

Fiscal equalization in the spatial economy

Marcel Henkel[‡]

Tobias Seidel

Jens Südekum

U Duisburg-Essen

U Duisburg-Essen,

U Düsseldorf,

CRED and CESifo

CEPR and CESifo

June 2017

PRELIMINARY VERSION

Abstract

We use a general equilibrium model with fiscal equalization to show that regional transfers are quantitatively important for understanding the spatial allocation of economic activity. We find that the abolishment of fiscal equalization in Germany would lead to a moderate welfare gain of about 0.33 percent implying migration of about 5 percent of the population in the long run. The increases in average real GDP per capita and average labor productivity are more pronounced at 5.8 percent and 9.2 percent, respectively.

JEL-Classification: F15, R12, R13, R23.

Keywords: Fiscal equalization, place-based policies, regional transfers, migration, spatial economics

[‡]Corresponding author: University of Duisburg-Essen, Mercator School of Management, Germany;
E-mail: marcel.henkel@uni-due.de

1 Introduction

Geography is important for the spatial allocation of economic activity. High consumption or production amenities and good access to trade partners (e.g. ports, railways, and highways) attract both workers and firms. Allen and Arkolakis (2014) have shown that geography explains between 20-70 percent of the variation in income across space in the US, depending on the choice of parameters. While these determinants are well understood, we aim at quantifying the importance of governmental activity in a spatial framework. As governments intervene in markets in a number of ways and for a number of reasons, we restrict governmental activity to taxation of income, the provision of local public goods, and the redistribution of resources across regions (fiscal equalization). The mobility response of workers to governmental intervention is important for local jurisdictions which try to attract economic resources, but also have to finance the provision of local public goods.

We build a multi-region general equilibrium model with income taxation, local public services and inter-regional transfers. A recipient region benefits from receiving transfers as local governments can raise the provision of local public services. On the contrary, donor regions experience welfare losses as public resources are not spent locally. These transfers stimulate labor migration to transfer recipients. At the aggregate level, we show that the introduction of a fiscal equalization scheme generally exhibits ambiguous welfare effects in the spatial economy. For example, higher relative local gross domestic product (GDP) of donors compared to recipients implies higher welfare gains when fiscal transfers are introduced. This is because a donor's transfer of one percent of local GDP translates into a higher *relative* subsidy for poorer recipients. In addition, geography matters for overall welfare effects. If resources are transferred from the core to the periphery, aggregate welfare declines as one unit of income buys less utility in locations with higher price indexes.

We proceed by assessing the role of fiscal transfers for the spatial allocation of economic activity and aggregate welfare for Germany. The largest European economy has established a fairly extensive system of fiscal equalization that raises financial capacity of some states from less than 50 percent to a level close to the mean. Using detailed information on inter-regional trade flows, income, population, tax rates and transfers for 411 districts in Germany in 2010, we show that inter-jurisdictional redistribution explains up to 31 percent of the spatial variation in income and is thus quantitatively of major importance for understanding the spatial economy. Moreover, we find that abolishing fiscal equalization between regions leads to welfare gains of 0.33 percent in the benchmark specification implying migration of about 4.6 million individuals or 5.7 percent of the population. The model predicts that the abolishment of transfers leads to outmigration in former recipient locations of up to one third of the initial population while former donors expect a pronounced inflow of migrants.

Our paper relates to a number of literatures. First, our paper adds to a recent and growing literature that extends quantitative trade models with factor mobility and exogenous local characteristics (e.g. Allen and Arkolakis, 2014, Bartelme, 2015, Behrens, Mion, Murata, Suedekum, 2017, Caliendo, Parro, Rossi-Hansberg and Sartre, 2014, Monte, Redding and Rossi-Hansberg, 2015, and Redding, 2016). Similar to Fajgelbaum, Morales, Suarez Surrato and Zidar (2016), we incorporate taxation and local public services into this class of models while explicitly allowing for inter-jurisdictional fiscal equalization. This allows us to quantify the role of fiscal equalization for the regional variation in welfare and migration.

Second, we contribute to the public finance literature on fiscal equalization (Boadway and Flatters, 1982, Watson, 1986), the role of federal taxation for the spatial allocation of economic activity (Albouy, 2009), and factor mobility in response to tax changes (Bartik, 1991, Moretti and Wilson, 2015). We add to this literature by quantifying a structural model. Albouy (2012) and Tombe and Winter (2017) undertake a similar exercise to ours for Canada, albeit with a different type of model.

Third, fiscal equalization can be regarded as one form of place-based policies as those jurisdictions with high tax income per capita (i.e. high fiscal capacity) are obliged to transfer resources to locations with lower fiscal capacity. The paper is therefore related to recent work in this area by Kline and Moretti (2014), Busso, Gregory and Kline (2013), Ehrlich and Seidel (2016), or Gottlieb and Glaeser (2008). We deviate from this work by evaluating fiscal equalization as one particular form of place-based policies.

The paper is organized as follows. We first introduce the model in section 2 and discuss underlying determinants of welfare effects of inter-regional transfers. Section 3 quantifies the model for Germany, derives the importance of fiscal equalization for the spatial allocation of economic activity and analyzes the welfare implications of abandoning transfers. Section 4 concludes.

2 A quantitative geography model with fiscal equalization

We consider an economy with N regions and \bar{L} mobile workers. Local governments collect income taxes to provide public services and reallocate resources across locations.

2.1 Production technologies

Each region $i \in N$ produces a unique variety of a differentiated good under perfect competition and assembles a final good $Q(i)$ from a continuum of varieties according to a

CES-aggregator such that

$$Q(i) = \left[\int_N q(n, i)^{\frac{\sigma-1}{\sigma}} dn \right]^{\frac{\sigma}{\sigma-1}}. \quad (1)$$

$q(n, i)$ denotes the quantity of the variety produced in location n and used for assembly in location i and $\sigma > 1$ represents the elasticity of substitution between varieties. The price of the final good in i is determined by the prices of varieties, $p(n, i)$, such that

$$P(i) = \left[\int_N p(n, i)^{1-\sigma} dn \right]^{\frac{1}{1-\sigma}}.$$

The final good is assembled locally at zero cost and not traded. Importantly, $Q(i)$ can be used by consumers for private consumption $C(i)$ and by local governments to provide public services $G(i)$. Thus, we have $Q(i) = C(i) + G(i)$.

Varieties require labor as the sole input in the production process and cause costs of transportation when traded between regions. We follow the standard iceberg notion such that $\tau(i, n) \geq 1$ units of a good have to be sent from location i for one unit to arrive in location n . We set intra-regional trade costs to zero, so $\tau(i, i) = 1$. Finally, locations may differ with regard to labor productivity $A(i)$.

2.2 Taxes, public spending, and fiscal equalization

The public sector taxes labor income to provide public services $G(i)$ and to reallocate resources across locations. Total tax revenues in region n are then given by $t(i)w(i)L(i)$, where $w(i)$ describes the wage rate. The tax rate $t(i)$ can be understood as a location-specific average tax rate on local income comprising different types of taxes. This notion provides sufficient flexibility for the empirical analysis and follows the observation that local governments possess at least some degree of tax authority.

Without inter-regional transfers, the public budget constraint is given by $G(i) = t(i)w(i)L(i)$. Considering fiscal equalization, however, every region either receives resources from other locations or transfers own income to recipients. We relate these resources relative to local GDP, so recipients receive $\theta(i)w(i)L(i)$ as overall subsidies where $\theta(i) > 0$ denotes the subsidy rate. For donor regions, $\theta(i) < 0$ so we refer to it as the transfer rate. Importantly, as overall transfers are related to local GDP, $\theta(i)$ is only equal in absolute terms between donors and recipients if local income is identical. If, as usual, donors have higher income, a transfer rate of one percent implies a higher subsidy rate in the destination region as recipients have a lower per-capita income, are less densely populated or both.

2.3 Preferences

Having introduced the technologies for final good production and public services, we are ready to turn to the specification of workers' utility. Individuals in location i derive utility from publicly provided services, their net real wage income spent on private consumption, and a location-specific amenity $u(i)$ such that

$$W(i) = u(i) \left[\frac{G(i)}{P(i)L(i)\eta} \right]^\gamma \left[(1 - t(i)) \frac{w(i)}{P(i)} \right]^{1-\gamma}. \quad (2)$$

We allow for different degrees of rivalry in the consumption of $G(i)$ governed by $\eta \in [0; 1]$. When $\eta = 0$, $G(i)$ is a pure public good. When $\eta = 1$, $G(i)/L(i)$ represents per-capita transfers in location i . The parameter γ describes the relative importance of private consumption and publicly provided services. The amenity $u(i)$ captures, for example, temperature or scenery, but also house prices (as a disamenity) or the rate at which local governments transform public spending into public goods (see Fajgelbaum et al., 2016). Transferring income to another region decreases welfare of donors through lower provision of public services while recipients experience higher welfare due to transfers.

Combining individual demand and public demand for the variety from location i in location n , we obtain aggregate demand

$$q(i, n) = \frac{p(i, n)^{-\sigma}}{P(n)^{1-\sigma}} E(n),$$

where $E(n) = (1 + \theta(n))w(n)L(n)$ represents the sum of private and public income including transfers that is available for expenditures in location n .

2.4 Profit maximization and inter-regional trade

As each location produces a unique variety of a composite good under perfect competition, profit-maximizing behavior equates prices to marginal production and transport costs. Consumers in location j have to pay $p(i, j) = \tau(i, j)w(i)/A(i)$ for a good produced in location i where, recall, $A(i)$ denotes location-specific labor productivity. Combining prices and aggregate demand delivers sales from i to j ,

$$X(i, j) = \left(\frac{\tau(i, j)w(i)}{A(i)P(j)} \right)^{1-\sigma} E(j), \quad (3)$$

where $P(j)$ is the CES price index:

$$P(j) = \left[\int_N \left(\frac{\tau(n, j)w(n)}{A(n)} \right)^{1-\sigma} dn \right]^{\frac{1}{1-\sigma}}. \quad (4)$$

As long as there is no free trade and productivity of labor is not equalized across locations, prices will differ.

2.5 Agglomeration and dispersion forces

Importantly, both location-specific productivities and amenities depend on the number of workers in a region. Thus, migration between regions gives rise to externalities that shape the spatial economy. In particular, we impose that

$$A(i) = \bar{A}(i)L(i)^\alpha \quad (5)$$

and

$$u(i) = \bar{u}(i)L(i)^\beta \quad (6)$$

Both productivities and amenities contain exogenous components, $\bar{A}(i)$ and $\bar{u}(i)$, and endogenous parts that are determined by population density in that location. We restrict parameters to empirically relevant values: $\alpha \geq 0$ implies that local productivity increases in population while $\beta \leq 0$ captures the notion of negative externalities (e.g. due to congestion).

2.6 Equilibrium

We use the following equilibrium conditions to solve the model:

1. **Labor market clearing.** This requires

$$\int_N L(n)dn = \bar{L} \quad (7)$$

2. **Goods market clearing with income transfers.** Total labor income in region i , $w(i)L(i)$, has to equal total sales of region i 's product in all locations $n \in N$. This delivers

$$w(i)L(i) = \int_N X(i, n)dn, \quad (8)$$

where $X(i, n)$ accounts for transfers according to (3).¹

3. **Balanced public budget.** Each government spends its available budget entirely on the provision of local public services, so

$$[t(i) + \theta(i)]w(i)L(i) = G(i). \quad (9)$$

¹Notice that inter-regional transfers imply trade imbalances in equilibrium. Donor regions produce more than they consume so they run a trade surplus. This phenomenon is well-understood from the international trade literature (see, e.g., Dekle, Eaton and Kortum, 2007). Total expenditures equal total imports, so $E(i) \equiv (1 + \theta(i))w(i)L(i) = \int_N X(n, i)dn$. Comparing this expression with (8) shows that the difference between exports and imports is given by $-\theta(i)w(i)L(i)$, while $\int_N (-\theta(n)w(n)L(n))dn = 0$.

Further, total paid transfers have to equal the sum of total received transfers, so

$$\int_N \theta(i)w(i)L(i)dn = 0. \quad (10)$$

4. Utility equalization. Free mobility of labor ensures that utility is equalized across all locations.

We derive a system of equations that allows us to (i) determine exogenous productivities and amenities and (ii) solve for endogenous wages and labor allocation across regions in the counterfactual analysis. First, we combine utility, (2), and bilateral exports, (3), with goods-market clearing, (8), to get

$$\begin{aligned} L(i)^{1-\alpha(\sigma-1)}w(i)^\sigma = & W^{1-\sigma}\bar{A}(i)^{\sigma-1} \int_N \tau(i,n)^{1-\sigma}\bar{u}(n)^{\sigma-1}\Omega(n)^{\sigma-1} \\ & (1+\theta(n))w(n)^\sigma L(n)^{1+(\sigma-1)[\beta+\gamma(1-\eta)]}dn, \end{aligned} \quad (11)$$

where $\Omega(n) \equiv (t(n) + \theta(n))^\gamma(1 - t(n))^{1-\gamma}$. Second, combining utility, (2), with the price index (4) delivers

$$\begin{aligned} w(i)^{1-\sigma}L(i)^{(1-\sigma)[\beta+\gamma(1-\eta)]} = & W^{1-\sigma}\Omega(i)^{\sigma-1}\bar{u}(i)^{\sigma-1} \\ & \int_N \tau(n,i)^{1-\sigma}\bar{A}(n)^{\sigma-1}w(n)^{1-\sigma}L(n)^{\alpha(\sigma-1)}dn. \end{aligned} \quad (12)$$

Similar to Allen and Arkolakis (2014), we are able to express the above system of two nonlinear integral equations as one equation providing a direct link between $w(i)$ and $L(i)$ for each location (see Appendix A.1 for details). We have

$$W(i)^{1-\sigma}A(i)^{1-\sigma}\Omega(i)^{\sigma-1}w(i)^\sigma L(i)^{1+\gamma(\sigma-1)(1-\eta)} = \phi w(i)^{1-\sigma}u(i)^{1-\sigma} \quad (13)$$

where $\phi > 0$ is some scalar. Plugging this relationship into (12) delivers

$$\begin{aligned} L(i)^{\tilde{\sigma}\lambda_1} = & W(i)^{(1-\sigma)(1-\tilde{\sigma})}\bar{u}(i)^{(1-\tilde{\sigma})(\sigma-1)}\bar{A}(i)^{\tilde{\sigma}(\sigma-1)}\Omega(i)^{(1-\tilde{\sigma})(\sigma-1)} \\ & \times \int_N W(n)^{(1-\sigma)\tilde{\sigma}}\tau(n,i)^{1-\sigma}\bar{u}(n)^{\tilde{\sigma}(\sigma-1)}\bar{A}(n)^{(1-\tilde{\sigma})(\sigma-1)}\Omega(n)^{\tilde{\sigma}(\sigma-1)} \left(L(n)^{\tilde{\sigma}\lambda_1}\right)^{\frac{\lambda_2}{\lambda_1}} dn, \end{aligned} \quad (14)$$

where we have defined

$$\begin{aligned} \lambda_1 & \equiv 1 - \alpha(\sigma - 1) - (\beta + \gamma(1 - \eta))\sigma \\ \lambda_2 & \equiv 1 + \alpha\sigma + (\beta + \gamma(1 - \eta))(\sigma - 1) \\ \tilde{\sigma} & \equiv \frac{\sigma - 1}{2\sigma - 1}. \end{aligned}$$

Using data on tax rates, bilateral trade costs, wages, and population jointly with the equilibrium conditions allows us to solve the model for exogenous productivities $\bar{A}(i)$ and

amenities $\bar{u}(i)$ up to a constant with $W^{\sigma-1}$ as the eigenvalue of the system. Following Allen and Arkolakis (2014), it can be shown that there is a unique and stable equilibrium if $\lambda_2/\lambda_1 \in [-1; 1]$. Furthermore, the solution for the equilibrium distribution of labor can be obtained as the uniform limit of a simple iterative procedure according to (14) if $\lambda_2/\lambda_1 \in (-1; 1]$. For $\alpha \in [0, 1]$ and $\beta \in [-1, 0]$, $\eta \in [0, 1]$ and $\gamma \in [0, 1]$, we see that $\lambda_2/\lambda_1 \in [-1; 1]$ if and only if $\alpha + (\beta + (1 - \eta)\gamma) \leq 0$. Intuitively, migration to location i has to generate a larger reduction in amenity $u(i)$ than increase in productivity $A(i)$ to ensure that all regions are populated (given γ and η).

2.7 Wages, population and welfare

Combining welfare (2) with (13) and taking logs yields

$$\lambda_1 \ln L(i) = C_L + \sigma \ln \bar{u}(i) + (\sigma - 1) \ln \bar{A}(i) + \sigma \ln \Omega(i) - (2\sigma - 1) \ln P(i) \quad (15)$$

$$\begin{aligned} \lambda_1 \ln w(i) = C_W - (1 - \alpha(\sigma - 1)) \ln \bar{u}(i) - (\sigma - 1)(\beta + \gamma(1 - \eta)) \ln \bar{A}(i) \\ - (1 - \alpha(\sigma - 1)) \ln \Omega(i) + (1 + (\sigma - 1)(\beta - \alpha + \gamma(1 - \eta))) \ln P(i), \end{aligned} \quad (16)$$

where the constants C_L and C_W are determined by the wage normalization and labor-market clearing. We observe that higher provision of public services (as measured by Ω) raises population density in that location as long as $\lambda_1 > 0$. With regard to wages, the effect of inter-regional transfers is generally ambiguous and depends on the sign of $1 - \alpha(\sigma - 1)$.

While it is immediate from (2) that transfers increase (decrease) welfare in recipient (donor) regions, the aggregate welfare effects of fiscal equalization are less straightforward. To better understand the driving mechanisms of aggregate welfare, we design a model economy with 100 locations and study (i) the role of income disparities between donor and recipient locations and (ii) the role of geography (i.e. trade costs). For the first exercise, we set trade costs to zero and split the economy into 50 donors and 50 recipients and impose a general tax rate on income for all locations. Further, we normalize the population of each region to unity. We then solve the model with different initial relative wages between donors and recipients. According to Panel (a) of Figure 1, the aggregate welfare gain of introducing a fiscal equalization scheme is zero if all regions are identical (relative initial GDP equal to one). This is intuitive as a transfer of one unit of income exerts the same marginal utility effect in absolute terms if regions are initially identical. Making donors relatively richer, that is moving right along the horizontal axis, leads to aggregate welfare gains. In contrast, making recipients richer, that is moving to the left, yields the opposite effect. As the transfer rate is kept constant, total transfers make up a larger share of recipients GDP if relative initial local GDP in donor regions is higher. Taking away one percent of income in rich donor regions raises expenditure by more than

one percent in poorer recipient locations.

Second, we focus on the role of geography and keep relative initial GDP constant at a ratio of one. We allocate all regions on a line with donors in the center and recipients in the periphery. Setting trade costs to zero replicates the finding from Panel (a) that the introduction of a fiscal equalization scheme has no aggregate welfare implications at the margin. However, raising trade costs leads to higher price indexes in the periphery compared to the core, so transferring income to the periphery generates less utility there than in the core. Hence, fiscal equalization leads to an aggregate welfare loss. Panel (b) of Figure 1 illustrates that this effect gets stronger in the level of trade frictions, albeit at decreasing rates.

3 Quantification: Fiscal equalization in Germany

In this section, we bring the model to data, identify underlying parameters and quantify aggregate effects. Germany runs a pronounced fiscal equalization scheme and therefore serves as an appropriate candidate for this exercise. We start with an overview of the institutional setting before introducing the data and discussing identification. In the counterfactual analysis, we explore aggregate effects when abandoning the fiscal equalization scheme.

3.1 Institutional background

Political power in Germany is divided between the federal government and 16 state governments (Länder). Each of these authorities is autonomous and independent with respect to budgetary issues, but at the same time responsible for carrying out their tasks in an effective way. Each of the 16 state governments has to ensure that municipalities on its territory are equipped with the necessary financial means.

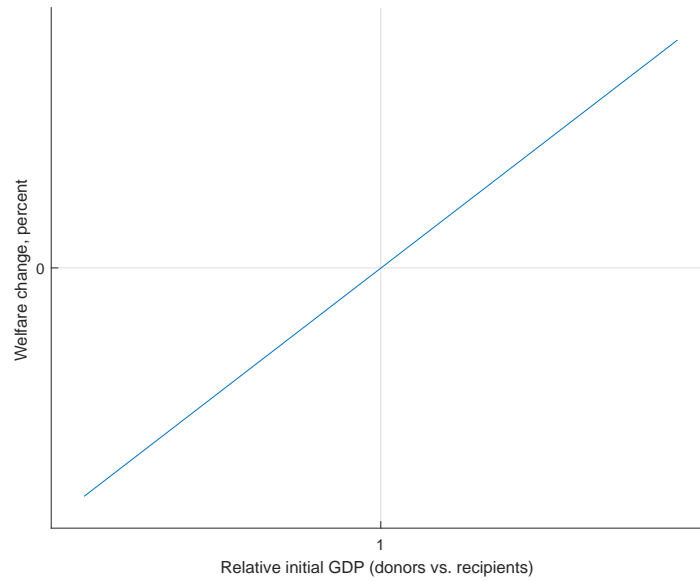
The federal government, the states, and the municipalities can set certain tax rates independently and keep (most of) the resulting tax revenues. The most important taxes with regard to revenue, however, are taxes that are *jointly* set by the federal government and the states implying a common tax schedule in all locations. The resulting revenues are shared between the two layers according to a specific formula. The most important joint taxes comprise income taxes, corporate taxes, and the value added tax (VAT). This implies that there is a common VAT rate and a common income tax schedule across states. As shown in Table 1, the latter accounted for 70.3 percent of overall tax revenues in 2010. The total sum of tax revenues summed up to 530.6 billion euros or 20.6 percent of GDP.²

Article 72 of the German Constitution postulates that the states have to provide

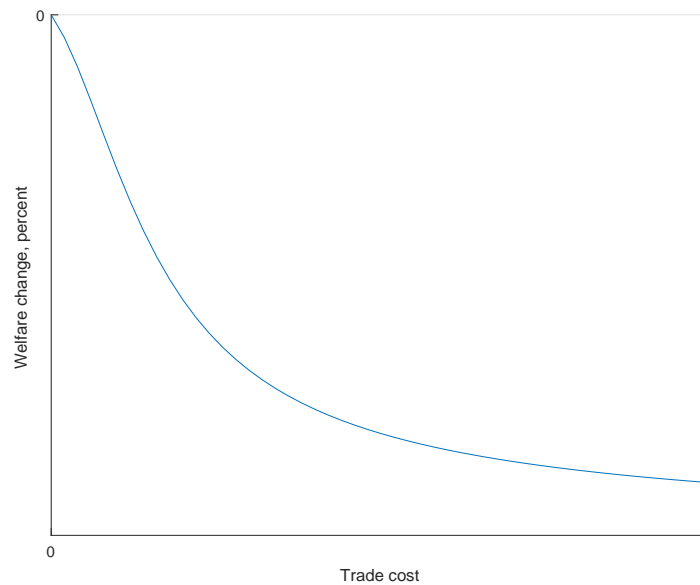
²See German Statistical Office (2011).

Figure 1: AGGREGATE WELFARE EFFECTS OF FISCAL EQUALIZATION

(a) Income dispersion



(b) Geography



Notes: The Figure illustrates the welfare consequences of introducing a fiscal equalization scheme. Panel (a) shows the association between the percentage change in welfare and the relative initial GDP of donors versus recipients. Panel (b) plots the reaction of welfare when trade becomes more costly and recipient regions are located in the periphery.

“equivalent living conditions” in all regions. However, this principle conflicts with uniform tax schedules and the fact that economic activity is unevenly distributed across the country. Based on the prior that all individuals have similar financial needs, installing equivalent living conditions can only be achieved by redistributing tax revenues from jurisdictions with higher financial capacity to those with lower tax revenues per capita.³ This mechanism is referred to as the German *Länderfinanzausgleich (LFA)* - the formula-based federal fiscal equalization scheme. The LFA takes place in four steps: First, revenues of joint taxes are distributed among the federal level, the states (as a whole), and the municipalities (*vertical distribution*). For example, the federal government and the states receive 42.5 percent of income taxes each while the remaining 15 percent accrue to municipalities.⁴ In a second step, the states’ share of VAT revenue is assigned to each of the 16 states. 75 percent of the total amount is distributed according to population shares while 25 percent is dedicated to those jurisdictions with below-average per-capita tax revenues. This allocation mechanism already exerts a substantial equalizing effect. Comparing Columns 2 and 3 of Table 2 reveals that Thuringia, for example, climbs from 48.7 percent of average financial capacity (before VAT redistribution) to 88 percent (after VAT redistribution) while Bavaria’s financial capacity is reduced from 129.3 to 115.6 percent.

Third, states with above-average financial capacity have to redistribute part of their tax income to those states below average. A progressive schedule ensures a further convergence to the mean of all 16 states (see Column 4). The fourth step involves transfers of the federal government to those states whose financial capacity per inhabitant falls short of 99.5 percent of the average. The respective transfers close 77.5 percent of this gap.⁵

Outside of the LFA-system, the federal government has transferred 10.3 billion euros of

Table 1: TAX REVENUES, 2010

	in billion euros	in percent
joint	372.9	70.3
federal and tariffs	97.8	18.4
state	12.1	2.3
municipality	47.8	9.0
sum	530.6	100

Source: German Statistical Office (2011).

³Financial capacity of a state is defined as the sum of its tax revenues plus 64 percent of the sum of the receipts of that state’s municipalities relative to population.

⁴See Federal Ministry of Finance (2016) for further details.

⁵Federal Ministry of Finance (2015).

Table 2: FISCAL REDISTRIBUTION, 2010

	Before VAT redistribution	After VAT redistribution	After fiscal equalization	After general suppl. federal grants
Bavaria	129.3	115.6	105.5	105.5
Baden-Württemberg	117.2	109.5	103.8	103.8
Berlin	88.2	68.1	90.5	97.5
Brandenburg	61.8	90.6	96.3	98.8
Bremen	95.1	74.1	91.9	97.8
Hamburg	157.5	102.1	101.1	101.0
Hesse	127.4	116.0	105.7	105.6
Lower Saxony	85.7	97.6	98.8	99.3
Mecklenburg Western Pomerania	49.0	86.5	95.1	98.5
North Rhine-Westphalia	100.5	98.5	99.2	99.4
Rhineland Palatinate	97.4	95.5	97.8	99.1
Saarland	79.6	94.3	97.4	99.0
Saxony	50.3	88.3	95.6	98.6
Saxony-Anhalt	48.3	88.0	95.5	98.6
Schleswig Holstein	93.4	97.4	98.7	99.3
Thuringia	48.7	88.0	95.5	98.6
Redistribution (in bn. euros)	6.62	7.04	2.62	

Source: Federal Ministry of Finance (2015).

special supplementary grants to selected states that face exceptional tasks like investments in public infrastructure in the new Länder in 2010. Together with the LFA-transfers, the total sum amounts to about 26.5 billion euros or 5 percent of the overall tax revenue of Germany. Moreover, each state government runs an individual transfer scheme to allocate resources between state and municipalities. In the data section below, we go into more detail on how we have computed the tax revenue and the available budget for each German district.

3.2 Data

Quantifying the model requires data on inter-regional trade flows, tax revenues per district, the distribution of tax income across regions, and data on population, labor income, and geographical information. Infrequent availability of inter-regional trade data restricts us to undertake the quantitative exercise for the year 2010.

Tax data. Information on the collection and distribution of taxes is provided by

the Statistical Office in Germany.⁶ The general challenge is to assign taxes to *one* local jurisdiction as required by the theoretical model although the German tax system consists of *three* main layers (federal, state, municipalities). Tax statistics follow the latter logic such that information on tax revenues per location is not readily available.

First, we need to compute average tax rates in location i . As municipalities keep a certain fraction of value added taxes and income taxes, we are able to infer from local tax revenues and the distributional share the overall revenue of these taxes. Other types of taxes like business or property taxes can be taken directly as they are municipality taxes.⁷ In sum, these directly assignable taxes make up about 73 percent of overall tax revenues in Germany. Aggregating these taxes at the district level allows us to compute each district's revenue share in each state and in Germany as a whole to assign the remaining state and federal taxes to the local jurisdiction. Relating each district's tax revenue to local GDP delivers the average tax rate $t(i)$.

To obtain transfer rates $\theta(i)$, we compute tax revenues *after* redistribution. From municipalities' gross income statistics we take tax revenues and transfers received from other government layers making up about 20 percent of overall tax revenues in Germany. As we know overall tax revenues after redistribution for both the state and the federal level, we are able to compute the differences with regard to state and federal taxes to be allocated. In contrast to the first step above, we now allocate the remaining taxes according to population shares rather than tax revenue shares. Relating these numbers at the district level to local GDP yields the average tax rate *after* equalization, $t(i) + \theta(i)$. Using $t(i)$ from the previous exercise allows us to back out the transfer rate $\theta(i)$ for each region.

Recall, recipients receive $\theta(i)w(i)L(i)$ as overall subsidies with $\theta(i) > 0$. For donor regions, $\theta(i) < 0$ so we refer to it as the transfer rate. In sum, the mechanism of the LFA relates per-capita transfers to local GDP as illustrated in Figure 2. Districts in East Germany benefit most from fiscal redistribution with per-capita transfers of more than 3,000 euros per year in some parts. Notice that darker areas indicate recipients, bright areas donors. Transfers are mainly financed by rich jurisdictions in West Germany. Frankfurt leads the list with per-capita transfers of about 11,000 euros. Munich, as another example, pays about 5,700 euros per capita.

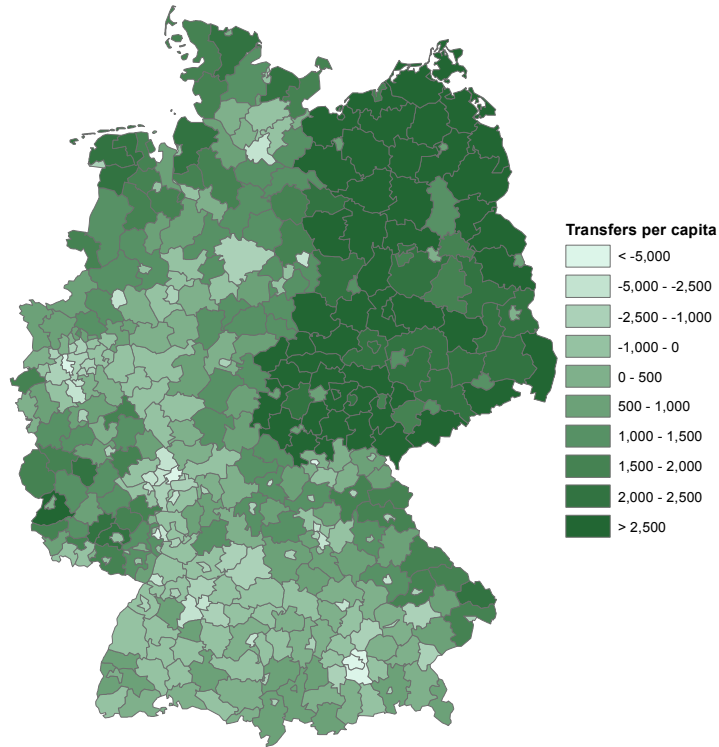
Trade data. We use information on trade flows from the Forecast of Nationwide Transport Relations in Germany 2030 (Verkehrsverflechtungsprognose 2030, henceforth VVP) provided by the Clearing House of Transport Data at the Institute of Transport Research of the German Aerospace Center.⁸ The data contain bilateral trade volumes

⁶The specific statistics are called Fachserie 14-4 (Steuerhaushalt) and Fachserie 14-10 (Realsteuervergleich), and Bruttoeinnahmen der Gemeinden (gross income of municipalities).

⁷Notice that the business tax has to be shared with the state the municipality is located in.

⁸The data can be accessed via <http://daten.clearingstelle-verkehr.de/276/>.

Figure 2: PER-CAPITA TRANSFERS (IN EUROS)



Notes: Darker areas indicate recipients, bright areas donors.

in metric tons between European regions where one German region is either exporter, importer or part of the trade route of the product for the year 2010.⁹ To derive the trade elasticity, we restrict the data to Germany. In total we use trade flows between the 411 German regions.

The data distinguish trade flows by transport mode (road, rail, water), so we aggregate over modes as we do not focus on differences in this dimension. Further, the model requires trade *values* rather than *volumes*. To convert volumes into values, we compute unit values from COMTRADE data that are available by product group at the aggregate national level. We take both a simple average of unit values by product group (to arrive at the two-digit level) and a weighted average where values serve as weights. Bilateral distances between regions' centroids are obtained using GIS software.

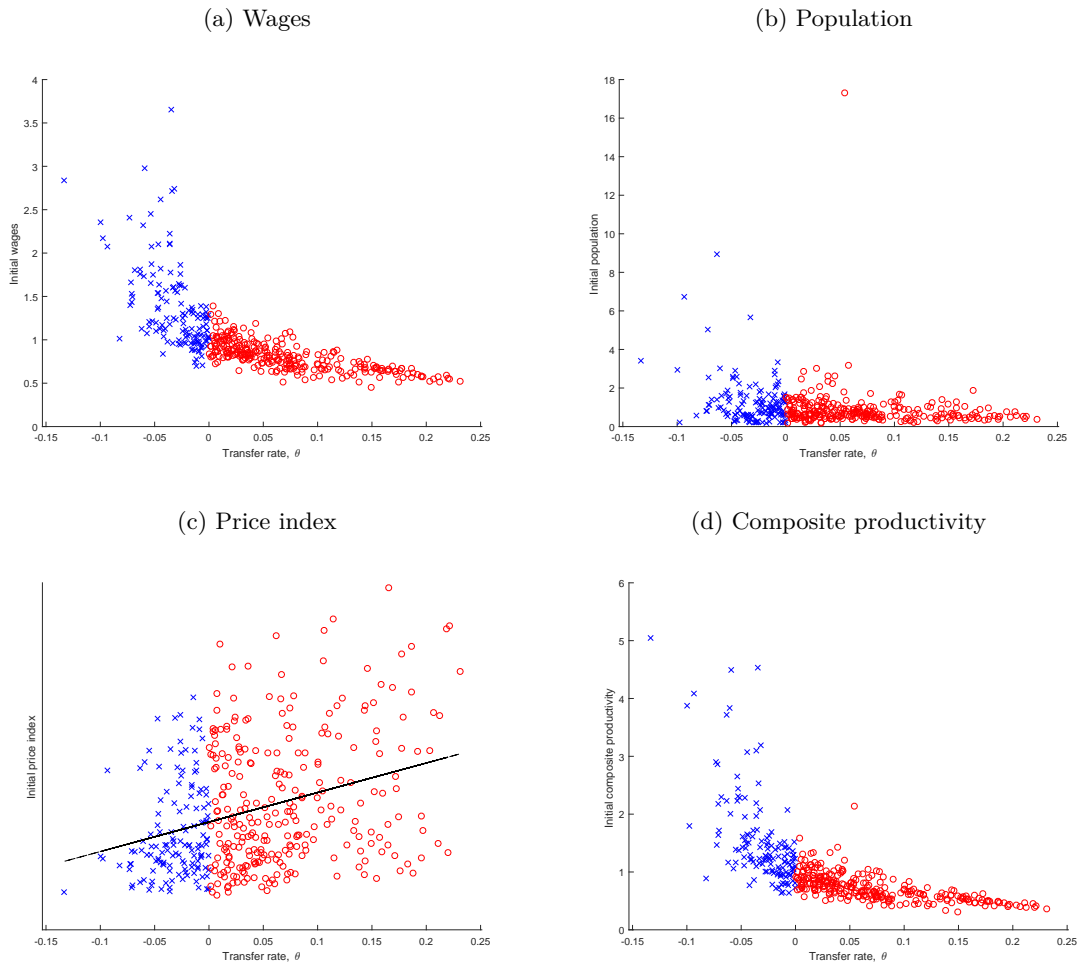
Income and population. Finally, we use data from Eurostat on GDP and population at the NUTS3-level and the ratio of both as a proxy for wages. We further normalize wages to have a mean of one without loss of generality.

Panels (a) and (b) of Figure 3 illustrate how wages and population relate to the transfer rate θ . Locations with high per-capita income are net donors, that is $\theta(i) < 0$. Donors are indicated by blue crosses while red circles indicate recipient regions. The picture

⁹See Henkel and Seidel (2015) for a more detailed description of the data set.

establishes credibility in the plausibility of the computed transfer rate. More populated locations are on average net donors, whereas small and less densely populated locations are net recipients of the transfer system. Berlin sticks out as the location with the largest population. It receives transfers of 5.3 percent of its local GDP. Importantly, discrepancy between donors and recipients with respect to population and per-capita income implies that paid transfers are lower relative to local GDP than received transfers. The average level of θ is -0.03 for donors and 0.07 for recipients.

Figure 3: RELATIONSHIP OF WAGES, POPULATION, PRICE INDEX AND PRODUCTIVITY WITH THE TRANSFER RATE



Notes: Panel (a) links wages to transfer rates $\theta(i)$. Panel (b) plots the relationship of population with the transfer rate $\theta(i)$. Panel (c) maps the level of the price index in relation with the transfer rate. In Panel (d), we have plotted the level of the estimated composite productivity $A(i)$. Notice that donors have a negative transfer rate $\theta < 0$ and are marked by crosses (in blue). Recipients are identified by positive transfer rates and are marked by circles (in red).

3.3 Identification and choice of parameters

In this subsection, we uncover bilateral trade costs $\tau(i, n)$, exogenous productivities $\bar{A}(i)$ and exogenous amenities $\bar{u}(i)$ and discuss the choice of additional model parameters.

Trade costs. We follow the standard procedure in the gravity literature (e.g. Head and Mayer, 2014) by estimating (3) with importer and exporter fixed effects to control for multilateral resistance. We proxy bilateral trade costs by the Euclidian distance $dist(i, n)$ between the centroids of locations i and n according to

$$\tau(i, n) = dist(i, n)^\theta \tilde{\epsilon}(i, n), \quad (17)$$

where $\tilde{\epsilon}(i, n)$ is the error term. Log-linearizing (3) and substituting for the parametrization of trade costs yields the following gravity equation for the value of bilateral trade flows from i to n :

$$\log X(i, n) = \delta(i) + \gamma(n) - (\sigma - 1)\theta \log dist(i, n) + (1 - \sigma)\beta' \mathbf{M} + \log \epsilon(i, n), \quad (18)$$

where $\delta(i)$ and $\gamma(n)$ are exporter and importer fixed effects that control for wages, productivity, population and the CES price index.¹⁰ \mathbf{M} collects standard bilateral control variables from the gravity literature and $\log \epsilon(i, n) = (1 - \sigma) \log \tilde{\epsilon}(i, n)$. Following Lameli, Nitsch, Suedekum, and Wolf (2015) we include a historical dialect similarity measure and dummy variables for adjacent regions and for regions located in different federal states.

Table 3 summarizes the regression output. Columns 3 to 4 build on bilateral trade values where the weighting relates to the unit values applied to the raw volume data. Following Nitsch and Wolf (2013), we also explore results for volumes instead of values as the dependent variable in Columns 1 and 2. Although this deviates from the theoretical model, it can be argued that trade values are proportional to trade volumes so the results are insightful for robustness reasons. Further, exporter and product-specific dummy variables account for the exporter- and product-specific price per ton that converts volume of exports into values.

In line with previous results of Lameli, Nitsch, Suedekum, and Wolf (2015) we find that distance, historical ties (as measured by dialect similarity), contiguity, and administrative borders affect trade flows between German regions. Cultural and geographical proximity have positive effects for trade between German regions. Furthermore, the volume and value of trade flows falls with distance and administrative borders. Indeed, the point estimates on log distance range between -0.93 and -1.26 . Moreover, they are statistically significant at the 1-percent level and compare nicely with standard estimates in the gravity literature. Given the estimated distance elasticity we parameterize trade costs according to

¹⁰As the data distinguish between product groups, we add product fixed effects in the estimation.

Table 3: ESTIMATED DISTANCE ELASTICITIES

	volumes		values	
log(distance)	-1.26*** (0.002)	-0.98*** (0.004)	-1.23*** (0.003)	-0.93*** (0.005)
dialect sim.		0.23*** (0.013)		0.24*** (0.015)
contiguity		0.52*** (0.010)		0.58*** (0.011)
state border		-0.46*** (0.005)		-0.46*** (0.006)
Exporter FE	✓	✓	✓	✓
Importer FE	✓	✓	✓	✓
Product FE	✓	✓	✓	✓
Constant	3.10*** (0.066)	3.56*** (0.065)	17.5*** (0.079)	18.0*** (0.078)
Observations	1,104,635	1,104,635	853,950	853,950
R^2	0.41	0.41	0.70	0.70

Notes: Columns 1 and 2 use the original volume data from VVP. Columns 3 and 4 are based on trade values where we have used the simple average of unit values per 2-digit product group. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$\tau(i, n)^{1-\sigma} = \text{dist}(i, n)^{-1.23}$. We are confident in this parametrization of trade costs as Head and Mayer (2014) summarize that estimates of the trade-distance elasticity parameter in typical gravity equations cluster around -1.1 with a standard deviation of 0.41.

Exogenous amenities and productivities. The values of exogenous productivities $\bar{A}(i)$ and amenities $\bar{u}(i)$ represent a second piece of information that is unobservable from data, but required for quantification of the model. To uncover these model parameters for 411 districts, we feed estimated trade costs together with information on population $L(i)$, wages $w(i)$ (proxied by GDP per capita), tax rates $t(i)$ and transfer rates $\theta(i)$ into (12) and (13) defining a system of 2×411 equations in 2×411 unknowns. Labor-market clearing pins down the equalized welfare level in this system.¹¹

Further parameters. We finally need to choose the values of five additional parameters – α , β , γ , σ and η – to derive values for $\bar{u}(i)$ and $\bar{A}(i)$. We motivate these values by estimates from the empirical literature. First, we set $\alpha = 0.1$ as Rosenthal and Strange (2004) show that productivity increases by up to 8 percent if population doubles. Second, our chosen value of $\beta = -2/3$ is derived as follows. Allen and Arkolakis (2014) show that their model is isomorphic to models where households spend a constant income share on housing, δ , such that $-\beta_0 = -\delta/(1 - \delta)$. According to Eurostat, average expenditure on housing amounted to 24.9 percent in Germany in 2010 leading to a value of β_0 of about

¹¹Details on solving for exogenous amenities and productivities are provided in the online appendix of Allen and Arkolakis (2014).

one third.¹² In addition, β can be understood to contain locational preferences of workers. If these preferences are distributed Frechet with shape parameter $k = 3$ as suggested by Bryan and Morten (2014), the overall value of β can be written as $\beta = -\beta_0 - 1/\theta$, where β_0 is the baseline congestion elasticity. Third, we need a value for γ governing the importance of public goods or transfers in the utility function. As the average tax rate amounts to about 25 percent, we choose $\gamma = 0.25$. In sum, these values ensure stability and uniqueness of the migration equilibrium as $\alpha + \beta + (1 - \eta)\gamma \leq 0$. Fourth, the elasticity of substitution σ plays a crucial role for quantifying welfare effects in trade models. We follow Simonovska and Waugh (2014) in choosing a value of five. Fifth, we assume that local governments provide pure public goods, so $\eta = 0$ in the baseline. We also study the other extreme of a pure private transfer when $\eta = 1$.

Figure 4 summarizes the pattern of exogenous productivities (Panel (a)) and exogenous amenities (Panel (b)). Locations with high per-capita income are characterized by higher values of exogenous productivity, like the south-west of Germany and bigger cities. Combining this information with location-specific population delivers composite productivity $A(i) = \bar{A}(i)L(i)^\alpha$ which is also higher in donor regions (see Panel (c) in Figure 3 above). Average labor productivity in donor regions is twice as high as in recipient locations. Turning to exogenous amenities, we observe from Panel (b) of Figure 4 that donor regions are also characterized by higher levels in this dimension. Combining these findings with location-specific population size (see Appendix 8) modifies this result because densely populated places suffer from negative congestion externalities. Finally, we observe from Panel (c) of Figure 3 that recipients are characterized by higher price indexes on average indicating that they are more remote than donor regions.

3.4 Importance of fiscal equalization

The model allows us to assess the importance of inter-regional transfers for the variation in local GDP. Combining (15) and (16) delivers a log-linear relationship between total income in location i and exogenous productivities, exogenous amenities, the price index and fiscal equalization:

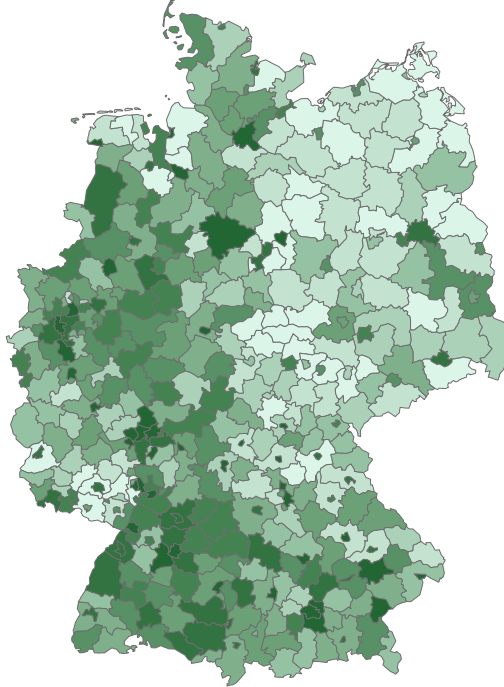
$$\begin{aligned} \frac{\lambda_1}{\sigma - 1} \ln Y(i) &= \frac{C_W + C_L}{\sigma - 1} + (1 - (\beta + \gamma(1 - \eta))) \ln \bar{A}(i) + (1 + \alpha) \ln \bar{u}(i) \\ &\quad - (2 + \alpha - (\beta + \gamma(1 - \eta))) \ln P(i) + (1 + \alpha) \ln \Omega(i). \end{aligned} \quad (19)$$

We apply a Shapley decomposition to (19) in order to determine the combined contribution of fiscal equalization (Ω) to the spatial dispersion of income. Figure 5 reports the fraction of the spatial variation in income that is due to fiscal equalization rather than

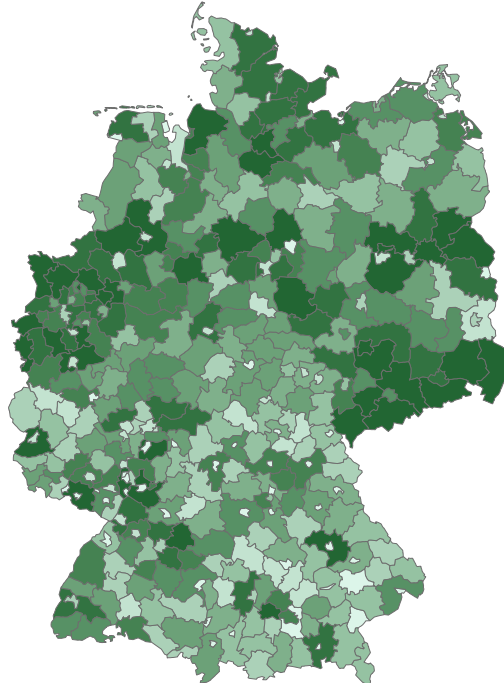
¹²We use information on the final consumption expenditure of households by consumption purpose (COICOP 3 digit) from Eurostat with the code: nama_10_co3_p3.

Figure 4: ESTIMATED EXOGENOUS PRODUCTIVITIES AND AMENITIES

(a) Exogenous productivities



(b) Exogenous amenities

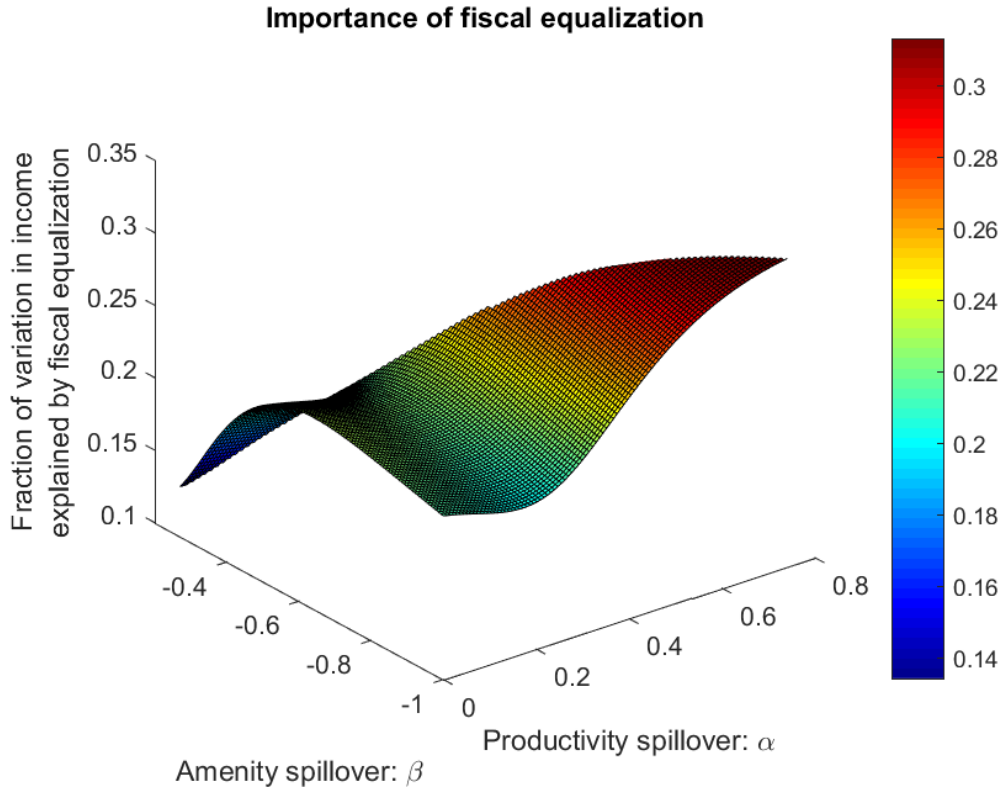


Notes: This figure plots the exogenous productivity $\bar{A}(i)$ and amenity $\bar{u}(i)$ for $\alpha = 0.1$, $\tilde{\beta} = -2/3$, $\gamma = 0.25$ and $\eta = 0$. A darker shading indicates higher values.

local characteristics or geographical location (that is P). For our baseline values $\gamma = 0.25$ and $\eta = 0$, we report the results of the decomposition for all combinations of $\alpha \in [0, 1]$ and $\beta \in [-1, 0]$ with a stable and unique equilibrium.

The decomposition suggests that at least 13 percent of the observed spatial variation in income is due to fiscal equalization. When the spillovers are such that $\alpha = 0.71$ and $\beta = -0.97$ fiscal equalization may account for up to 31 percent of the observed variation in income. In sum, the results indicate that the fiscal equalization scheme in Germany is important for the spatial variation in incomes across regions. Geographical location, in contrast, explains only a minor fraction of spatial income variation.

Figure 5: FRACTION OF SPATIAL VARIATION IN INCOME DUE TO FISCAL EQUALIZATION IN GERMANY



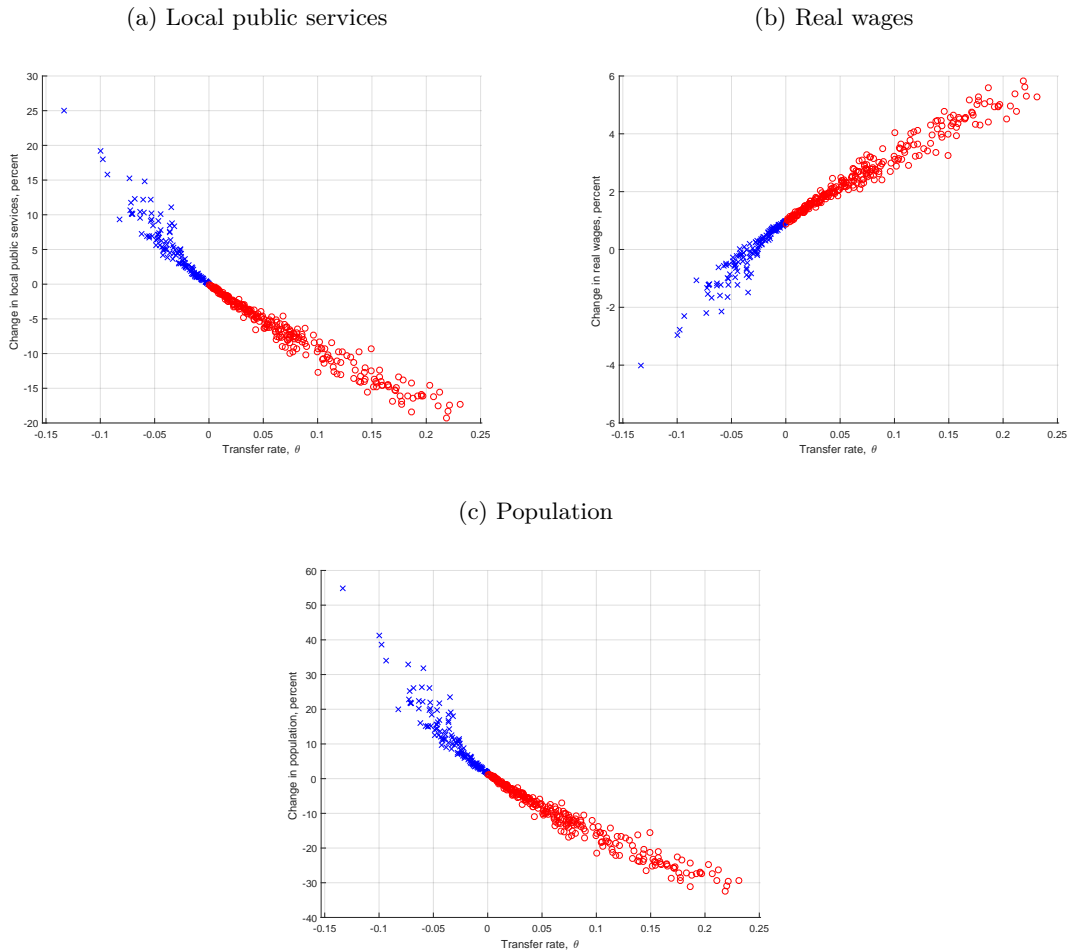
Notes: This figure shows the fraction of the observed variation in income across regions in Germany in 2010 that is due to fiscal equalization. For $\gamma = 0.25$ and $\eta = 0$ we calculated the results of the decomposition for all combinations of $\alpha \in [0, 1]$ and $\beta \in [-1, 0]$ with a stable and unique equilibrium.

3.5 Abolishing the redistribution scheme

To assess aggregate effects of fiscal equalization, we run a counterfactual scenario where we set the transfer rates to zero in all regions, so $\theta(i) = 0$ for all $i \in N$, and compare the counterfactual equilibrium values of the model with those of the baseline scenario. On average, abandoning fiscal equalization leads to a welfare gain of 0.33 percent in this

model. The data feature a significant dispersion of income between donors and recipients, so we should expect negative aggregate welfare effects from abandoning inter-regional transfers according to this channel. Recall that a transfer of one percent of income from a rich location implies a subsidy of more than one percent in a poorer location. However, we have also observed from Panel (c) of Figure 3 that recipient regions are on average more remote as indicated by a higher price index. Transferring money “back” from the periphery to the core works towards aggregate welfare gains in the model. The estimated positive welfare effect of abandoning the fiscal equalization scheme therefore suggests that geography dominates the effect of income dispersion between donors and recipients.

Figure 6: CHANGES IN LOCAL PUBLIC SERVICES, REAL WAGES AND POPULATION



Notes: Panel (a.) shows the association between changes in local public services and the transfer rate θ . Panel (b.) plots the relationship of changes in real wages and the transfer rate θ . Panel (c.) presents the relationship of population changes and the transfer rate θ . Net donors have a negative transfer rate θ and are marked by x (in blue). Net recipients observe positive transfer rates and are marked by circles (in red).

We explore the components of the welfare function more closely by reformulating (2):

$$W(i) = \bar{u}(i)\Omega(i)\frac{w(i)}{P(i)}L(i)^{\beta+\gamma(1-\eta)}. \quad (2')$$

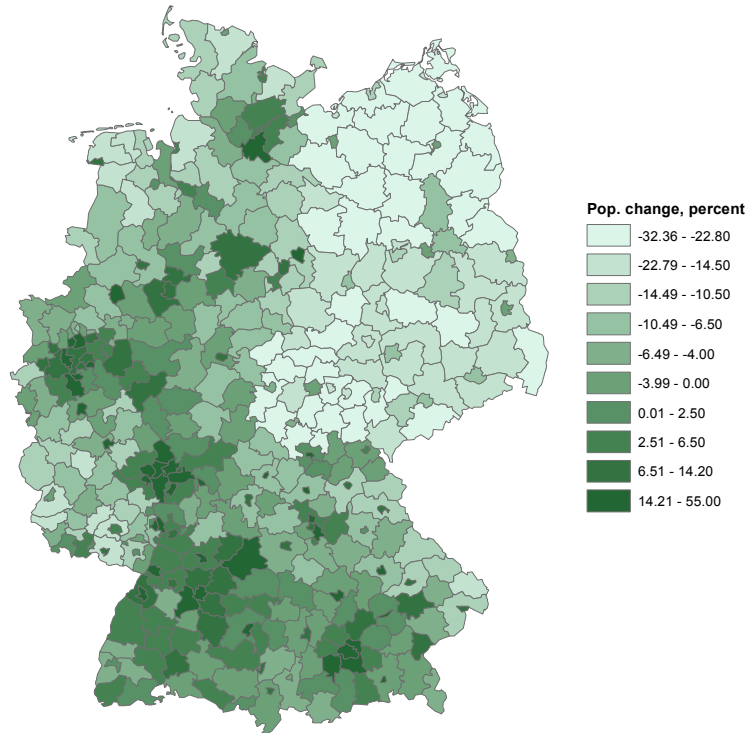
Abandoning transfers exerts a direct impact via $\Omega(i)$ that is decreasing for recipients and increasing for donors. This effect is illustrated in Panel (a) of Figure 6. As welfare has to be equalized in a spatial equilibrium, individuals migrate to previous donor regions. This changes the relative supply of goods and the spatial distribution of income in the economy. To ensure goods-market clearing, prices need to fall in regions that experience immigration. This takes place via lower nominal wages and higher labor productivity $A(i)$. As geography matters, however, real wages do not decline in all former donor regions. Those locations with a low negative transfer rate benefit from the overall decline in the price index, so their real wage increases. The real wage increase even compensates the negative effect of abandoning transfers for some former recipient regions with a low positive transfer rate, so those regions even experience immigration. This is evident from Panel (c) of Figure 6. The model predicts a very large inflow of individuals in Frankfurt/Main of more than 50 percent in the long run. The city is the largest contributor to the fiscal equalization scheme and also located in the center of Germany. Hence, both a high relative gain in public services and a low price index explain the pronounced increase in attractiveness of this location.

Geographically, migration would take place from East German and less densely populated regions to highly agglomerated regions in the western and southern parts of the country (see Figure 7). Locations in East Germany experience the largest decline in population of more than one third. In contrast, wealthy and densely populated areas in the west and south of Germany experience the largest migration inflows. At the aggregate level, abandoning fiscal transfers stimulates migration of 4.6 million individuals or 5.7 percent of the German population.

We have discussed in section 2 that shocks lead to new equilibria if dispersion forces are stronger than agglomeration forces. Hence, amenities decline substantially in locations that experience an increase in population. These amenities are difficult to grasp, so the public debate on regional transfers centers around the distribution of income, mostly only in nominal terms. Our counterfactual analysis informs this debate as we can derive changes in average real wages and average (labor) productivity. As is evident from Panel (b) of Figure 6, abandoning regional transfers would contribute to a reduction in the dispersion of real wages. Furthermore, the model predicts that real wages increase by about 5.75 percent. The aggregate effect is mainly driven by the relocation of workers from sparsely populated peripheral regions with low productivity to densely populated districts with higher productivity. This reallocation increases average productivity by 9.2 percent.

Public goods versus per-capita transfers. So far, we largely ignored the role of η in our model. Recall that η governs the rivalry of public services in consumption. In the baseline scenario, we assumed public services to be pure local public goods, so $\eta = 0$. In this case, we observe from (2') that local welfare is increasing in population. Intuitively, a larger market allows higher per-capita consumption of public services when there is no

Figure 7: GEOGRAPHICAL RELOCATION OF LABOR



Notes: This figure plots the percentage change in population after abandoning the redistribution scheme.

rivalry in consumption. This establishes an additional agglomeration force.

Table 4 summarizes aggregate effects of welfare, average real wages, average (labor) productivity and migration in absolute and relative terms. We observe that for $\eta = 1$ aggregate welfare effects become negative (-0.21 percent) when we abolish fiscal equalization payments. Intuitively, welfare has to be smaller in the case of per-capita transfers because resources are re-directed to more populous districts in our application. With $\eta = 0$, this generates an additional advantage compared to the case of $\eta = 1$. Consequently, inter-regional migration flows are less pronounced.

Weight of public services. Another important parameter is the Cobb-Douglas parameter γ governing the importance of public services in the utility function. Table 4 reveals that higher values of γ are associated with higher or less negative welfare changes. Intuitively, γ affects the strength of agglomeration forces. If individuals value public services more, transferring income leads to more pronounced responses in labor mobility. If population size matters in addition, so $\eta = 0$, then changes in γ exert an even stronger effect on aggregate outcome.

Table 4: AGGREGATE EFFECTS: WELFARE, REAL WAGES, LABOR PRODUCTIVITY AND MIGRATION

η	γ	\hat{W} <i>in percent</i>	$\widehat{w/P}$ <i>in percent</i>	\hat{A} <i>in percent</i>	\hat{L} <i>in millions</i>	\hat{L} <i>in percent</i>
0	0.20	0.07	4.17	6.57	3.38	4.14
0	0.25	0.33	5.75	9.21	4.64	5.67
0	0.30	0.77	7.89	12.57	6.15	7.53
1	0.20	-0.23	3.10	4.81	2.51	3.07
1	0.25	-0.21	3.86	6.08	3.14	3.84
1	0.30	-0.15	4.65	7.39	3.77	4.61

Notes: This table reports changes in welfare, average real wages, average labor productivity and migration (in millions and in percent of the total population) for $\sigma = 5$, $\alpha = 0.1$, $\beta = -0.66$ and different parameter values of η when income redistribution between locations is abolished.

4 Conclusions

We have argued in this paper that it is important to account for fiscal transfers between jurisdictions to understand the spatial organization of an economy. We use a general equilibrium model with trade and labor mobility to derive insights about the welfare costs about fiscal equalization. We argue that transfers from rich to poor regions raises welfare as a transfer of one percent of income in donor regions makes up more than one percent in target regions. This effect rises in the dispersion of income. Further, geography matters. If recipients are located in the periphery, one unit of income buys less utility there due to a higher price index.

We quantify the model for Germany with data on population, income and inter-regional trade and explore aggregate effects by abolishing the fiscal equalization scheme. We find moderate welfare effects of 0.33 percent indicating that geography plays an important role. About 5 percent of the population would change their place of residence and employment to reinstall a spatial equilibrium.

As migration changes the spatial allocation of production as well as local consumption and production amenities, we find that the abolishment of transfers raises average real per-capita income by 5.8 percent in the long run, which is largely driven by an increase in average labor productivity of more than 9 percent. Overall, regional transfers are able to explain up to about 30 percent of the variation in local income.

References

- Albouy, D.** 2009. The unequal geographic burden of federal taxation. *Journal of Political Economy*. **117(4)**, 635-667.
- Albouy, D.** 2012. Evaluating the efficiency and equity of federal fiscal equalization. *Journal of Public Economics*. **117(4)**, 635-667.
- Allen, T. and C. Arkolakis.** 2014. Trade and the topography of the spatial economy. *Quarterly Journal of Economics*. **129(3)**, 1085-1139.
- Bartelme, D.** 2015. Trade costs and economic geography: Evidence from the U.S., Working Paper.
- Bartik, T.** 1991. Who benefits from state and local economic development policies? Unpublished manuscript, Upjohn Institute.
- Behrens, K., G. Mion, Y. Murata and J. Suedekum.** 2017. Spatial frictions, *Journal of Urban Economics*, **97(1)**, 40-70.
- Boadway, R. and F. Flatters.** 1982. Efficiency and equalization payments in a federal system of governments: A synthesis and an extension of recent results. *Canadian Journal of Economics* **15**, 613-633.
- Bryan, G. and M. Morten.** 2014. Economic development and the spatial allocation of labor: Evidence from Indonesia, Stanford University, mimeograph.
- Busso, M., J. Gregory, and P. Kline.** 2013. Assessing the incidence and efficiency of a prominent place-based policy. *American Economic Review* **103(2)**, 897-947.
- Caliendo L., F. Parro, E. Rossi-Hansberg and P.D. Sarte.** 2014. The impact of regional and sectoral productivity changes on the U.S. economy. *NBER Working Paper* 20168.
- Chetty, R.** 2006. A New Method of Estimating Risk Aversion. *American Economic Review*, **96(5)**, 1821-1834.
- Dekle, R., J. Eaton and S. Kortum.** 2007. Unbalanced Trade. *American Economic Review*, **97(2)**, 351-355.
- Ehrlich, M. von and T. Seidel.** 2016. The persistence effects of place-based policies. Evidence from the West-German Zonenrandgebiet. Unpublished manuscript, University of Duisburg-Essen.
- Fajgelbaum, P.D., E. Morales, J.C. Suárez Serrato and O. Zidar.** 2016. State taxes and spatial misallocation. *NBER Working Paper No. 21760*.

- Federal Ministry of Finance.** 2015. Bund-Länder-Finanzbeziehungen auf der Grundlage der Finanzverfassung and own calculations, Berlin.
- Federal Ministry of Finance.** 2016. The federal fiscal equalisation system in Germany, Berlin.
- German Statistical Office.** 2011. Fachserie 14 Reihe 4, Finanzen und Steuern. Wiesbaden.
- Glaeser, E. and J. Gottlieb.** 2008. The economics of place-making policies. *Brookings Papers on Economic Activity* Spring: 155-253.
- Head, K. and T. Mayer.** 2014. Chapter 3 - Gravity equations: Workhorse, toolkit, and cookbook. *Handbook of International Economics*, Elsevier. Gita Gopinath, E. H. and Rogoff, K. (Eds.), 4, 131-195.
- Henkel, M. and T. Seidel** 2016. A Spatial Perspective on European Integration: Heterogeneous Welfare and Migration Effects from the Single Market and the Brexit. *CESifo Working Paper Series, No. 6289*.
- Kline, P. and E. Moretti.** 2014. Local economic development, agglomeration economies and the big push: 100 years of evidence from the Tennessee Valley Authority. *Quarterly Journal of Economics*, **129(1)**, 275-331.
- Lameli, A., V. Nitsch, J. Suedekum, and N. Wolf.** 2015. Same Same But Different: Dialects and Trade, *German Economic Review*, Verein für Socialpolitik, **16(3)**, 290-306.
- Monte, F., S. Redding, S. and E. Rossi-Hansberg.** 2015. Commuting, migration and local employment elasticities. *National Bureau of Economic Research*.
- Moretti, E. and D. Wilson.** 2017. The effect of state taxes on the geographic location of top earners: Evidence from star scientists. *American Economic Review*, forthcoming.
- Nitsch, V. and Wolf, N.** 2013. Tear down this wall: on the persistence of borders in trade, *Canadian Journal of Economics*, **46(1)**, 154-179.
- Redding, S. J.** 2016. Goods trade, factor mobility and welfare. *Journal of International Economics*, **101**, 148-167.
- Rosenthal, S. S. and Strange, W. C.** 2004. Chapter 49 - Evidence on the nature and sources of agglomeration economies. *Cities and Geography*, Elsevier. Henderson, J. V. and Thisse, J.-F. (Eds.), 4, 2119 - 2171.
- Simonovska, I. and Waugh, M. E.** 2014. The Elasticity of trade: Estimates and evidence. *Journal of International Economics*, **92(1)**, 34-50.

- Statistical Office of the European Communities.** 2016. EUROSTAT: Regions and cities: Regional statistics illustrated. Luxembourg: Eurostat.
- Tombe, T. and Winter, J.** 2017. Fiscal Integration with Internal Trade: Quantifying the Effects of Equalizing Transfers. mimeo.
- United Nations.** 2016. UN COMTRADE database. <http://comtrade.un.org/>.
- Watson, W.G.** 1986. An estimate of the welfare gain from fiscal equalization. *Canadian Journal of Economics*, **19**, 298-308.

A Appendix

A.1 Derivation of (13)

To derive (13), we define

$$\lambda(i) \equiv \frac{(1 + \theta(i))\bar{A}(i)^{1-\sigma}w(i)^\sigma L(i)^{1-\alpha(\sigma-1)}}{\Omega(i)^{1-\sigma}\bar{u}(i)^{1-\sigma}w(i)^{1-\sigma}L(i)^{(1-\sigma)[\beta+\gamma(1-\eta)]}}.$$

Assuming symmetric trade costs, $\tau(i, n) = \tau(n, i)$, we get from (11) and (12):

$$\begin{aligned} \frac{\lambda(i)}{1 + \theta(i)} &= \frac{\int_N \tau(i, n)^{1-\sigma}\bar{u}(n)^{\sigma-1}\Omega(n)^{\sigma-1} (1 + \theta(n)) w(n)^\sigma L(n)^{1+(\sigma-1)(\beta+\gamma(1-\eta))} dn}{\int_N \tau(n, i)^{1-\sigma}\bar{A}(n)^{\sigma-1}w(n)^{1-\sigma}L(n)^{\alpha(\sigma-1)}} \\ &= \frac{\int_N \lambda(n)^\beta F(n, i) dn}{\int_N \lambda(n)^{\beta-1} F(n, i) dn}, \end{aligned}$$

where $F(n, i) \equiv \tau(n, i)^{1-\sigma}\bar{u}(n)^{(1-\beta)(\sigma-1)}\bar{A}(n)^{\beta(\sigma-1)}\Omega(n)^{(\sigma-1)(1-\beta)}(1 + \theta(n))^{1-\beta}w(n)^{\sigma+\beta(1-2\sigma)}L(n)^{1+\beta(\sigma-1)+\beta((\alpha-\beta)(\sigma-1)-1)+(1-\beta)\gamma(\sigma-1)(1-\eta)}$.

Rearranging terms delivers

$$\frac{\lambda(i)^\beta}{\lambda(i)^{\beta-1}} = (1 + \theta(i)) \frac{\int_N F(n, i) \lambda(n)^\beta dn}{\int_N F(n, i) \lambda(n)^{\beta-1} dn}.$$

Following the logic in Allen and Arkolakis (2014) and referring to the generalized Jentzsch theorem, $\lambda(i)^\beta = (1 + \theta(i))\phi\lambda(i)^{\beta-1}$ and thus $\lambda(i)/(1 + \theta(i)) = \phi$. Plugging this relationship into the definition of $\lambda(i)$ above yields (13).

A.2 Data

To compile the tax data, we first subtract an amount of 37,895.9 million euros that is primarily used for child allowance. This is the standard procedure in the fiscal equalization scheme and appropriate in our context as this item is a main transfer for families. As a consequence, overall tax income in 2006 of 526,218.2 million euros shrinks to 488,775.3 million euros. In the following, we describe in detail how we obtain the two key tax variables of interest. First, we need to know how much tax revenue each district has generated in 2010. Second, we compute each district's share of the overall tax budget. These data are not readily available as Germany is characterized by several jurisdictional layers that have both common and individual tax authority. Therefore, tax statistics provide information on tax income for different types of taxes and different jurisdictional entities. As our model abstracts from these layers (and the complexity of different types of taxes), we need to assign tax income to each district.

First, we calculate tax income generated in each district. Using the statistic ‘‘Real-

steuervergleich” from the German Statistical Office, we obtain information on business and property tax revenues that can be directly linked to each location. Further, we can derive total revenues of VAT and income taxes collected in each district. For this, we take advantage of the fact that municipalities can keep a certain fraction of the total that is fixed at a certain rate for every jurisdiction. As we know the total amount each district can keep, we can infer the total amount collected. VAT and income taxes are the two most important taxes with regard to revenues accounting for about 61 percent of total tax income in Germany. Together with business and property taxes, the share rises to 70 percent that can be unambiguously assigned to each locality. The remaining 30 percent of tax income comprises federal and state taxes that we assign to each district according to the share of tax income that is directly attributable to each location. This follows the idea that districts with higher VAT and income tax revenue are characterized by higher economic activity leading to higher revenues of other taxes as well.

Second, we compute the tax budget of each district. This figure does not necessarily match the previous figure on collected taxes at the local level, as major taxes are shared between different layers of government and, most importantly, there is inter-regional redistribution. From the German Statistical Office’s “Bruttoeinnahmen der Gemeinden”, we know each location’s tax budget plus transfers from the state or the federal level. As Germany is characterized by an elaborate federal system where municipalities, states, and the federal level itself are responsible for certain tasks that are fixed by the constitution. Hence, these layers have a claim for a certain share of the overall tax budget. Therefore, tax statistics do only report tax budgets for each layer and we need to distribute the state and federal budgets to each district.

We have shown in the main part of this paper that a substantial amount of resources is transferred between the federal level and the states and between the states. We thus use information about the available tax budget of each state after fiscal equalization. These budgets differ substantially from collected taxes. We then need to make an assumption about how these state budgets are distributed across each state’s districts (municipalities). To capture the idea that the state is obliged to install equal living conditions across regions, we distribute these tax budgets according to population shares (rather than tax income shares). What remains is the federal tax budget that we also distribute according to population shares.

Having completed these two tasks delivers two variables: Total tax income of each district before equalization and total tax income of each district after equalization. The difference defines transfers each district pays or receives. Relating these data to local GDP delivers the transfer rate $\theta(i)$.

Table 5 shows the volume of redistribution at each stage of the process. In sum, this amounts to about 26.5 billion euros or 5 percent of tax revenues.

Table 5: VOLUME OF REDISTRIBUTION, 2010

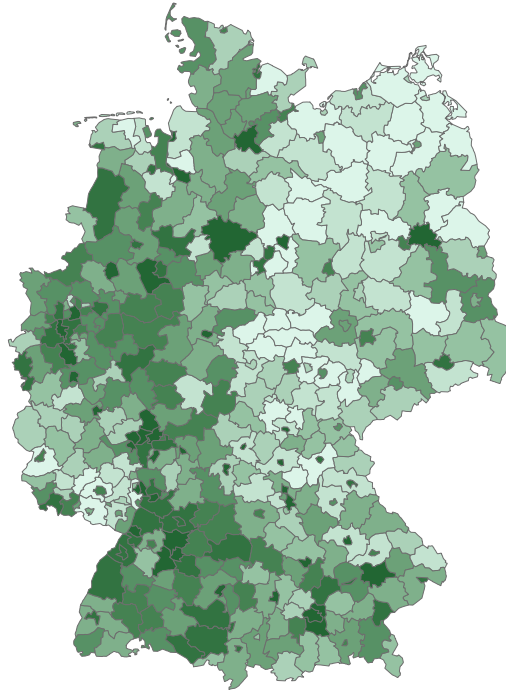
	VAT redistribution (million euros)	Horizontal equalization (million euros)	General grants (million euros)	Special grants (million euros)	Per capita transfers (euros)
Bavaria	-1,545	-3,511	0	0	-403
Baden-Württemberg	-1,327	-1,709	0	0	-282
Berlin	58	2,900	912	1,706	1,611
Brandenburg	864	401	176	1,498	1,174
Bremen	-46	445	146	60	916
Hamburg	-220	-66	0	0	-160
Hesse	-749	-1,752	0	0	-412
Lower Saxony	378	259	127	0	96
Mecklenburg Western Pomerania	830	399	157	1,110	1,520
North Rhine-Westphalia	-2,204	354	119	0	-97
Rhineland Palatinate	-393	267	144	46	16
Saarland	125	89	46	63	317
Saxony	2,024	854	350	2,625	1,411
Saxony-Anhalt	1,201	497	202	1,616	1,506
Schleswig Holstein	-136	101	51	53	24
Thuringia	1,139	472	192	1,483	1,470
Sum	6,620	7,039	2,624	10,260	

Source: Federal Ministry of Finance (2015).

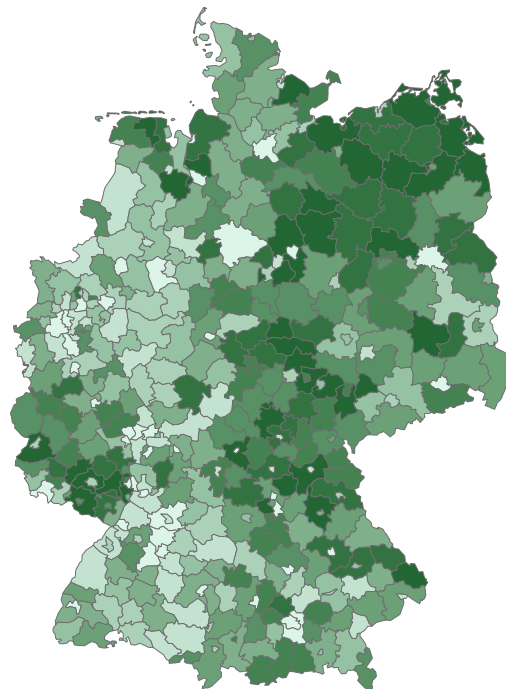
A.3 Composite productivities and amenities

Figure 8: ESTIMATED COMPOSITE PRODUCTIVITIES AND AMENITIES

(a) Composite productivities



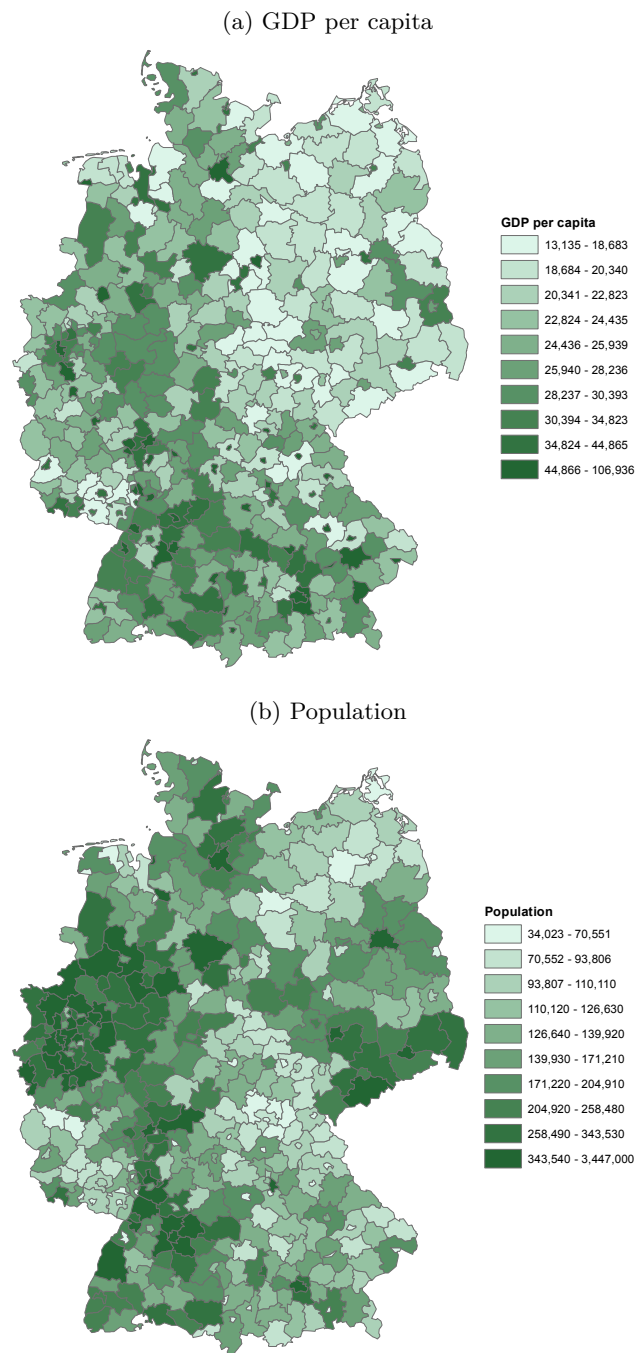
(b) Composite amenities



Notes: This figure shows composite productivity $A(i)$ and composite amenity $u(i)$ for $\alpha = 0.1$, $\tilde{\beta} = -2/3$, $\gamma = 0.25$ and $\eta = 0$. A darker shading indicates higher values.

A.4 GDP per capita and population density

Figure 9: DISTRIBUTION OF GDP PER CAPITA AND POPULATION DENSITY IN 2010



Notes: This figure plots the quantiles of the GDP per capita distribution in Panel (a) and of the population distribution in Panel (b) for the year 2010. A darker shading indicates higher values.