The impact of fiscal policy and internal migration on regional growth and convergence in Germany

Katharina Weddige-Haaf
(Utrecht University)
k.weddige@uu.nl

Clemens Kool
(CPB and Utrecht University)

Abstract

The paper seeks to determine the sources of real per capita income growth and convergence in the 16 German states over the period 1995-2014 using a panel approach. The empirical analysis applies the popular growth – initial income equation which has its theoretical foundations in the neoclassical Ramsey model. We augment the basic model specification with a trend term and a crisis dummy to get a better understanding of the convergence mechanisms. We then include additional explanatory variables into the augmented model. The purpose is to investigate the impact of internal migration and different forms of fiscal policy – tax transfers and structural funding – on economic growth and convergence. We find that internal migration has a positive impact on growth in the East and thus contributes to the convergence between East and West. Horizontal tax equalisation is ineffective in promoting growth and convergence, but the positive growth impetus from federal supplementary grants has contributed to convergence between grant receiving and non-receiving states. Structural funding is found to have opposing growth effects on Eastern and Western states and has thus significantly promoted convergence.

Key words: Convergence; Growth; Internal migration; Fiscal equalisation; Structural funding; Germany

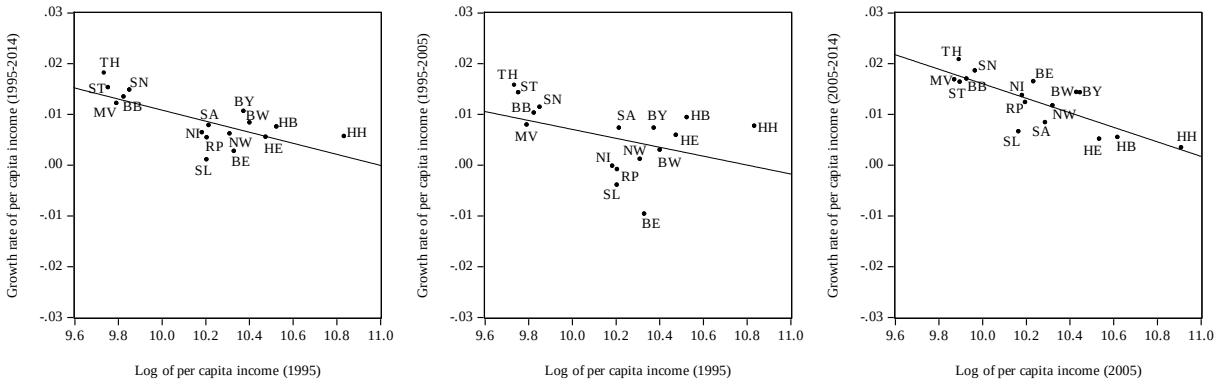
JEL codes: C33; E13; E62; O15; O47

1. Introduction

Ever since the German reunification in 1990, German authorities have put in tremendous efforts to transform the East-German industry into an internationally competitive economy and to equalise living conditions[1] between the Eastern and the Western part of the country. This requires poorer regions to grow faster than richer ones. To investigate the equalisation of living conditions, real per capita income is the relevant prosperity indicator of choice, see Eltges (2013).

Figure 1 (left panel) provides a graphical illustration. It shows the relation between initial real per capita incomes in 1995 and the corresponding growth rates over the period 1995-2014 for the 16 German federal states, as well as a fitted regression line (Figure 1, left panel). The negatively sloped regression line indicates that states with lower initial incomes grew faster on average than states with higher initial incomes over the period, suggesting convergence of incomes. The two clusters in the figure demonstrate the clear division between the low income-high growth rate states in the East and the higher income-lower growth rate states in the West.

Figure 1 Relationship between average annual growth rate and initial per capita income[2]



Note that our sample includes the financial crisis and subsequent recovery. To investigate the stability of the convergence process over time, we divide the period into two sub-periods (Figure 1). The fitted line is flatter in 1995-2005 than in 2005-2014, indicating faster convergence in the second period. Also, the right panel shows divergence of income within the group of Western states in the second sub-period (Deutscher Bundestag, 2016).

A substantial literature on the – lack of – convergence in Germany exists. In this paper we investigate growth and convergence in real per capita incomes between the 16 German federal states[3] over the period 1995-2014, using panel estimation. We include three additional explanatory variables into the model to investigate the impact of internal (net) migration and two different forms of fiscal policy – tax transfers and structural funding – on economic growth and convergence. Our analysis contributes

[1] Art. 72 Abs.2 GG (German constitution)
[2] Please refer to Appendix I for the list of abbreviations.
[3] The study is based on this level of aggregation because the federal equalisation system works at the level of the German federal states.

to the literature in three ways. First, the time frame of the study extends beyond the recent financial crisis, allowing for an assessment over a longer and more volatile period than is done in most other related studies. We use a dummy variable for the financial crisis period. Second, we explicitly account for potential misspecification due to ongoing technology growth by including a trend term in our panel analysis. Third, we hypothesise that the effect of our three additional explanatory variables on growth depends on initial conditions. In the majority of earlier studies, those explanatory variables are simply added to the original equation, measuring the direct effect of these variables on economic growth. To take account of the hypothesized conditionality, we introduce interaction effects for the additional explanatory variables in our empirical model. This leads to a non-linear specification and allows for the analysis of conditional marginal effects. Variables for migration, fiscal equalisation and regional structural funding are not included jointly, but added in turn to the growth – initial income equation.

We find that internal migration has a positive impact on growth in the East and thus contributes to the convergence between Eastern and Western states. Horizontal tax equalisation is ineffective in promoting growth and convergence, but the positive growth impetus from federal supplementary grants has contributed to convergence between grant receiving and non-receiving states. Structural funding is found to have opposing growth effects on Eastern and Western states and has thus significantly promoted convergence.

The paper is structured as follows. Section 2 summarises the literature on convergence in Germany in general and with respect to migration, the fiscal transfer system and structural funding in particular. Section 3 presents stylised facts of the data that we use in our empirical analysis. Section 4 presents the empirical results of the panel estimations. Section 5 concludes.

2. Literature on convergence in Germany

In this section we summarise the literature on convergence in Germany. In section 2.1, we introduce the concepts β-convergence and discuss various empirical applications to Germany. We proceed with a summary of the empirical evidence for the impact of migration on regional growth and convergence in section 2.2. We focus on the German federal equalisation system and its impact in section 2.3 and on the effects of regional structural policy in section 2.4. In the literature, the empirical evidence for convergence in Germany is mixed. Unconditional β-convergence is identified in a number of studies, but the results are often not robust to the inclusion of additional explanatory variables. Internal migratory flows between East and West have been identified advantageous for convergence. Studies on fiscal equalisation focus on the growth impact of various measures of horizontal and vertical redistribution, which are not found to have had the intended effects. The empirical evidence for structural funding is somewhat more promising in general.

2.1. Concepts of convergence

The concept of β-convergence is a popular approach in empirical studies of economic convergence across countries or regions within a country (Barro and Sala-i-Martin, 1992). Two types of β-convergence can be distinguished. Unconditional (also: absolute) β-convergence assumes that the only difference across economies is their initial level of capital and hence that all economies converge to the same steady state level of per capita income. Under this assumption, a poor economy tends to grow faster than a rich one, since the speed of convergence to the steady state is increasing in the distance from the steady state. Poor countries catch up to the rich ones in terms of levels of per capita income. This concept is generally accepted for regional data sets rather than for international data sets, since different regions within a country are more likely to be similar with respect to technology and preferences than individual countries (Barro and Sala-i-Martin, 2004). Conditional convergence emphasises possible differences in the steady state between economies. Since the speed of convergence depends on the distance of an economy from its own steady state, it is possible that poorer economies grow slower than rich ones if they are closer to their own steady state.

The growth-initial level equation which is generally applied empirically to test for β-convergence (Barro and Sala-i-Martin, 1992) has its roots in the neoclassical growth model and is given by

$$ln(y_{it}/y_{it-T})/T = c_{it} - \left(1 - e^{-\beta T}\right)/T\, ln(y_{it-T}) + u_{it} \qquad (1)$$

where $ln(y_{it}/y_{it-T})/T$ is the average per capita growth rate over horizon *T*, $ln(y_{it-T})$ is the level of per capita income in the starting period, and the subscripts t and i denote time and the country or region respectively. c_{it} is a constant that includes the steady state level of per capita income and the steady state growth rate. The steady state level of income is determined by the savings rate, population growth, the rate of depreciation, technology and the share of capital. The values of the steady state level and growth rate are unknown and determine the value of β, which is the speed of convergence to the steady state and the key parameter to be estimated.

In the case of unconditional convergence, the savings rate, population growth, the rate of depreciation, technology and the share of capital are assumed to be the same for all economies, so that $c_{it} = c_t, \forall i$. Then, in empirical estimations, the sign of β should be positive[4] even if no other explanatory variable is included into the estimations. In the case of conditional convergence, $c_{it} \neq c_{jt}, \forall i, j$; appropriate explanatory variables need to be included into the empirical estimations to control for these differences (Sala-i-Martin, 1995; Islam, 2003). The simplest way to test equation (1) is to use a cross-section dataset. However, having just one data point for a country or region provides a weak basis for estimation of the convergence parameter (Islam, 2003). Panel estimation (cf. Eggert et al., 2007) is an

[4] In the neoclassical growth model with labour-augmenting technological progress, $\beta = (1 - \alpha) \times (\delta + n + x)$, where α is the share of capital in the production function, δ is the rate of depreciation, n is population growth and x is the rate of productivity growth. Since $0 < \alpha < 1$, $\beta > 0$.

extension of the cross-section approach (cf. Berthold and Kullas, 2009; Maseland, 2014; Boltho et al., 2016) and allows studying per capita income over several periods. [5]

Applications of the growth-initial level equation to Germany vary in the choice of convergence indicators and levels of regional data aggregation. The two most popular convergence indicators (Eltges, 2013) are GDP per capita (Boltho et al., 2016; Scheufele and Ludwig, 2009; Eggert et al., 2007) and GDP per effective unit of labour (Alecke et al., 2011; Berthold and Kullas, 2009; Kubis and Schneider, 2009). Maseland (2014) studies German districts, Eltges (2013) and Alecke et al. (2011) investigate German labour market regions, Eggert et al. (2007) look at NUTS2 and NUTS3 regions, Boltho et al. (2016), Scheufele and Ludwig (2009) and Berthold and Kullas (2009) study the German federal states. The empirical evidence for convergence between German regions is mixed. Berthold and Kullas (2009), Eggert et al. (2007), Scheufele and Ludwig (2009) and Maseland (2014) find unconditional convergence, but the results are not always robust to the inclusion of additional variables (Eggert et al., 2007; Scheufele and Ludwig, 2009; Maseland, 2014). In the presence of a dummy "East", Kubis and Schneider (2009) find the convergence of labour productivity to be higher between Eastern than between Western districts, and their result is robust to the inclusion of net migration. To the contrary, Boltho et al. (2016) do not find support of convergence between German states in the presence of the dummy.

2.2. Migration

According to neoclassical theory, the movement of people from regions with lower income per capita to regions with higher income per capita should raise income per capita in the former while reducing that of the latter, due to diminishing returns to capital. In this way, migration is theoretically expected to contribute to the convergence of per capita incomes across regions (Shioji, 2001). If migration was an important source of convergence, the convergence coefficient estimated in empirical growth regressions would include the effect from migration so that the estimated speed of convergence should become smaller when migration is included as an explanatory variable in the growth regressions (Barro and Sala-i-Martin, 2004).

The number of studies that empirically investigate the impact of internal migration[6] on regional growth is rather limited. Etzo (2008b) presents an overview of international applications and shows that the empirical support for the positive impact of migration on convergence is generally rather weak. Shioji (2001) argues that one of the reasons for the failure to empirically identify the positive migration effect is the assumption of labour homogeneity in the theoretical model. Convergence is

[5] Equation (1) has been tested empirically to study convergence between countries Baumol (1986); Sala-i-Martin (1995); Sousa and Pereira (2012) and between regions (for example Barro and Sala-i-Martin (1991); Barro and Sala-i-Martin (1992); Sala-i-Martin (1995)).

[6] Internal migration involves the reallocation of people within the national borders. In contrast, international migration studies focus on the movement of people across different countries.

based on the effects of migration that work through changing the amount of labour input (quantity effect). However, if heterogeneity of labour is allowed for (composition effect)[7], the impact of migration on convergence is ambiguous (Kubis and Schneider, 2009).

Migration flows from East to West have dominated German internal migration until recently. Kubis and Schneider (2009) have investigated the relationship between migration and regional convergence for German counties using a cross-section approach over the period 1995-2006 and find a positive correlation between growth and migration for more productive regions and a negative correlation between growth and migration for less productive regions in Germany. For the latter, higher growth rates are hence associated with large negative net migration rates; the reallocation of people from low-productivity regions to high productivity regions is found to be advantageous from a macroeconomic perspective. Scheufele and Ludwig (2009) argue that migratory flows have had a significant impact on the growth rates of per capita incomes. IWH (2011) states that convergence in per capita incomes between East and West has been the result of a decline in East German population. Migratory flows between East and West seem therefore to have supported convergence in per capita incomes.

2.3. Federal financial equalisation system (Länderfinanzausgleich)

One of the key fiscal policy tools for promoting convergence and equalising living conditions between German regions is the federal fiscal equalisation system (Länderfinanzausgleich), which aligns the fiscal revenues between states. The Eastern states have joined the tax-sharing arrangement in 1995 after having received special fiscal transfers for several years.

Germany has three independent tiers of government: the federal government (Bund), state governments (Länder) and municipalities (Gemeinden) which are linked by a multitude of political and fiscal relationships. The sharing of tax revenues between the various levels of government lies at the core of those intergovernmental relations. Personal and corporate income taxes as well as value-added taxes (VAT) are part of the tax-sharing arrangement. We refer to Appendix II for further details on the revenue sharing system.

Various empirical studies (Berthold et al., 2001; Berthold and Fricke, 2005, Berthold and Fricke, 2007) study the impact of horizontal[8] and vertical[9] fiscal redistribution on economic growth of the 16 German states over various periods after 1991 using a panel model. Vertical and horizontal fiscal redistribution are consistently found to have a highly significant but negative impact on growth. In a recent study Baskaran et al. (2016) investigate the effect of intergovernmental transfers on economic growth in West German states over the period 1975-2005 using a panel dataset. For the period under

[7] Shioji (2001) reviews studies on migration and population composition which provide evidence that migrants tend to have different characteristics from those of non-movers.
[8] Third stage intergovernmental redistribution and redistributive element of VAT.
[9] Variable includes GRW funding and supplementary federal funds, among others.

consideration they find that transfer dependence was at best irrelevant and possibly even harmful for economic growth. Overall, there is no empirical support for the growth promoting or convergence effect of fiscal equalisation.

2.4. Regional structural policy

German structural funding (GRW-Förderung[10]) is the main tool of the German federal and provincial governments for subsidising investments in structurally disadvantaged regions and for promoting regional growth. A brief introduction to regional structural policy is given in Appendix III.

A number of empirical papers have studied the impact of structural funding in Germany in a growth and convergence context. Eggert et al. (2007) focus on EU structural funding using a panel for the 16 German states. It is the only study in this review using state-level data. The following studies all use district level data. Alecke and Untiedt (2007) and Alecke et al. (2011) estimate cross-section and panel models to study the impact of total GRW funding[11] on growth and convergence of per-capita incomes. SVR - Sachverständigenrat zur Begutachtung der gesamtwirtschaflichen Entwicklung (2004) studies the impact of corporate and infrastructure GRW funding on productivity growth of East German labour market regions. Koetter and Wedow (2013) and Eberle and Brenner (2016) also focus on GRW infrastructure and corporate investment subsidies. The cross-sectional study by Eckey and Kosfeld (2005) takes account of spatial spillover effects of GRW intervention.

The findings of these empirical studies are ambiguous. EU structural funding is found to promote convergence between German states, but the overall impact on macroeconomic growth is negative (Eggert et al., 2007). Whereas Alecke and Untiedt (2007) and Alecke et al. (2011) find total GRW funding to have a significantly positive impact on the growth of per capita income and to have a positive impact on the convergence process between regions, Eckey and Kosfeld (2005) cannot identify a statistically significant direct (subsidy to the region) or indirect (subsidy to neighbouring region) impact of GRW subsidies. A positive impact of corporate GRW funding on productivity growth is identified by SVR - Sachverständigenrat zur Begutachtung der gesamtwirtschaflichen Entwicklung (2004). Koetter and Wedow, to the contrary, find a statistically significant growth impetus of corporate subsidies only when higher infrastructure investments are paired with regional business support; but the positive growth effect of corporate subsidies is crowded out by the negative influence of infrastructure subsidies. Further, the subsidies do not promote convergence between East and West. Similar results have been presented by Eberle and Brenner (2016). Their analysis shows that, on average, GRW investments do not foster economic growth in German regions and that subsidies of infrastructure investments negatively influence the growth of regions. It appears that both

[10] Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur".
[11] Total of corporate and infrastructure funding.

the empirical approach and the definition of the underlying funding series determine the outcome of the analysis.

3. Data

This paper uses annual data for the 16 German national states and covers the period 1995-2014[12]. The data for nominal GDP was taken from the German regional accounts. Data on CPI[13], which is used for the deflation of the various nominal time series, and data on internal migration were taken from the German statistical office. Population data was published by Eurostat. Data on fiscal equalisation comes from the German Ministry of Finance. Data on structural funds was provided by the Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA)[14]. It comprises appropriated funds to industry and economic infrastructure that have actually been paid out, assigned to the year in which the funds have been granted. The data distinguishes between German (GRW) and European structural funding (ERDF). The dependent variable is the regional per capita growth rate of real GDP. The descriptive statistics of the data are presented in Table 1.

Before turning to the formal analysis of convergence, we present the stylised facts of our data. In our empirical analysis, we use real GDP per capita as convergence indicator. Table 1 shows that a discrepancy remains between per capita incomes in the Eastern and Western states and that none of the Eastern states has reached West German per capita income levels to this point. We observe that the dispersion of per capita incomes in Germany is higher than the dispersion among both Eastern and Western states, and that the dispersion of per capita incomes is smaller between Eastern than between Western states. The growth rate of per capita GDP has on average been higher in the East suggesting convergence of per capita incomes between the Eastern and the Western part of the country.

We follow Etzo (2008a) and define the gross migration rates as $m_{it}^{out} = \frac{E_{it}}{P_{it-1}}$ and $m_{it}^{in} = \frac{I_{it}}{P_{it-1}}$ where E_{it} $(I_{it})$is the number of people who left (arrived in) region i during period t, P_{it-1} is the population in region i at the beginning of year t, and m_{it}^{out} $\left(m_{it}^{in}\right)$ is the corresponding emigration (immigration) rate. The net migration rate is then defined as the difference of the two gross migration rates $m_{it}^{net} = m_{it}^{in} - m_{it}^{out}$, where m_{it}^{net} is the net migration rate. Migration from the East to the West has exceeded migration from the West to the East ever since reunification and the gap has only closed in recent years. Except for Brandenburg[15], all East-German states have experienced a permanent decline in

[12] Some variables are introduced into the estimations with a lag. The series cover the period 1991-2014. Please refer to Table 1 for an overview.
[13] Consumer Price Index. Not all German states publish individual CPI series. We assume that the inflation rate is approximately the same across German states.
[14] We thank Ms. Antje Puhlmann from BAFA for providing the data and for her explanatory comments.
[15] Brandenburg exhibits a positive net migration rate over the period. Migration patterns in Brandenburg are characterised by rural-urban migration between Brandenburg and the city of Berlin; the two states show almost complementary migration balances Kubis and Schneider (2008).

population, as a result of continuous negative internal net migration. The migration-patterns for the West-German states are less clear cut.

Table 1 Descriptive Statistics

	Mean	Max	Min	Std	Obs
Real per capita GDP (log) [a)]	10.256	10.942	9.736	0.285	320
East	9.924	10.134	9.736	0.084	100
West	10.407	10.942	10.157	0.206	220
Growth rate of real per capita GDP [b)]	0.009	0.027	-0.011	0.009	64
West	0.007	0.021	-0.011	0.008	64
East	0.015	0.027	0.004	0.006	64
Net internal migration [c)]	-0.732	7.211	-13.920	3.547	384
East	-3.396	7.211	-13.920	3.563	120
West	0.479	6.998	-9.381	2.805	264
Horizontal fiscal equalisation [a)]	133.566	968.862	-527.134	314.251	320
East	255.751	326.062	159.664	32.538	100
West	78.027	968.862	-527.134	365.312	220
Federal supplementary grants [a)]	379.126	1987.493	0.000	421.015	320
East	721.649	918.368	479.539	118.024	100
West	223.434	1987.493	0.000	417.100	220
Corporate funding (total) [c)]	36.569	301.581	0.000	60.034	384
East	103.730	301.581	1.922	68.889	120
West	6.041	77.871	0.000	10.380	264
Corporate funding (German) [c)]	31.850	301.581	0.000	56.093	384
East	89.612	301.581	1.078	70.768	120
West	5.595	77.871	0.000	10.091	264
Corporate funding (European) [c)]	4.718	59.738	0.000	9.872	384
East	14.118	59.738	0.000	13.479	120
West	0.445	5.643	0.000	1.035	264
Infrastructure funding (total) [c)]	17.746	321.543	0.000	36.584	384
East	48.007	321.543	0.000	51.735	120
West	3.991	114.452	0.000	11.414	264
Infrastructure funding (German) [c)]	14.339	311.347	0.000	31.497	384
East	38.165	311.347	0.000	46.113	120
West	3.509	113.477	0.000	10.286	264
Infrastructure funding (European) [c)]	3.406	77.605	0.000	9.250	384
East	9.841	77.605	0.000	14.382	120
West	0.481	22.803	0.000	1.874	264

[a)] 1995-2014

[b)] 5-year averages

[c)] 1991-201

We use two definitions of fiscal equalisation as explanatory variables in our analysis: the amounts of horizontal fiscal equalisation[16] and the amounts of federal supplementary grants[17]. The variable is computed as

$$lfa_{it}^{pc} = \frac{LFA_{it}}{P_t Pop_{it}}$$

where lfa_{it}^{pc} [18] is the real per capita fiscal equalisation amount paid/received by region i in period t, LFA_{it} is the nominal fiscal equalisation amount paid/received by region i in period t, P_t is the German consumer price index at time t (2010=100) and Pop_{it} is the population in state i in period t. The increase in total redistributed amounts and general supplementary funds has been in line with GDP growth over the period. At the same time, overall spending on supplementary federal grants (including both general and special-need) has declined. Since 2010, horizontal fiscal redistribution is financed by only four Western states[19]. The cities of Berlin and Bremen are the main recipients in per capita terms. Every year, Berlin receives between 35% and 42% of the total redistributed funds. The share of funds received by the Eastern states has decreased from about 50% in 1995 to roughly 35% in the past few years.

The data on structural funds can be distinguished between the sources of funds (GRW or ERDF) and the destination of funds (industrial or economic infrastructure projects). We follow Alecke et al. (2011) and compute the structural funds data in real per capita terms. For each state i the series for structural funds in real per capita terms have been computed as

$$funds_{it}^{pc} = \frac{FUNDS_{it}}{P_t POP_{it}}, \forall i, t$$

where $FUNDS_{it}$ is the nominal amount of either GRW, ERDF or their sum[20] to state i in period t, P_t is the German price level (2010=100) in period t, POP_{it} is the population in state i in period t.[21] Corporate structural funding has exceeded funding to infrastructure in all periods. Budget resources available for structural funding have decreased over time (Deutscher Bundestag, 2016). The Eastern states are the prime destinations of structural funding; more than 75% of total structural funds have been spent in the East.

[16] Only tax redistribution; excludes general federal supplementary grants. Compensatory amounts of the receiving states and the compensation payments of the contributing states.
[17] Sum of general and special-need supplementary grants.
[18] In empirical application, we use the value at the beginning of the period.
[19] Bavaria, Baden-Württemberg, Hesse, Hamburg.
[20] The funding statistics of the BAFA provides data on appropriated funds and data on appropriated funds for which the proof of the use of resources has been obtained. Data from the latter statistics are used in the empirical applications of this paper. The proof of the use of funds is received by the BAFA with a delay of several years; the data is assigned to the year in which the funds have been granted. Over the long term this proof is received for about 87% of the appropriated funds Bade and Alm (2010). However, this percentage might be much lower for the more recent years of our dataset.
[21] For estimations, we use simple averages over the period over which the growth rates of real per capita income are computed.

4. Empirical results

This section discusses the empirical results, using panel estimation. We derive a basic specification for the growth – initial level equation including a time trend and a crisis dummy and then add in turn variables for net migration, fiscal equalisation and structural funding. We derive a non-linear specification to take account of the conditionality of our additional explanatory variables and compute marginal effects to investigate the significance of their impact on growth and convergence. We find that internal migration has a positive impact on growth in the East and thus contributes to the convergence between East and West. Horizontal tax equalisation is ineffective in promoting growth and convergence, but the positive growth impetus from federal supplementary grants has contributed to convergence between grant receiving and non-receiving states. Structural funding is found to have opposing growth effects on Eastern and Western states and has thus significantly promoted convergence.

4.1. Model specification

First, we expand equation (1) by assuming that the steady state level of income is not a constant but is itself growing over time at rate x. It can be shown that[22]

$$\frac{ln(y_t/y_{t-T})}{T} = x + \frac{\left(1-e^{-\beta T}\right)}{T}x(t-T) + \frac{\left(1-e^{-\beta T}\right)}{T}ln(y_0^*) - \frac{\left(1-e^{-\beta T}\right)}{T}ln(y_{t-T}) \qquad (2)$$

and the equation to be estimated becomes

$$ln(y_t/y_{t-T})/T = \mu + \theta t + b[ln(y_{t-T})] + u_t \qquad (3)$$

with $\mu = x + \left(1-e^{-\beta T}\right)/T\,[ln(y_0^*)]$, $\theta = \left(1-e^{-\beta T}\right)/T\,x$ and $b = -\left(1-e^{-\beta T}\right)/T$.[23]

In addition, we allow other explanatory variables to explain growth differences between German states. If these variables are important in explaining growth and convergence, equation (3) would be misspecified and the estimated value of the convergence coefficient b would include the omitted variable effect (Barro and Sala-i-Martin, 2004). In the majority of earlier studies, additional explanatory variables are simply added to the original equation, measuring the direct effect of these variables on economic growth. However, we also include indirect – interaction – effects, to allow the impact of our additional explanatory variables to depend on initial conditions, i.e. the relative prosperity of a region. When we take account of this conditionality a general non-linear specification results which has the following form:

$$ln(y_t/y_{t-T})/T = c + b_0 ln(y_{t-T}) + b_1 X ln(y_{t-T}) + \gamma X + u_t \qquad (4)$$

[22] For convenience, we omit subscript *i*.
[23] Please refer to Appendix IV for the derivation of this result.

where X is any variable assumed to explain growth and convergence.[24] The marginal effect of X on the growth rate of y is given by

$$\frac{\partial ln(y_t/y_{t-T})/T}{\partial X} = b_1 ln(y_{t-T}) + \gamma \quad (5)$$

X is state-specific and may or may not be time-dependent. In our application, we choose X to be a measure of net migration, fiscal equalisation and structural funding consecutively.

Figure 1 already graphically suggested that the recent financial and economic crisis affected German states unevenly. The growth rates in the West have slumped compared with the East during the contraction and risen more in the aftermath. We introduce a time-dependent dummy variable $dummy_{crisis} = 1$ for the period 2005-2010 and 0 in all other periods. In our standard specification, we also hypothesize that the effect of the crisis may be state-dependent so that we use an interaction term similarly as for variables X. The resulting equation is given by

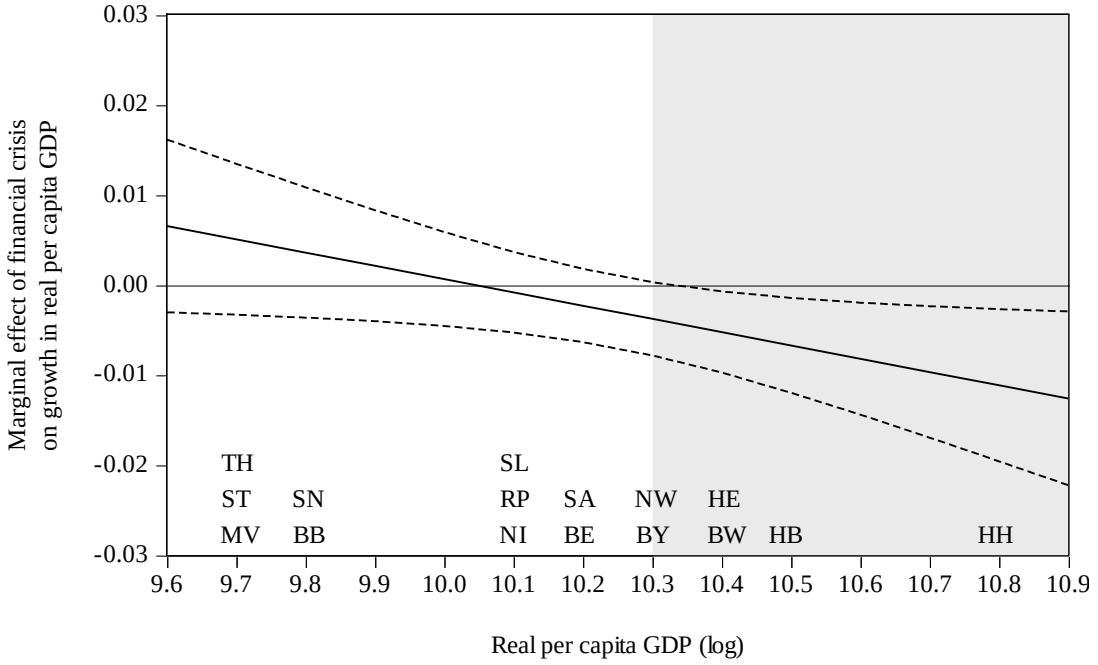
$$\begin{aligned} ln(y_t/y_{t-T})/T = {} & \mu + \theta t + b_0 ln(y_{t-T}) + b_1 X ln(y_{t-T}) + \gamma X + b_2 dummy_{crisis} ln(y_{t-T}) \\ & + \delta dummy_{crisis} + u_t \end{aligned} \quad (6)$$

4.2. Estimation results

We estimate equation (6) with panel estimation. In our application, we divide the 1995-2014 sample period into 5-year intervals (1995-2000, 2000-2005, 2005-2010, 2010-2014). It balances the desire for more observations with that of limiting the impact of cyclical disturbances (Etzo, 2008a; Islam, 1995; Islam, 2003; Schmidt, 1997; Eggert et al., 2007). In the basic specification, we include the trend term as well as the crisis dummy and crisis interaction term. Subsequently, we add each variable X in turn. The estimation results are displayed in Table 2. The first column contains the results for the basic specification. All coefficients are significant and have the expected sign. When appropriate account is taken of trend growth due to technological progress and of the financial crisis, the convergence coefficient equals -0.0075. The overall – marginal – effect is positive, i.e. $b_2 ln(y_{t-T}) + \delta > 0$, if $ln(y_{t-T}) < -\delta/b_2$, with estimated $b_2 < 0$ and estimated $\delta > 0$. The solid line in Figure 2 graphically illustrates how the marginal effect of the crisis changes across the observed range of initial incomes. The 95% confidence bands indicate for which income levels – shown by shaded area – the financial crisis had a statistically significant effect on the growth rate of per capita GDP. To allow for an assessment of the impact of the crisis, the abbreviations of the various states are placed around their approximate average per capita income (in logs). Whereas the crisis did not significantly influence the growth rates of lower income states, its impact significantly reduced the growth rates of the German states with the highest per capita income. In this way, the crisis has promoted "convergence" between lower and higher income states, though there has not been a catch-up by the East.

[24] We refer to Brambor et al. (2006) for a thorough analysis of multiplicative interaction models.

Figure 2 Growth effect of the financial crisis



Note: Solid lines give the marginal effect of the financial crisis (2005-2010); the dashed lines indicate the 95% confidence interval. The shaded areas indicate the ranges of significance

Starting from this basic specification, we now investigate the impact of net migration, fiscal equalisation and structural funding on the convergence process.

4.2.1. Migration

The continuous out-migration from East-Germany towards West-Germany which has started in the immediate aftermath of the border opening has levelled off only in recent years. We study the impact of net migration on growth and convergence of per capita incomes between German states. Our approach implicitly assumes labour homogeneity as we do not take account of the human capital content of migrants. If the share of higher educated people in net migration exceeded the share of lower educated people, the human capital gap between poorer Eastern and wealthier Western regions would increase and the convergence effect of migration as predicted by neoclassical theory could be reversed (Shioji, 2001). We define $X = m_{t-T-4}$, where m_{t-T-4} is the net migration variable lagged by 4 years.[25] The second column of Table 2 shows that the direct effect of initial income on growth (convergence parameter b_0) becomes insignificant. The estimated direct effect of net migration on growth is negative and significant: an increase in the net migration rate reduces the growth rate. Given

[25] We have tested five different lag-specifications for migration. The specification $t - T - 4$, i.e. the net migration rate four years prior to initial income, yielded the most significant results. Hence, migration impacts on growth with a lag and is therefore an exogenous variable in the regression.

that low income states have had negative net migration rates and high income states have had positive migration rates, net migration directly promotes convergence. Our evidence on the direct effect is consistent with Scheufele and Ludwig (2009) and Kubis and Schneider (2009). Because of the interaction between initial income and net migration, there is also an indirect effect of migration on growth which depends on the level of initial income in a specific region. The estimated coefficient on the interaction term is significantly positive; a positive net migration rate has a positive impact on growth in a region and this relationship is stronger in a richer region. The overall – marginal – effect is positive, i.e. $b_1 ln(y_{t-T}) + \gamma > 0$, if $ln(y_{t-T}) > -\gamma/b_1$, with estimated $b_1 > 0$ and estimated $\gamma < 0$. The solid line in Figure 3 graphically illustrates how the marginal effect of net migration changes across the observed range of initial incomes. To allow for an assessment of the impact of migration on convergence, the abbreviations of the various states are printed in bold when net migration rates are negative.

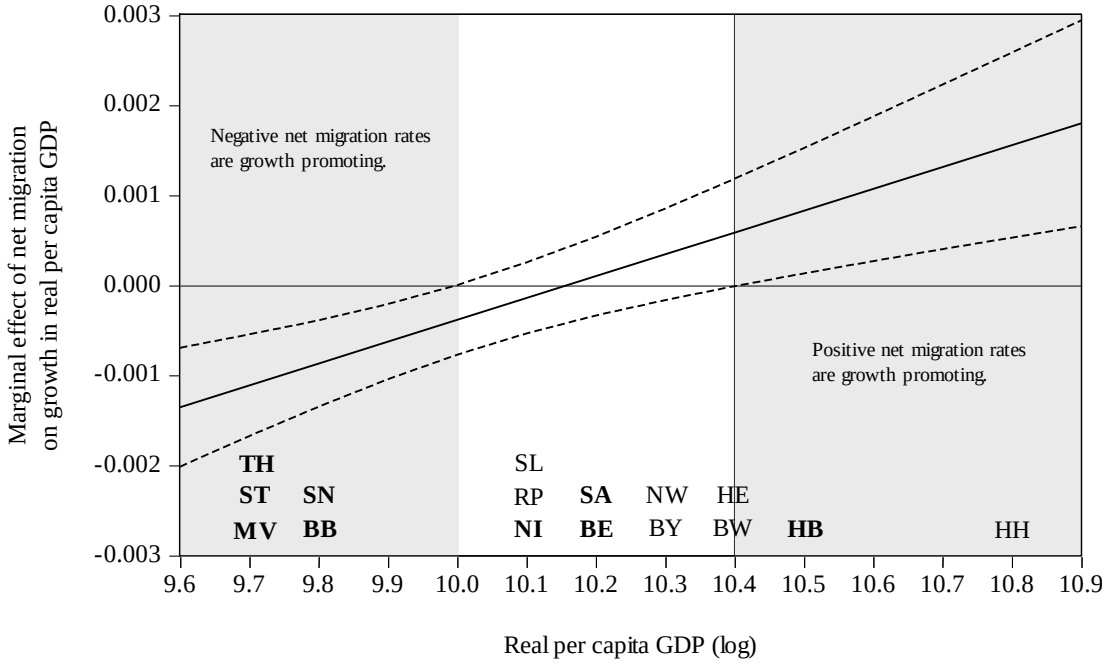
The marginal effect of net migration on growth is significantly negative for the Eastern low income states (BB, TH, SN, ST, MV). Since it is exactly these states that have substantial negative net migration, they experience higher growth through the migration effect. On the other side of the range, the marginal effect of net migration on growth is significantly positive for the two city states Bremen and Hamburg (HH and HB) and marginally significant for Hesse and Baden-Württemberg (HE and BW). Only Hamburg experienced a substantial positive migration balance, suggesting its growth rate was positively influenced by migration. In the other three, the migration balance is small and for Bremen it is even negative. Per capita income in the other German states lies in the range where the marginal migration effect is insignificant. Overall, the results suggest that migration did not have a statistically significant effect on growth in Western states in general – Hamburg excluded – but did contribute to faster growth and some catch-up in the five poorer Eastern states. This is consistent with the fact that the convergence parameter b_0 becomes insignificant when migration is included in the regression.

Table 2 Panel estimations (II)

1995-2014	Unconditional	Net Migration	Horizontal tax redistribution	Federal supplementary grants	Corporate funding			Structural funding in infrastructure		
c	**0.0807**** (0.0349)	**0.0366** (0.0370)	**0.0731** (0.0455)	**-0.0152** (0.0571)	**0.0031** (0.0468)	**0.0015** (0.0457)	**0.0840**** (0.0400)	**0.0329** (0.0418)	**0.0380** (0.0413)	**0.0437** (0.0384)
b	**-0.0075**** (0.0034)	**-0.0034** (0.0036)	**-0.0068** (0.0044)	**0.0016** (0.0055)	**-2.04E-06** (0.0045)	**0.0002** (0.0044)	**-0.0078**** (0.0039)	**-0.0029** (0.0040)	**-0.0033** (0.0040)	**-0.0039** (0.0037)
$trend$	**0.0038***** (0.0008)	**0.0044***** (0.0007)	**0.0039***** (0.0008)	**0.0039***** (0.0008)	**0.0044***** (0.0008)	**0.0044***** (0.0008)	**0.0042***** (0.0009)	**0.0041***** (0.0008)	**0.0040***** (0.0008)	**0.0041***** (0.0008)
crisis_dummy	**0.1481**** (0.0704)	**0.1780***** (0.0636)	**0.1524**** (0.0712)	**0.1261*** (0.0697)	**0.2075***** (0.0650)	**0.2111***** (0.0655)	**0.1559**** (0.0757)	**0.1905***** (0.0683)	**0.1869***** (0.0688)	**0.1835***** (0.0669)
$lnyr \times crisis\_dummy$	**-0.0147**** (0.0069)	**-0.0177***** (0.0062)	**-0.0152**** (0.0069)	**-0.0126*** (0.0068)	**-0.0205***** (0.0063)	**-0.0209***** (0.0064)	**-0.0155**** (0.0074)	**-0.0189***** (0.0067)	**-0.0185***** (0.0067)	**-0.0182***** (0.0065)
net migration		**-0.0246***** (0.0064)								
$lnyr \times net\ migration$		**0.0024***** (0.0006)								
lfa			**8.97E-05** (0.0002)	**0.0002*** (8.65E-05)						
$lnyr \times lfa$			**-8.82E-06** (1.45E-05)	**-1.51E-05*** (8.33E-06)						
gw					**0.0041***** (0.0012)					
$lnyr \times gw$					**-0.0004***** (0.0001)					
wi								**0.0037***** (0.0012)		
$lnyr \times wi$								**-0.0004***** (0.0001)		
grw						**0.0042***** (0.0013)			**0.0047***** (0.0015)	
$lnyr \times grw$						**-0.0004***** (0.0001)			**-0.0005***** (0.0002)	
$erdf$							**0.0188** (0.0163)			**0.0147***** (0.0050)
$lnyr \times erdf$							**-0.0019** (0.0016)			**-0.0015***** (0.0005)
R^2	0.40	0.54	0.41	0.45	0.53	0.54	0.42	0.50	0.49	0.49
$\bar{R}^2$	0.36	0.49	0.35	0.39	0.49	0.49	0.35	0.44	0.44	0.44

Note: *** significance at the 1% level of significance, ** significance at the 5% level of significance, * significance at the 1% level of significance. Standard errors in parenthesis.

Figure 3 Growth effect of net migration (95% confidence band)



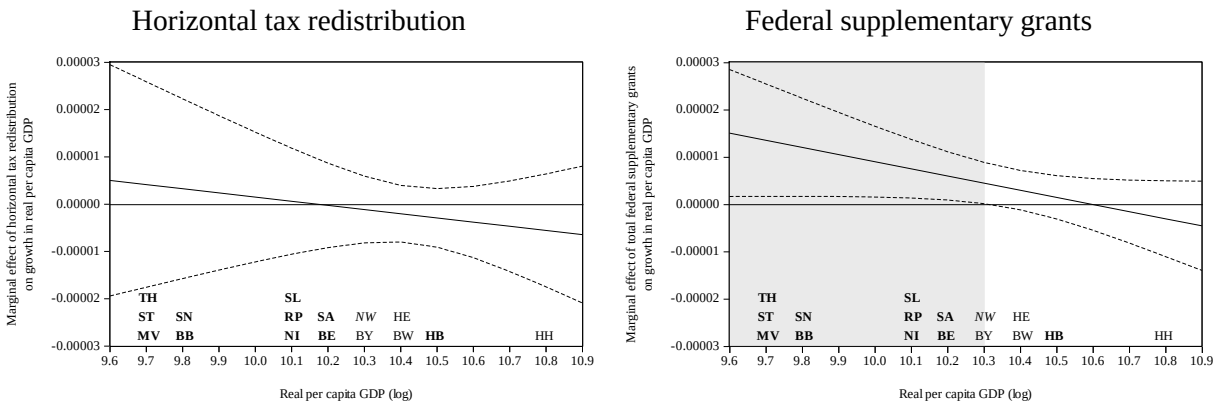
Note: The solid line gives the marginal effect of net migration, the dashed lines indicate the 95% confidence interval. Bold prints of states' abbreviations indicate negative net migration rates. The shaded areas indicate the ranges of significance.

4.2.2. Fiscal equalisation

Next, we investigate the impact of fiscal equalisation on growth and convergence between the various German states and use two specifications for fiscal equalisation, namely the horizontal tax redistribution and the sum of federal supplementary grants, in the starting year. The coefficients on initial income and the fiscal equalisation variables are statistically insignificant (Table 2). There is no direct or indirect impact of either fiscal equalisation measure on growth. Our findings for the direct effect compare with those of Baskaran et al. (2016). However, our result is different when we look at the marginal effect of the fiscal equalisation variable on the growth rate. The left panel of Figure 4 shows the marginal impact of horizontal tax redistribution and the right panel of Figure 4 shows the marginal impact of federal supplementary grants over the observed range of initial incomes. Bold printing of the states' abbreviations indicates recipient states. The marginal effect of horizontal tax redistribution is not statistically significant across the observed range of incomes; tax redistribution in itself has been ineffective in promoting growth and convergence across states. To the contrary, we find the marginal effect of federal supplementary grants on growth to be positive for lower income states, and the effect is decreasing in initial income. All grant receiving states (BB, BE, MV, NI, RP, SA, SL, SN, ST, TH) except Bremen (HB) have therefore experienced a positive growth impetus from federal supplementary grants, which has contributed to convergence between grant receiving and non-receiving states. This result contradicts especially the findings of Berthold et al. (2001), Berthold and Fricke (2005) and Berthold and Fricke (2007) who conclude significantly negative effects of both

horizontal and vertical redistribution. The variable of vertical fiscal redistribution in those studies includes both supplementary federal grants and payments within the framework of GRW funding. In our paper, the impact of regional structural policy on economic growth is considered separately and will be discussed in the next section.

Figure 4 Growth effect of fiscal equalisation (95% confidence band)



Note: The solid lines give the marginal effect; the dashed lines indicate the 95% confidence interval. Bold prints of states' abbreviations indicate net recipients, cursive prints indicate that the state has become a net recipient over the time horizon, normal prints are net contributors. The shaded area indicates the ranges of significance.

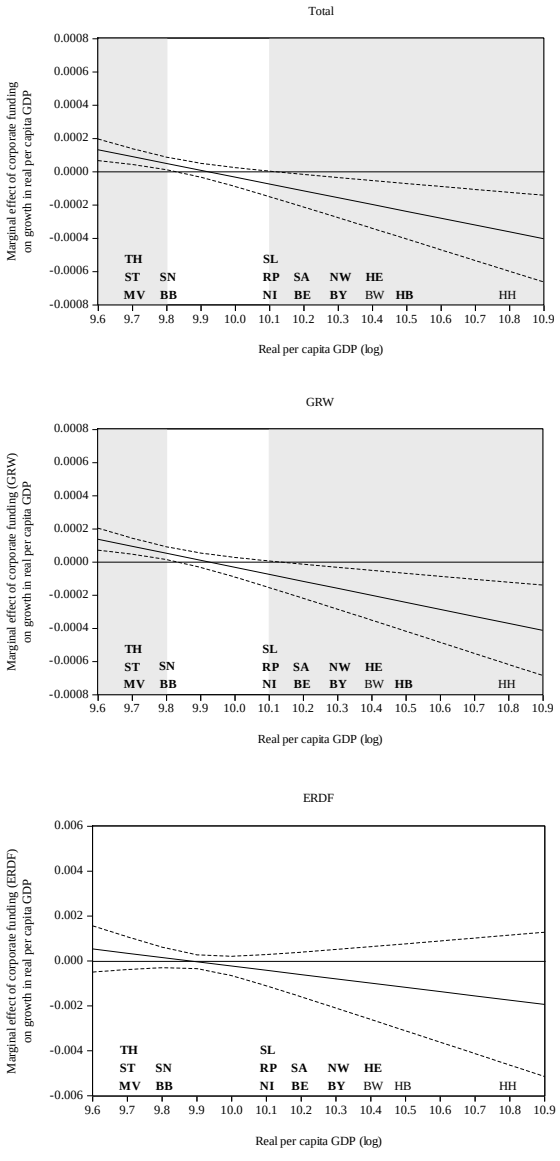
4.2.3. Regional structural policy

Finally, we investigate the impact of structural funds on growth and convergence between German states, and distinguish between the sources of funding (German, European, total) and the destinations of funding (corporate projects and economic infrastructure projects). Our data refer to the funds that have actually been paid out according to the expenditure of funds and are assigned to the year in which the funds have been granted.[26] The regions qualifying for structural funding as well as the intensity of support are determined on the basis of several economic indicators (see Section 2.4). The resulting causality between growth and the level of income on the one hand and the amount of transfer payments on the other hand can be addressed by introducing the structural funding variables into the estimated equations with a lag (Eggert et al., 2007).[27] Implicit in our empirical set up is the assumption that regions receiving structural transfers and regions not receiving structural transfers converge to the same steady state, which is reflected in the common constant c. Furthermore, transfers do not influence the long-run steady state or long-run equilibrium growth. Instead structural funding leads to a capital inflow in the receiving region and is expected to temporarily increase growth towards the steady state (Alecke et al., 2011).

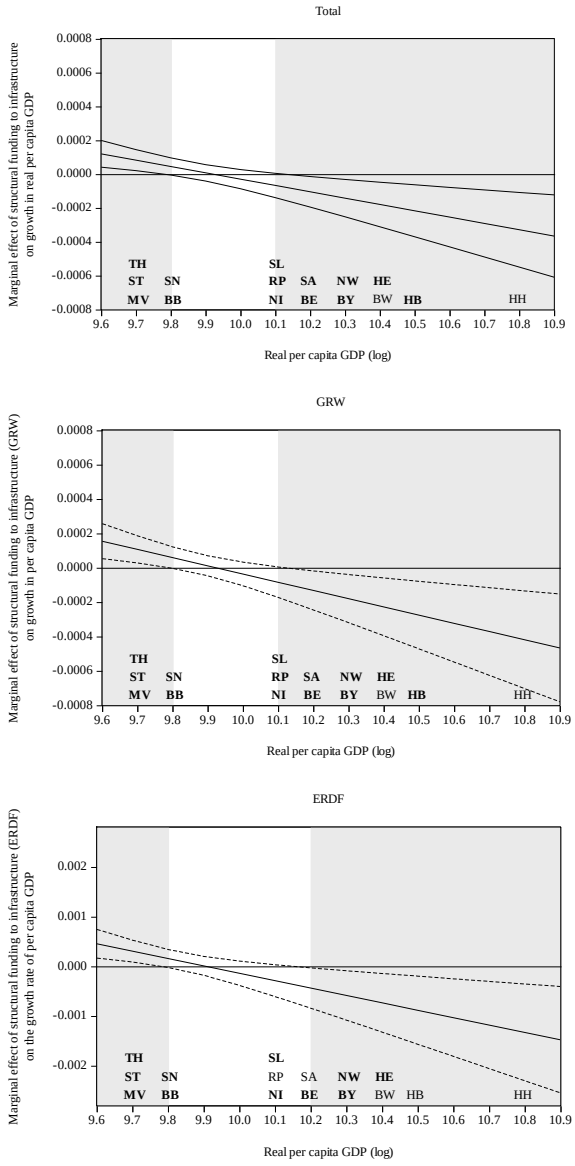
[26] Since the delay between payment and the report on expenditure might be several years, there is an apparent decrease in funding in some states over the past years, which might be related to the lack of data on confirmed actual expenditure.
[27] We use the observation prior to the starting year.

Figure 5 Growth effect of structural funding

Corporate structural funding



Structural funding to infrastructure



Note: Solid lines give the marginal effect of structural funding, the dashed lines indicate the 95% confidence interval. Bold prints of states' abbreviations indicate that the state has received a positive amount of structural funding. The shaded areas indicate the ranges of significance.

Table 2 reports the results from pooled OLS estimations for corporate and infrastructure projects, split up according to the sources of funding. The direct effect of funding on growth is significantly positive for almost all funding specifications: an increase in structural investment spending has a positive impact on growth in a subsidised region. However, the positive direct effect of transfer payments on growth is crowded out by the indirect effect and this effect becomes stronger with rising initial per capita income. Figure 5 presents the marginal impact of corporate and infrastructure funding from various sources on growth, over the range of observed initial incomes. The results suggest that

structural funding in general has significantly affected economic growth across a wide range of observed incomes, but the effect has been uneven across states. Whereas the marginal effect of structural funding is significantly positive for the Eastern low income states (BB, MV, SN, ST, TH), it is found to be significantly negative in subsidised higher income states (BE, BY, HB, HE, NI, NW, RP, SA, SL). German structural funding to both corporate and infrastructure projects significantly affects economic growth and convergence. To the contrary, European corporate funding has been ineffective in explaining growth differences; this is consistent with the fact that the convergence parameter b_0 continues to be significant when structural funding is included in the regression. The payment of subsidies has thus reached the target of speeding up the convergence process between East and West, but at the cost of macroeconomic growth in the West.

4.3. Robustness analyses

We conduct a series of robustness checks to demonstrate that our results are insensitive to alternative measures and specifications. The results are presented in Table 3. First, we compute the impact of a lagged variable of horizontal tax distribution. Since data on fiscal equalisation among all German states is available only from 1995 onwards, we apply a dummy variable approach[28]. Neither the coefficients on initial income nor the fiscal equalisation variable are statistically significant in this specification, hence confirming our earlier results. The marginal impact is given in Appendix V. The results for structural funding are computed using the real per capita averages over the period preceding the period under consideration. Since some states are recipients of structural funding in some years and not in others, period averages might provide a more complete picture of the impact of structural funding payments. Our results confirm the direct significantly positive impact of structural funding on economic growth and the significantly growth-reducing indirect effect. In our modified specifications, corporate funding from European sources continues to be ineffective in explaining growth differences between German states. Marginal impacts are given in Appendix VI.

[28] Until 1994, fiscal equalisation was operational only between the West German states; the Eastern states have benefitted from the fond "Deutsche Einheit" between 1990 and 1994. Our (lagged) dummy has been created as follows. For the period 1995-2000, the dummy refers to the fiscal equalisation period 1991-1994. It is set equal to "1" ("0)") if a state is on average a net recipient (contributor) under West-German fiscal equalisation; all Eastern states are considered net recipients ("1") over the period. For all other periods, the dummy is set equal to "1" ("0") if a states has been on average a net recipient (contributor) over the period preceding the period under consideration.

Table 3 Robustness analyses

1995-2014	Fiscal equalisation	Corporate funding			Funding to infrastructure		
c	**0.0708** (0.0989)	**-0.0400** (0.0530)	**-0.0409** (0.0516)	**0.0854**** (0.0401)	**0.0245** (0.0454)	**0.0224** (0.0439)	**0.0720*** (0.0400)
$lnyr$	**-0.0064** (0.0094)	**0.0040** (0.0051)	**0.0041** (0.0049)	**-0.0079**** (0.0039)	**-0.0020** (0.0044)	**-0.0018** (0.0042)	**-0.0066*** (0.0039)
$trend$	**0.0038***** (0.0008)	**0.0047***** (0.0007)	**0.0047***** (0.0008)	**0.0042***** (0.0010)	**0.0041***** (0.0008)	**0.0040***** (0.0008)	**0.0042***** (0.0008)
$crisis\_dummy$	**0.1586**** (0.0714)	**0.2208***** (0.0652)	**0.2329***** (0.0661)	**0.1495*** (0.0767)	**0.1849***** (0.0663)	**0.1862***** (0.0668)	**0.1809***** (0.0672)
$lnyr \times crisis\_dummy$	**-0.0158**** (0.0070)	**-0.0218***** (0.0064)	**-0.0229***** (0.0064)	**-0.0149*** (0.0075)	**-0.0183***** (0.0065)	**-0.0184***** (0.0065)	**-0.0179***** (0.0066)
lfa	**0.0420** (0.1043)						
$lnyr \times lfa$	**-0.0043** (0.0100)						
gw		**0.0031**** (0.0012)					
$lnyr\_gw$		**-0.0003**** (0.0001)					
wi					**0.0054***** (0.0016)		
$lnyr\_wi$					**-0.0005***** (0.0002)		
grw			**0.0031**** (0.0013)			**0.0059***** (0.0017)	
$lnyr\_grw$			**-0.0003**** (0.0001)			**-0.0006***** (0.0002)	
$erdf$				**0.0104** (0.0157)			**0.0374***** (0.0121)
$lnyr\_erdf$				**-0.0011** (0.0016)			**-0.0038***** (0.0012)
R^2	0.42	0.54	0.54	0.41	0.51	0.51	0.49
$\bar{R}^2$	0.36	0.49	0.50	0.34	0.46	0.46	0.43

Note: *** significance at the 1% level of significance, ** significance at the 5% level of significance, * significance at the 1% level of significance. Standard errors in parenthesis

5. Conclusions

In this paper we have studied the presence and sources of growth and convergence in real per capita incomes between German states in the period following the German reunification. Our analysis applies the popular neoclassical growth – initial income equation in a panel framework, and the basic panel framework is extended in various ways. We include a trend to pick up technological progress and a dummy variable to model the financial crisis. To this basic specification, we add in turn net migration, fiscal transfers and investment subsidies. In the majority of earlier studies, those explanatory variables are simply added to the original equation, measuring the direct effect of these variables on economic growth. Our study also includes indirect – interaction – effects, to allow the impact of net migration and fiscal policy to depend on initial conditions. A general, non-linear specification results. We estimate the various specifications for the period 1995-2014, and compute the marginal effects of our variables and the corresponding confidence intervals.

Our measures of technology and the financial crisis are highly significant and have the expected signs in all estimated specifications. The empirical evidence for our explanatory variables to explain growth and convergence is promising, and our presumption that the marginal effect of our explanatory variables on the growth rate depends on the relative prosperity of a region is confirmed by our analysis. Net migration is found to have a negative impact on growth for very low levels of income and a positive impact on growth for high levels of income. As a result of the internal migration patterns, Eastern states have experienced higher growth and some catch up with the West through the migration effect. Growth in the average West German states has not been affected by internal migration. Despite the important amounts of fiscal redistribution across German states, the general findings of earlier studies suggest that the impact of fiscal equalisation on growth is at best missing. Our analysis distinguishes between horizontal tax redistribution and vertical redistribution (supplementary federal grants). Horizontal tax redistribution cannot explain growth differences between German states. However, we identify significantly positive marginal effects of federal supplementary grants on the growth rates of the grant receiving states, which has contributed to convergence between grant receiving and non-receiving states and which provide evidence of the effectiveness of at least some components of the fiscal redistribution scheme. Our analysis of structural funding distinguishes between the sources (German and European) and the destination of funds (corporate and economic infrastructure projects). We find a positive direct impact of structural funding on growth in general, but this effect is crowded out by the indirect effect which becomes stronger with rising initial per capita income. The marginal effect of structural funding on growth is positive for the Eastern and negative for the Western German states, and the marginal effects of German funding dominate the marginal effects of funding from European sources. The payment of

investment subsidies has thus reached the target of speeding up the convergence process between East and West, but at the cost of growth in the Western states.

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Appendix I

Table A.1 List of abbreviations

Federal state	**Abbreviation**
Baden-Württemberg	BW
Bavaria	BY
Berlin	BE
Brandenburg	*BB*
Bremen	HB
Hamburg	HH
Hesse	HE
Mecklenburg Western Pomerania	*MV*
Lower Saxony	NI
Northrhine-Westphalia	NW
Rhineland Palatinate	RP
Saarland	SA
Saxony	*SN*
Saxony Anhalt	*ST*
Schleswig Holstein	SL
Thuringia	*TH*

Note: States in cursive belong to "East".

Appendix II – The federal fiscal equalisation system

Here, we elaborate on the details of the federal fiscal equalisation system (Länderfinanzausgleich), distinguishing between the federal, state and municipal levels. The revenue sharing system is divided into four stages.

In the first stage, revenues from personal and corporate income tax as well as from VAT are distributed vertically. The shares for distribution of personal and corporate income tax revenues are fixed by constitutional law. The federal and the state tier each receive 42.5 percent of gross revenues from personal income taxes, the municipalities receive 15 percent. The corporate income tax revenues are shared equally between the federal and the state tier. The shares for distributing the VAT revenues fluctuate over time. In 1995, the federal tier received 56 percent and the state tier received 44 percent of total VAT revenues. In 2014, the federal tier received 53.5 percent of VAT revenues, the state tier 44.5 percent, and the municipalities the remaining 2 percent (BMF, 2014).

In the second stage, the personal and corporate tax revenues as well as VAT revenues belonging to the Länder as a whole are distributed among the individual states. Apart from VAT, the individual states are entitled, in principle, to the tax revenue which is collected by the revenue authorities on their territory (principle of local revenue). VAT is not distributed according to the principle of local revenue, but contains a redistributive element. Up to 25 % of the states' share of VAT goes as a supplementary portion to those states whose receipts from the income tax, the corporation tax and the state taxes per capita are lower than the per capita average of all the states. This redistribution partially closes the gap between the tax revenue of the fiscally weak states and the state average. The remainder of the state share of VAT, at least 75 %, is distributed according to the number of inhabitants among all states.

In the third stage, intergovernmental transfers flow from fiscally well-endowed to poorly-endowed states. The actual amounts to be paid or received by each state are determined by comparing a state's fiscal capacity (state share of joint taxes, the tax revenues of the states and partially the tax revenues of municipalities in per capita terms) to its fiscal needs (federation-wide average tax revenues per capita[29]). Equalisation among the states takes place without changing the ranking of the states in terms of their fiscal endowment.

In the fourth step, the federal government provides grants to selected states (Bundesergänzungszuweisungen). General supplementary federal grants are meant to further reduce the gap between the average financial capacity per inhabitant and that of poor Länder which still remains after fiscal equalisation among the Länder. Supplementary federal grants for special needs serve to compensate individual poor states for special burdens they have to bear. Within the scope of

[29] Population figures to compute tax revenues per capita are scaled up for very densely or very sparsely populated states (Baskaran et al., 2016).

the Solidarity Pact II (Solidarpakt II) East German states will receive, until 2019, special-need supplementary federal grants to build up infrastructure and to compensate for the disproportionately weak financial capacity of the municipalities. In addition, East German states receive funds to compensate for the special burdens placed on them by structural unemployment. Small poor Länder receive supplementary grants to make up for their above-average administrative costs (Löwer, 2005; Baskaran et al., 2016, BMF, 2017).

Appendix III – Regional structural poliy

The GRW was introduced in 1969 and subsidises business investment in plant and equipment as well as investment in local economic infrastructure. Infrastructure investments include the development and restoration of industrial sites as well as the relevant transport connections, touristic infrastructure, development of technology and industrial centres, vocational training facilities, communication links, wastewater and waste systems, ports. (Deutscher Bundestag, 2016; Koordinierungsrahmen der Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur", 2016. The federal and provincial governments determine the guidelines for subsidisation and they monitor and evaluate the programme. Several economic indicators (average rate of unemployment, gross annual earnings per employee subject to social insurance contributions, employment prospect, and infrastructure indicator) are used to rank German labour market regions in order to determine the regions qualifying for assistance, the eligibility of projects as well as the intensity of the support, in accordance with EU law (Deutscher Bundestag, 2016). Within the scope of the yearly budgetary legislation, the federal and provincial governments decide on the amount of funds to be provided for the common task (50% federal and 50% provincial). All East German states have received assistance over the period 1995-2014. In addition, EU structural and cohesion funds (in particular the European Regional Development Fund - ERDF) are used to co-finance GRW projects The principle of additionality applies, which means that Community assistance complements the contributions of Member states rather than reducing them. (Titze, 2007). Bundesministerium für Wirtschaft und Energie (2016) and Deutscher Bundestag (2016), for instance, describe in detail the formalities of the GRW.

Appendix IV - Derivation of the trend equation

In the neoclassical growth model, technological progress is assumed to be labour-augmenting. It is assumed that $\hat{y}_t = \frac{Y_t}{\hat{L}_t}$, where $\hat{y}_t$ is output per effective unit of labour, and $\hat{L}_t = xtL_t$ is the effective amount of labour with the rate of technological progress x. The steady state value $\hat{y}^*$ is assumed to be constant. When expanded around the steady state position $log(\hat{y}_t) = \left(1 - e^{-\beta T}\right) log(\hat{y}^*) + e^{-\beta T} log(\hat{y}_{t-T})$ (Barro and Sala-i-Martin, 2004).

In empirical applications, the rate of technological progress is not taken account of if we look at per capita output. If we write the above equation in per capita terms, the steady state level of per capita output grows at rate x:

$$log(y_t e^{-xt}) = \left(1 - e^{-\beta T}\right) log(y_t^* e^{-xt}) + e^{-\beta T} log\left(y_{t-T} e^{-x(t-T)}\right)$$

$$log(y_t) = xt + \left(1 - e^{-\beta T}\right) log(y_t^*) - \left(1 - e^{-\beta T}\right) xt + e^{-\beta T} log(y_{t-T}) - e^{-\beta T}\, x(t-T)$$

$$log(y_t) = \left(1 - e^{-\beta T}\right) log(y_t^*) + e^{-\beta T} xt + e^{-\beta T} log(y_{t-T}) - e^{-\beta T}\, xt + e^{-\beta T}\, xT$$

$$log(y_t) = \left(1 - e^{-\beta T}\right) log(y_t^*) + e^{-\beta T}\, xT + e^{-\beta T} log(y_{t-T})$$

Let $y_t^* = y_0^* e^{xt}$, then

$$log(y_t) = \left(1 - e^{-\beta T}\right) log(y_0^* e^{xt}) + e^{-\beta T}\, xT + e^{-\beta T} log(y_{t-T})$$

$$log(y_t) = \left(1 - e^{-\beta T}\right) log(y_0^*) + \left(1 - e^{-\beta T}\right) xt + e^{-\beta T}\, xT + e^{-\beta T} log(y_{t-T})$$

$$log(y_t) = \left(1 - e^{-\beta T}\right) log(y_0^*) + \left(1 - e^{-\beta T}\right) x(t-T) + \, xT + e^{-\beta T} log(y_{t-T})$$

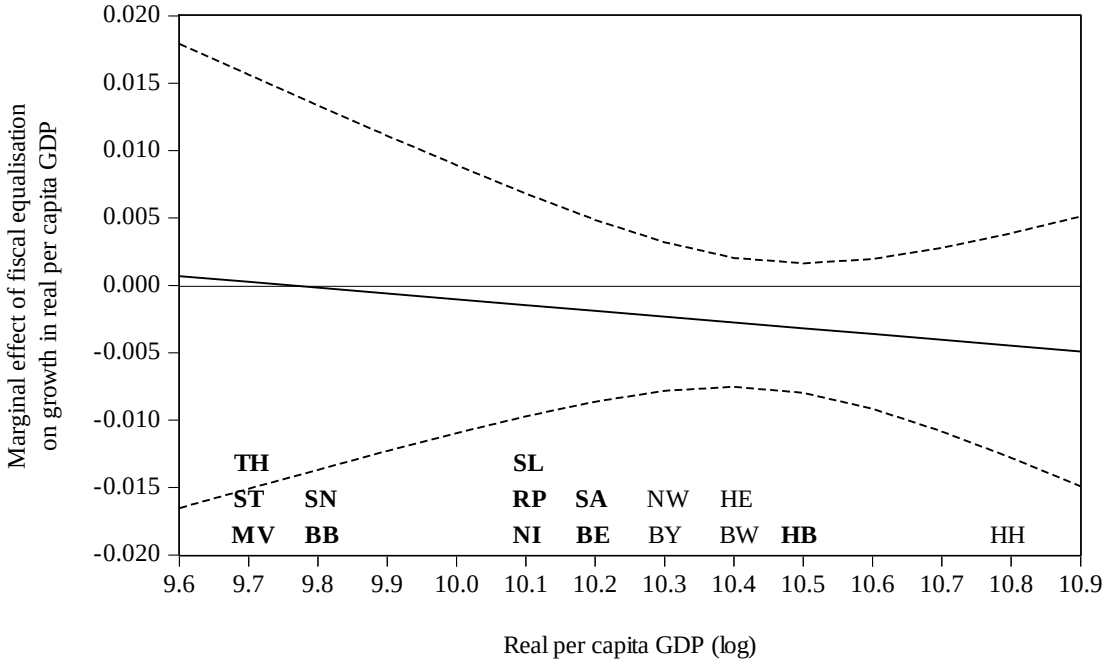
If we now consider the average growth rate over T in per capita terms,

$$\frac{log(y_t / y_{t-T})}{T} = x + \frac{\left(1 - e^{-\beta T}\right)}{T} log(y_0^*) + \frac{\left(1 - e^{-\beta T}\right)}{T} x(t-T) - \frac{\left(1 - e^{-\beta T}\right)}{T} log(y_{t-T})$$

which is equation (2) in the main text.

Appendix V Growth effect of fiscal equalisation (robustness)

Graph A. 1 Growth effect of fiscal equalisation

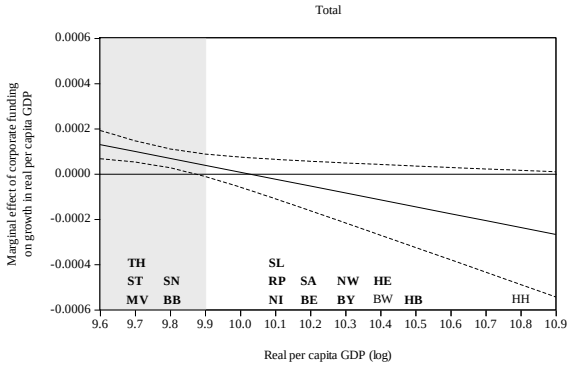


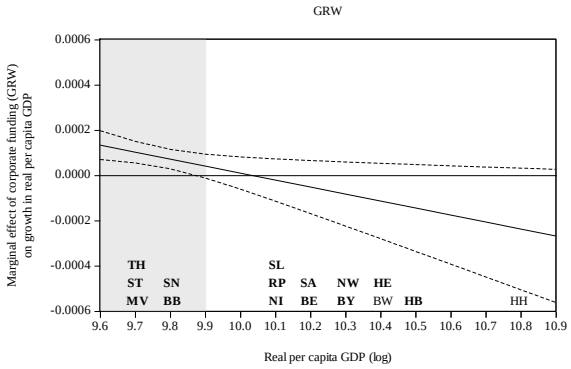
Note: The solid lines give the marginal effect; the dashed lines indicate the 95% confidence interval. Bold prints of states' abbreviations indicate net recipients, cursive prints indicate that the state has become a net recipient over the time horizon, normal prints are net contributors. The shaded area indicates the ranges of significance.

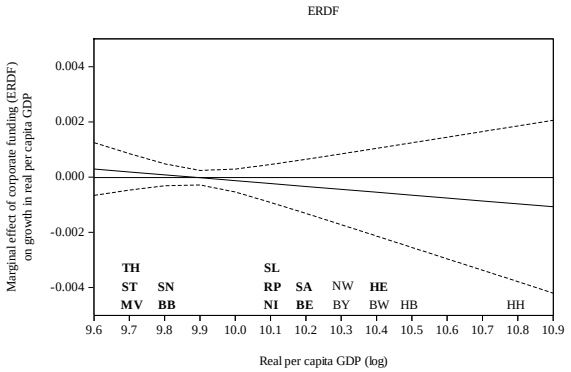
Appendix VI Growth effect of structural funding (robustness)

Graph A. 2 Growth effect of structural funding

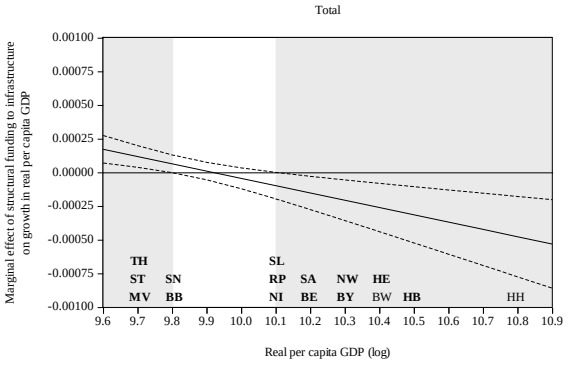
Corporate structural funding

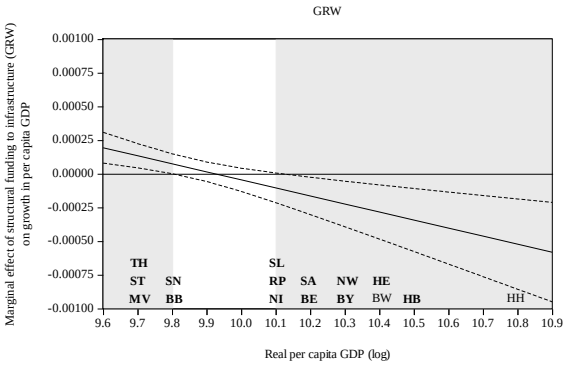


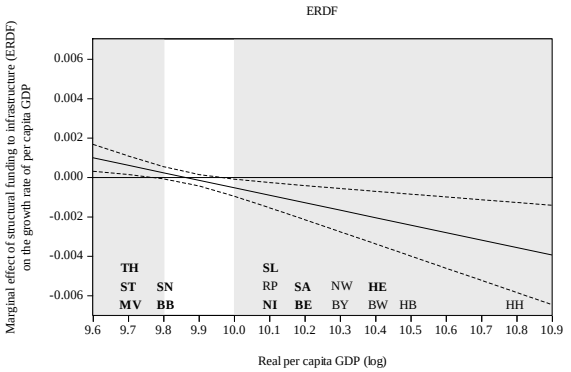




Structural funding to infrastructure







Note: Solid lines give the marginal effect of structural funding, the dashed lines indicate the 95% confidence interval. Bold prints of states' abbreviations indicate that the state has received a positive amount of structural funding. The shaded areas indicate the ranges of significance.