0.099**	0.070**	0.038***	-0.012
	(0.503)	(0.026)	(0.049)	(0.034)	(0.008)	(0.058)
plm::lag(gdp, 1)	-0.014	-0.007**	-0.010**	-0.008**	0.002***	0.009
	(0.053)	(0.003)	(0.005)	(0.004)	(0.001)	(0.006)
plm::lag(spinvq, 1)	0.496***	0.001**	0.003**	-0.001	-0.00002	-0.001
	(0.012)	(0.001)	(0.001)	(0.001)	(0.0002)	(0.001)
plm::lag(spemp, 1)	-1.480***	0.532***	-0.150***	-0.059***	0.049***	0.123***
	(0.313)	(0.016)	(0.031)	(0.021)	(0.005)	(0.036)
plm::lag(spempl_uni, 1)	0.155	0.024***	0.769***	0.041***	-0.036***	0.116***
	(0.145)	(0.007)	(0.014)	(0.010)	(0.002)	(0.017)
plm::lag(spinc, 1)	0.611***	0.032***	0.017	0.456***	-0.001	0.010
	(0.185)	(0.009)	(0.018)	(0.012)	(0.003)	(0.021)
plm::lag(spmig, 1)	-1.405	0.047	0.155*	0.034	0.311***	0.066
	(0.860)	(0.044)	(0.084)	(0.058)	(0.014)	(0.099)
plm::lag(spgdp, 1)	0.437***	0.058***	0.087***	0.063***	0.016***	0.459***
	(0.112)	(0.006)	(0.011)	(0.008)	(0.002)	(0.013)
plm::lag(sp2invq, 1)	0.113***	-0.001	0.003	-0.002	0.0005*	0.0005
	(0.016)	(0.001)	(0.002)	(0.001)	(0.0003)	(0.002)
plm::lag(sp2emp, 1)	1.452***	0.175***	0.254***	0.133***	-0.048***	0.098**
	(0.344)	(0.018)	(0.034)	(0.023)	(0.005)	(0.040)
plm::lag(sp2empl_uni, 1)	-0.987***	-0.094***	-0.100***	-0.015	0.019***	-0.069***
	(0.167)	(0.009)	(0.016)	(0.011)	(0.003)	(0.019)
plm::lag(sp2inc, 1)	0.909***	-0.100***	-0.149***	-0.170***	-0.020***	-0.153***
	(0.280)	(0.014)	(0.028)	(0.019)	(0.004)	(0.032)
plm::lag(sp2mig, 1)	-7.109***	0.861***	1.352***	0.523***	0.144***	0.327**
	(1.263)	(0.064)	(0.124)	(0.085)	(0.020)	(0.146)
plm::lag(sp2gdp, 1)	-0.058	0.014*	0.060***	-0.015	0.015***	-0.015
	(0.163)	(0.008)	(0.016)	(0.011)	(0.003)	(0.019)
Observations	6,137	6,137	6,137	6,137	6,137	6,137
R2	0.281	0.541	0.597	0.280	0.200	0.251
Adjusted R2	0.232	0.509	0.569	0.230	0.145	0.200
F Statistic (df = 18; 5742)	124.603***	375.713***	472.683***	123.753***	79.716***	107.142***

Notes : i_w variables are dependent variable
**p<0.1; **p<0.05; ***p<0.01*

Table A5.6: 2nd neighbor models - i_{ww} is dependent variable

	Dependent variable:					
	SP2INVQ	SP2EMP	SP2EMPL_UNI	SP2INC	SP2MIG	SPGDP
plm::lag(spinvq, 1)	0.066***	-0.001***	-0.0003	-0.002***	-0.0005***	0.001
	(0.008)	(0.0004)	(0.001)	(0.001)	(0.0001)	(0.001)
plm::lag(spemp, 1)	0.371*	0.012	-0.010	-0.013	-0.013***	0.068***
	(0.216)	(0.011)	(0.024)	(0.014)	(0.003)	(0.024)
plm::lag(spempl_uni, 1)	-0.212**	-0.047***	-0.006	-0.003	0.003**	-0.044***
	(0.101)	(0.005)	(0.011)	(0.007)	(0.001)	(0.011)
plm::lag(spinc, 1)	-0.076	-0.007	-0.051***	-0.045***	-0.006***	-0.016
	(0.126)	(0.007)	(0.014)	(0.008)	(0.002)	(0.014)
plm::lag(spmig, 1)	-2.882***	0.179***	0.318***	0.276***	0.076***	0.152**
	(0.595)	(0.031)	(0.066)	(0.039)	(0.008)	(0.066)
plm::lag(spgdp, 1)	0.253***	0.009**	0.025***	0.014***	0.001	0.014
	(0.078)	(0.004)	(0.009)	(0.005)	(0.001)	(0.009)
plm::lag(sp2invq, 1)	0.475***	0.003***	0.008***	-0.002**	0.0004**	0.002
	(0.011)	(0.001)	(0.001)	(0.001)	(0.0002)	(0.001)
plm::lag(sp2emp, 1)	-1.117***	0.606***	0.016	0.046**	0.005	-0.059*
	(0.284)	(0.015)	(0.032)	(0.019)	(0.004)	(0.032)
plm::lag(sp2empl_uni, 1)	-0.660***	-0.011*	0.674***	0.017**	-0.018***	0.118***
	(0.125)	(0.007)	(0.014)	(0.008)	(0.002)	(0.014)
plm::lag(sp2inc, 1)	0.424**	-0.018*	-0.054**	0.344***	0.018***	-0.126***
	(0.204)	(0.011)	(0.023)	(0.014)	(0.003)	(0.023)
plm::lag(sp2mig, 1)	-0.022	0.310***	0.264**	-0.090	0.357***	-0.120
	(0.924)	(0.048)	(0.103)	(0.061)	(0.013)	(0.103)
plm::lag(sp2gdp, 1)	0.424***	0.060***	0.128***	0.078***	0.013***	0.425***
	(0.120)	(0.006)	(0.013)	(0.008)	(0.002)	(0.013)
plm::lag(sp3invq, 1)	0.049***	-0.0004	0.005***	-0.002**	-0.0004*	-0.002
	(0.014)	(0.001)	(0.002)	(0.001)	(0.0002)	(0.002)
plm::lag(sp3emp, 1)	1.674***	0.132***	0.197***	0.114***	-0.019***	-0.066**
	(0.302)	(0.016)	(0.034)	(0.020)	(0.004)	(0.034)
plm::lag(sp3empl_uni, 1)	-0.870***	-0.066***	-0.074***	-0.028***	0.011***	0.017
	(0.130)	(0.007)	(0.014)	(0.009)	(0.002)	(0.014)
plm::lag(sp3inc, 1)	-0.447*	-0.083***	-0.124***	-0.197***	-0.026***	-0.145***
	(0.246)	(0.013)	(0.027)	(0.016)	(0.003)	(0.027)
plm::lag(sp3mig, 1)	-4.735***	0.796***	1.003***	-0.110	0.146***	0.155
	(1.105)	(0.058)	(0.123)	(0.073)	(0.015)	(0.123)
plm::lag(sp3gdp, 1)	0.029	0.017**	0.061***	0.042***	0.001	0.076***
	(0.133)	(0.007)	(0.015)	(0.009)	(0.002)	(0.015)
Observations	6,137	6,137	6,137	6,137	6,137	6,137
R2	0.318	0.610	0.558	0.227	0.302	0.245
Adjusted R2	0.271	0.584	0.527	0.174	0.255	0.193
F Statistic (df = 18; 5742)	148.668***	499.556***	402.046***	93.532***	138.280***	103.239***

Notes : i_w variables are dependent variable
**p<0.1; **p<0.05; ***p<0.0*

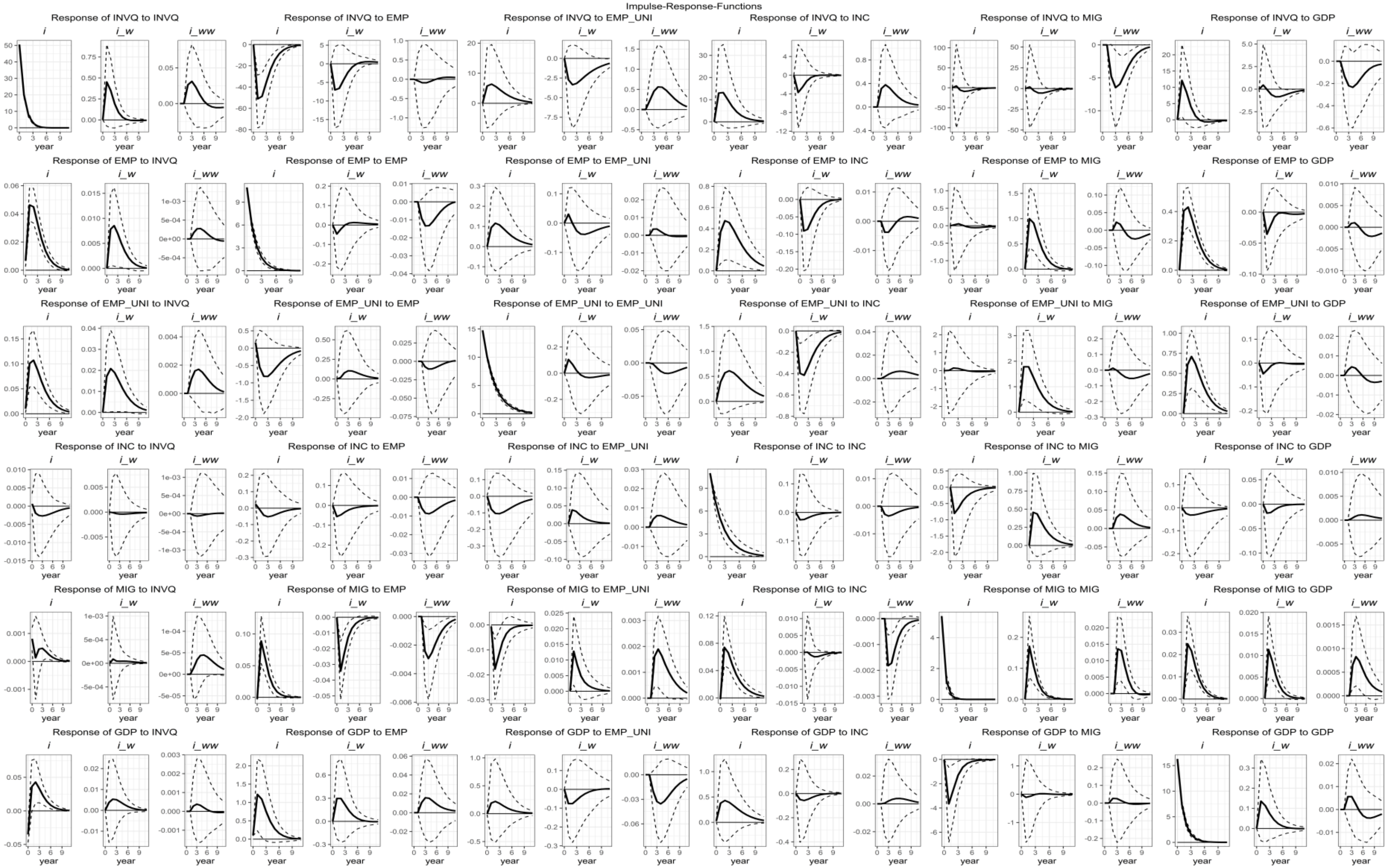

Figure A5.1: Full set of estimated IRFs. *Notes: Model as presented in Section 5.3. Graph Specifications equal Figure 5.2*

6. General Conclusions

This thesis consists of four stand-alone research papers that examine the effects of public regional policies on regional living conditions using spatial vector autoregressive methods. The thesis contributes to the existing literature by emphasizing multidimensional outcomes of regional policy measures that are not limited to effects on economic growth, while using well-grounded theory. Moreover, it contributes to the development of appropriate spatial econometric research designs in the analysis of regional policy effects. This combination of spatial econometric methods and socioeconomic research questions and variables has rarely been found in policy evaluation studies so far.

The analyses carried out in this thesis show that the reduction of regional inequalities and promotion of spatially equivalent living conditions is an important topic in regional science and economic geography due to its economic, social and political implications. Socioeconomic trends such as demographic change and the new geography of jobs are leading to increasing disparities. As a result, dynamic metropolitan areas with economic strength, young populations and high levels of attractiveness and opportunities are emerging, while structurally weak and more rural areas are being left behind by this development. As shown in section 1, the discussion about regional disparities cannot be reduced to economic disparities, since they determine individual quality of life and life chances, making regional redistributive policies social policies by economic means (Iammarino et al., 2019). Thus, by maintaining more equal opportunities, improving individual life perspectives and life chances, and safeguarding democratic stability, efficacious regional policies are powerful political instruments in spatial economic and social development. These outcomes justify policies aimed at spatial equity, even though they may not provide the most efficient economic outcomes.

Table 6.1: Summary of key research findings – Section 2 to 4

Title: *How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany*

Policies:	Fiscal equalization scheme & GRW	*Key findings:* Equalization scheme grants have significant positive effects on net migration rates. This is particularly the case for regions with low endogenous fiscal capacity and persons under 50 years of age. GRW subsidies have almost no impact on regional net migration rates.
Regional level:	German labor market regions	
Main indicators:	Net migration rates	

Title: *Measuring the regional, multifaceted, direct and indirect Effects of European Cohesion Policies*

Policies:	ERDF, ESF & Cohesion fund	*Key findings:* ERDF funding has positive effects on regional GDP, employment and household income growth. Effects are stronger in less developed regions. No robust effects are found for ESF and Cohesion Fund. Migration rates are not affected by any of the policies.
Regional level:	EU28, NUTS-2	
Main indicators:	GDP, Employment rates Household Incomes Migration rates	

Title: *Who benefits from structural investment policy? An empirical analysis of the German structural fund GRW on regional wage structures*

Policy:	GRW Industry & Infrastructure schemes	*Key findings:* GRW industry subsidies lead to growth in wages above the median wages in West-Germany and growth in all wages except 90^{th} percentile in the East. Infrastructure subsidies have no effects on wages in the West, but lead to robust growth of wages at the 25^{th}, 50^{th} and 75^{th} percentile in the East. Positive effects are found in the service sector, but not in the industrial sector.
Regional level:	German county districts and independent cities	
Main indicators:	Wages at 10^{th}, 25^{th}, 50^{th}, 75^{th} & 90^{th} percentile	

However, based on the findings of the research conducted, it is not possible to draw unambiguous conclusions about the efficacy of policy instruments on the outcome variables examined in sections 2 to 4. The empirical findings suggest, that policies have multiple effects on regional migration rates and wages, suggesting that they can be effective in increasing the quality of life and material living standards in subsidized regions, but the presence and strength of effects are highly dependent on the policies modes of action, regional socioeconomic preconditions and the regional outcome variables studied. This indicates that the policies under investigation in this thesis have different transmission channels and that a closer look into the findings is needed to draw more general conclusions. Table 6.1 provides an overview on the key findings from the research conducted in section 2 to 4.

Section 5 has a different approach than the other papers und therefore has an exceptional position in this thesis. It builds upon the methodological progress of spatially indirect responses to variable shocks presented in section 2 by presenting a method that allows to estimate additional IRFs that account not only for within-region interdependencies between variables, but also for cross-regional interdependencies through spatial spillovers in an extended vector-autoregressive system. This paper does not primarily aim to measure the effectiveness of a particular policy, but to improve the SpVAR methodology, since the method has been found to be very well suited in policy evaluation. Table 6.2. presents the key results of this paper.

Table 6.2: Summary of key research findings – Section 5

Title: *Analyzing the spatio-temporal diffusion of economic change –Advanced statistical approach and exemplary application*

Policy:	-	*Key findings:*
Regional level:	German county regions	Extension of the SpVAR approach to SptpVARs improves the approach and brings new insights by capturing all spatio-temporal dynamics. For example: employment growth leads to regional growth of net migration rates, but declining net migration rates in linked regions of 1st and 2nd dimension. This brings additional information in the assessment of policy effects.
Main indicators:	GDP & employment growth Household incomes Migration rate	

6.1 Overall findings and policy implications

The research findings presented in Table 6.1 allow conclusions on the general efficacy of regional policies in different regional and institutional settings that can be of high interest to policy makers. In this section, more general conclusions will be drawn along the initial research questions provided in section 1.

1. *How can individual well-being and the dynamic development of multidimensional regional inequalities be measured in a suitable way beyond economic parameters?*

As presented in section 1, the use of self-reported measures of well-being or indices generated by political institutions or the researcher itself can introduce significant biases in assessing the impact of regional policy measures on the quality of life. Section 1 and 2 show why finding appropriate measures of quality of life is a very challenging issue. Additional difficulties arise from the problem of finding reliable datasets that are dynamic enough to represent policy effects.

The main solution in this thesis is to build upon regional changes in net migration rates as a dynamic indicator of the quality of life development in a region. As argued in detail in section

2, regional net migration rates provide valuable information about the appeal of regions to individuals. This is what Faggian et al. (2012) refer to as people "voting by their feet" for the attractiveness of regions. Policy interventions that create new regional amenities or improve existing ones should have positive effects on net migration rates. Moreover, using changes in net migration rates allows for individual weighting of regional amenities that improve people's individually perceived quality of life. This makes the indicator more attractive than other conceivable indicators. This solution works well in the context of this thesis and brings useful information for policy analysis, although it should be noted that it is a rather general indicator that definitely has shortcomings. However, as outlined in the thesis, the advantages outweigh the disadvantages.

In addition, wages, as used in section 4, are an appealing indicator to assess the material benefits that people derive from policy subsidies. It allows for more accurate statements about people's welfare growth than regional GDP development does. Most importantly, examining different quantiles of the wage distribution makes it possible to examine the intra-regional distributional effects, which allows to draw conclusions about the social effects of the policy. Since the econometric method chosen allows the evaluation of both socioeconomic and variable factors, the combination of these elements provides important information for policy evaluation.

Of course, the use of other indicators is also possible. However, they must be dynamic, of reliable data quality, and have the desired explanatory power. Recent publications (e.g. Ferrara et al., 2020) show that other approaches bring additional information into the discussion. An improved data accessibility may lead to an increase in other indicators capable of measuring new dimensions of regional policy outcomes in the future.

Research question 2 and 3 are thematically connected and can be discussed together:

2. *Which policy measures are proving particularly effective to reduce dimensions of regional inequalities?*
3. *Are there differences in the regional effects between those policy measures that directly affect public institutions and the municipal budget (e.g. formula-allocations in fiscal equalizations) and those that directly support private actors (e.g. structural funds)?*

The findings suggest that all policies examined are capable of supporting a more balanced spatial development. All of them, GRW, fiscal equalization and European Cohesion Policies show some positive regional outcomes, but no universal efficacy. It can be concluded that the existence of policy effects is not self-evident, but depends on a variety of factors and on the effects intended by policymakers.

To increase the regional quality of life, fiscal equalization seems to be the most appropriate among the policies studied in this thesis. With its particular efficiency in regions with low endogenous fiscal capacities, it seems to support the experienced regional amenities and to be a useful policy to prevent out-migration from structurally weak regions. This would help to reduce the negative regional consequences resulting from long-term outmigration and thus break a potential negative spiral of regional development, by, for example, making public and private investments in infrastructure and housing more worthwhile again. An explanation for the effects found is that equalization grants give regional actors the largest freedom in the use of the grants and are therefore better tailored to regional needs and because it offers extended financial securities compared to GRW and Cohesion subsidies, which are disbursed only once to a specific project. The latter policies do not appear to have an impact on regional net migration and non-economic amenities. However, many studies emphasize the economic growth effects from structural funds, implying that they are useful in this sense (e.g. Eberle Mitze et al., 2019; Alecke et al., 2013 for GRW; Crescenzi & Guia, 2020; Fiaschi et al., 2018; Pellegrini & Cerqua, 2017 for ESIF funds). Moreover, section 3 supports this by finding that the ERDF has positive effects on economic growth and household income growth. Section 4 proves that GRW can support material living standards by increasing wages and that subsidies to projects co-financed by public actors (infrastructure scheme) are also more effective to increase wages in East-Germany than subsidies to private actors (industry subsidies). This supports the conclusion that increasing the public budget is a promising method to increase regional living conditions.

Both material living standards and non-economic amenities are important for the development of living conditions and individual opportunities and capabilities in the regions. This thesis shows that economic growth and perceived quality of life are not directly related, since fiscal equalization reveals effects on regional net migrations without promoting economic growth, while the opposite is observed for GRW and the ERDF subsidies. Thus, economic growth does not seem to be the most important factor for perceived quality of life, which again shows how important it is to assess new regional dimensions of policy outcomes.

Several policy implications can be derived from this. First, unconditional policy grants appear to be more effective in promoting non-material living conditions and creating regional amenities than earmarked single-payment subsidies. This presence of particularly positive effects of fiscal equalization on migration rates suggests that financial freedoms in the public budget are an important factor that allows governments to address individual problems and promote endogenous regional development potentials without the pressure of economic efficiency. Regional quality of life seems to depend to some extent on public financial resources. This is an important finding as many regions, especially those that are structurally weak, face financial challenges and limited public budgets. In Germany, municipal debt is widespread, and severely affected municipalities are not allowed to invest in potential development factors due to budget protection regularities (*In German: Haushaltsicherungskonzept*).

Thus, the first policy implication for ensuring a more balanced spatial development is that policies should increase the financial freedom of municipalities and their abilities to act. This does not mean that other policy settings cannot be effective. However, the findings suggest that they are effective only in some cases. Thus, the second implication is: policy design and subsidy payment should be more flexible, allow for the freest possible use and be individually tailored to regional preconditions and needs in order to increase their efficacy and to achieve the intended results. Rather rigid policy designs appear to be less suitable to the individual needs of the regions.

4. *Are there regional differences in the effectiveness of funds, for example between rural and urban areas? Can regional factors be identified that have a particular (positive or negative) influence on the impact of policy measures in the selected areas of life (e.g. population density, demographics or economic strength)?*

Although, it is found that all policies can have positive effects, all three research papers on policy effectiveness indicate a high degree of conditionality in the effects. In all cases, the policies had significant and stronger effects in regions that are economically weaker than others in the area covered by the policy. This can be found for net migration rates, which stronger responses to equalization grants in East Germany and in regions with low fiscal capacities than in the other regions. ERDF effects are found to be stronger in less developed regions in the EU, while any significant effects found for the Social Fund are also limited to Eastern Europe. Wage effects of the GRW policy are almost limited to East-Germany. This pattern indicates that policy effects seem to be considerably stronger in regions that have higher needs for regional policy interventions. In contrast, subsidies for economically strong regions seem to be less effective. Due to the policy design, eligibility of funds in the economically strongest regions is not possible (GRW & Cohesion Fund) or severely limited (ERDF & ESF), while almost all regions benefit from equalization grants. The resulting policy implication is that funding should be concentrated even more on structurally weak regions, as this is where the greatest effectiveness could be found and where the need for policy interventions to ensure spatially balanced development is the highest.

Another, more general policy implication results from section 5. Policy makers and evaluators must also consider spatially indirect policy effects. The thesis shows by adding on econometrical methods that positive effects in the funded region can have negative effects in neighboring regions. This may result in a zero-sum effect or even in a negative effect, because the neighboring regions becomes in need for stronger policy interventions as well, which then could trigger negative effects in the initially successfully funded region. Policy analysis should pay more attention to this problem.

6.2 Limitations and research outlook.

A real-world research setting always entails limitations that must be considered when evaluating the research findings. The underlying research highlights that multidimensional regional policy outcomes are not easy to assess. There are several reasons for this.

First, there are methodological constraints. The time lag between a subsidy and its effects in a region is unknown and depends on the type of the subsidy or the associated project. In any case, our tests show that the explanatory effect of the models is best when a lag of one year between funding and outcome measurement is used (two in the additional estimation case for ESIF funds.). However, this estimation strategy does not account for effects that unfold their effects later in time (e.g., infrastructure projects that have a long construction period, or indirect effects that occur over time, such as long-term effects due to productivity gains). The SpVAr models allow these indirect effects to be included as accurately as possible, but there will still be effects that are missed in the response calculation.

A second problem arises from the complexity of regional outcomes. SpVAR models assume the completeness of all relevant variables in the system in order to mitigate potential bias from variables that are not included in the model. This is obviously impossible in complex spatial interaction system and could affect the results. However, the variables used in the empirical research have been carefully selected and grounded in theoretical considerations, so that it seems very unlikely that there are influencing factors that would completely change the results. Moreover, the key results presented in this thesis prove to be robust, supporting this assumption. Nevertheless, the causality of the estimated relationships in the SpVAR system should be interpreted cautiously, even though the impulse response functions can be claimed as causal effects in theory (Di Giacinto, 2010)

Another limitation results from the dynamic panel models underlying the SpVAR estimations. Much care has been taken to carefully estimate reliable models, but no econometric system is perfect, especially when it comes to dynamic panel data models. It is explained, why all commonly used dynamic panel models that include fixed-effects have shortcomings that may bias the results. However, a careful check of the robustness of the results as it is done in the empirical research papers seems to be a good way to mitigate potential biases rather than using models that ignore individual or time constant effects in the models.

Sections 2 and 5 improve the spatial econometric methods used and provide complementary insights by estimating additional spatial IRFs. This helps to overcome the shortcoming of incorrect spatial spillover estimation that is presented in detail in section 5. This can be an advantage for future policy analyses using SpVAR methods. The developed method can be easily tailored to other indicators, policies, regional levels and estimation techniques. New panel data estimators such as transformed likelihood estimators could be a way to improve the known shortcomings from fixed-effect estimators (Pickup & Hopkins, 2020). Unfortunately, this technique has not proven to be appropriate for the data used in this thesis.

Assessing other policies might be useful, as there are important policies at the international level (such as the European Agricultural Fund for Rural Development) or even within Germany (e.g. the Urban Development Fund) whose effects have not yet been analyzed in this context. The heterogeneous findings in this thesis suggest that different results can be expected for other policies as well. Moreover, the research on fiscal equalization schemes is still very sparse compared to structural funds, despite the enormous financial volume of the schemes. Our research suggests, however, that equalization schemes appear to be appropriate to support the goal of spatially equivalent living conditions. Future research could take this finding as an opportunity to focus more on these kinds of unconditional policy measures.

In addition, some information might get lost due to data structure. First the regional level of the included variables has implications for the results and for spatial spillover effects. Section 2 explains why using a large regional scale can be a shortcoming for estimating differentiated policy outcomes. Moreover, it is explained above why time is an important factor. The use of annual intervals in the panel data may be too inflexible to correctly assess policy impacts. Shorter time intervals might be better for in depths analysis. Thus, SpVARs with aggregated regional variables are appropriate to estimate overall policy effects, but have shortcomings in identifying regional transmission channels, which, based on our results, seem to rely on individual regional factors.

It should be noted that the indicators used in this thesis also have shortcomings. These are discussed in detail, particularly with regard to the migration indicator. However, it appears that there is a need for studies focusing on non-economic indicators to measure regional quality of life and living standards beyond GDP policy outcomes, as exemplified by recent publications by Ferarra et al. (2020) or the European initiative for a Social Progress Indicator (Annoni & Bolsi, 2020). The social and economic trends described in this thesis suggest that the analysis of regional disparities will remain an exciting and active field that has not yet reached its limits.

At the same time, the amount of accessible data is growing, which will allow future studies to focus on new outcome dimensions and explore new questions beyond measuring GDP effects. These studies could also assess regional sustainability goals. These are of great interest for future regional, economic and social development and have found their way into regional growth models (Nordhaus, 2018) and Cohesion Policy goals (European Commission, 2019).

As a final point, the results obtained from the research papers indicate a high degree of regional conditionality in policy efficacy. In order to get closer to actual regional transmission channels that promote the efficacy of redistributive policies, the factors that influence this conditionality need to be examined in more detail. While this thesis focuses primarily on economic conditionality, there might be other relevant factors such as the quality of government and local institutions that define the absorptive capacities of regions (Rodriguez-Pose & Garcilazo, 2015; Fratesi & Wishlade, 2017). Finding these factors would help to develop and improve regional policies that are specifically tailored to regional needs.

6.3 Final remarks

Structurally weak regions are more than just peripheral spaces with a lack of economic strength and jobs. They are home to many people, the place of their families and friends and local communities. Thus, home regions have an important function for people. I personally believe that in an increasingly globalized world, the region, the county or city will still play an important role for people, due to local characteristics such as local languages, customs or dishes that can provide a sense of stability and orientation in the modern world and, with other obligations and frictions, are the reason why the place of residence is not simply interchangeable for many people. Moreover, these regions contribute to social and cultural diversity and are therefore worth of not simply being abandoned despite their structural problems.

This thesis aimed to investigate whether regional policies can support this goal and affect the people's daily life by helping to make life in the regions more livable and to increase their individual perspectives, chances or wages. With regard to the theoretical considerations and empirical findings, the thesis is able to contribute to the discussion about regional living conditions and regional policy effects and perhaps even to policy making by providing empirical policy implications. The thesis shows that regional policies can contribute to future spatially balanced regional development in various context.

Policymakers have to be open to new ideas, keep an eye on economic and social trends and have to design flexible policies in order to meet the needs of the municipalities and population and unfold their effects in the regions. The introductory quote from the German coalition agreement and the ongoing revisions to the European Cohesion Policies illustrate that policy designs will evolve in the future. If empirical research such as this thesis can contribute to this, its goal will have been met.

6.4 References

Alecke, B., Mitze, T. & Untiedt, G. (2013). Growth effects of regional policy in Germany: Results from a spatially augmented multiplicative interaction model. *The Annals of Regional Science*, 50, 535-554, DOI 10.1007/s00168-012-0503-7.

Annoni, P. & Bolsi, P. (2020). The Regional Dimension of Social Progress in Europe – Presenting the new EU Social Progress Index. *European Commission Working Paper 06/2020*. Luxemburg: Publications Office of the European Union.

Crescenzi, R. & Guia, M. (2020). One or Many Cohesion Policies of the European Union? On the differential economic impacts of Cohesion Policy across Member States. *Regional Studies,* 54, 10-20. DOI: 10.1080/00343404.2019.1665174.

Di Giacinto, V. (2010). On vector autoregressive modelling in space and time. *Journal of Geographical Systems,* 12, 125-154. DOI: 10.1007/s10109-010-0116-6.

Eberle, J., Brenner, T. & Mitze, T. (2019). A look behind the curtain: Measuring the complex economic effects of regional structural funds in Germany. *Papers in Regional Science*, 98, 701-735. DOI: 10.1111/pirs.12373.

European Comission (Ed.) (2019): Integration of environmental concerns in Cohesion Policy Funds (ERDF, ESF, CF) - Results, evolution and trends through three programming periods (2000-2006, 2007-2013, 2014-2020). Luxemburg: Publication Office of the European Union. DOI: 10.2779/748821.

Faggian, A., Olfert, M. & Partridge, M. (2012). Inferring regional well-being from individual revealed preferences: the voting with your feet approach. *Cambridge Journal of Regions, Economy and Society,* 5, 163-180. DOI: 10.1093/cjres/rsr016.

Ferrara, A., Dijkstra, L., McCann, P. & Nistico, R. (2020). The Response of Regional Well-Being to EU Cohesion Policy Interventions. *SSRN Working Paper.* DOI: http://dx.doi.org/10.2139/ssrn.

Fiaschi, D., Lavezzi, A. & Parenti, A. (2018) Does EU cohesion policy work? Theory and evidence. *Journal of Regional Science,* 58, 386-423. DOI: 10.1111/jors.12364.

Fratesi, U. & Wishlade, F. (2017). The impact of European Cohesion Policy in different contexts, *Regional Studies* 51, 817-821. DOI: 10.1080/00343404.2017.1326673.

Iammarino, S., Rodriguez-Pose, A & Storper, M. (2019). Regional Inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*, 19, 273-298. DOI: 10.1093/jeg/lby021.

Nordhaus, W. (2018). Evolution of modeling of the economics of global warming: changes in the DICE model, 1992–2017. Climatic Change, 148, 623-640. DOI: 10.1007/s10584-018-2218-y.

Pellegrini, G. & Cerqua, A. (2017). Are we spending too much to grow? The case of structural funds. *Journal of Regional Science,* 58, 535-563. DOI: 10.1111/jors.12365.

Pickup, M. & Hopkins, V. (2020). Transformed-likelihood estimators for dynamic panel models with a very small T. *Political Science Research and Methods*. Advance online publication. DOI:10.1017/psrm.2020.30.

Rodríguez-Pose, A. & Garcilazo, E. (2015). Quality of Government and the Returns of Investment: Examining the Impact of Cohesion Expenditure in European Regions. *Regional Studies,* 49, 1274-1290. DOI: 10.1080/00343404.2015.1007933.

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Erklärung

Ich erkläre an Eides statt, dass ich meine Dissertation mit dem Titel

"Multifaceted effects of public regional policy measures on regional living conditions. Evidence from German redistribution policies and European Cohesion Policy"

selbstständig und ohne unerlaubte Hilfe angefertigt und mich dabei keinerlei anderen als der von mir genannten Quellen und Hilfen bedient habe.
Die Dissertation wurde in der jetzigen oder einer ähnlichen Form noch bei keiner anderen Hochschule eingereicht und hat bislang noch keinen sonstigen Prüfungszwecken gedient.

Marburg, den 03.03.2021

Sven Wardenburg