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Abstract

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JEL Classification: F15, R11

Keywords: Fiscal equalization, regional transfers, migration, spatial economics

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Fiscal Transfers in the Spatial Economy

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Abstract

Many countries operate pronounced fiscal equalization schemes that shift tax revenue across jurisdictions. We use a general equilibrium model with multiple asymmetric regions, costly trade and labor mobility to carve out the aggregate implications of this policy. Calibrating the model for Germany, we find that it indeed delivers smaller spatial economic disparities across regions. This comes at the cost of lower national output, however, because activity is diverted away from core cities and towards remote areas with low productivity. But despite this output loss, fiscal transfers may still raise national welfare, because they effectively countervail over-congestion in large cities.

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1 Introduction

Many countries conduct spatial development policies targeted at economically lagging regions within their territory. Those place-based policies often take the form of discretionary grants or spending programs by higher-order government layers, such as the Federal level, to subsidize investment or job creation in designated recipient areas.[1] Examples include enterprise zones in the United States or structural funds in the European Union. But those regional policies are not the only means to shift resources across jurisdictions.

An equally, if not more, important instrument are fiscal equalization schemes. This policy re-distributes tax revenue from areas with high financial capacity to poorer jurisdictions, and thus effectively allows recipient regions to offer more public goods than they otherwise could in the absence of transfers. Fiscal equalization schemes are used by many countries to tackle spatial economic disparities, including Germany on which we focus in this paper.[2] We estimate that a remarkable total volume of 65.7 billion Euro worth of transfers is shifted across jurisdictions every year. This includes the Federal scheme which allocates tax revenue between the 16 States and the Federal level (*Länderfinanzausgleich*), and various lower-tier schemes which provide additional equalization across municipalities within States. To set this into perspective, the amount of fiscal transfers within Germany is more than twice as large as all EU structural funds taken together.[3]

Despite the prevalence of fiscal equalization schemes, surprisingly little is known about their implications. How do they affect aggregate economic activity and the distribution of population and income across space? What is their impact on productivity and welfare at the national level? How do they shape regional migration flows? To shed light on these important questions, we set up and quantify a general equilibrium model with multiple asymmetric regions, costly interregional trade and labor mobility, and inter-jurisdictional fiscal transfers. We calibrate the model, taking into account taxes and transfers as observed in the data. In a counterfactual analysis, we then simulate how the equilibrium would change if Germany were to abandon its equalization schemes completely. In this hypothetical scenario, local public goods are financed solely by taxing local economic activity, but there are no more transfers across jurisdictions. Comparing this counterfactual to the actual equilibrium allows us to provide quantitative answers to the questions how, and through which channels, fiscal equalization affects the spatial economy.

[1]The theoretical rationale for place-based policies is discussed by Kline and Moretti (2014) and Gottlieb and Glaeser (2008). Newmark and Simpson (2014) summarize the empirical literature. Specific policies have been evaluated, among others, by Busso, Gregory and Kline (2013), Becker, Egger and Ehrlich (2017) and Ehrlich and Seidel (2018). Recent contributions by Glaeser and Summers (2018) and Rodriguez-Pose (2018) discuss those policies in the context of the recent rise in populist vote shares in lagging regions.

[2]See Blöchliger et al. (2007) for a recent cross-country overview of fiscal equalization schemes and an estimation of their overall volumes across OECD countries.

[3]The volume of fiscal equalization also dwarfs the classical regional development policies within Germany. The main instrument, labeled *Gemeinschaftsaufgabe regionale Wirtschaftsstruktur (GRW)*, is similar to the US enterprise zones program, and is operated jointly via discretionary grants by the Federal and the State governments. It amounts to an annual volume of only 1.5 billion Euro.

Such a quantitative approach is needed, because the welfare implications of fiscal equalization are not clear-cut from a purely theoretical point of view. On the one hand, by shifting resources from rich to poor places, transfers may distort incentives and induce some workers or firms to locate in regions that they otherwise would not have chosen (Kline and Moretti, 2014). These mis-allocations may be particularly severe when recipient areas have low levels of productivity, or when they are remotely located so that transport losses in interregional trade are exacerbated. The fiscal transfers may therefore reduce aggregate output at the national level, because they shift economic activity away from core cities (Hsieh and Moretti, 2017). On the other hand, the spatial economy might be affected by various externalities that individuals do not take into account when making location decisions. For instance, individuals ignore their impact on others that is transmitted via local price index effects or through different agglomeration and congestion forces. A laissez-faire equilibrium without transfers may therefore be characterized by an inefficient spatial structure, and in particular, by cities that are "too large" from a social point of view (Henderson 1974; Albouy et al. 2017). By reducing over-congestion in cities, the fiscal transfers may therefore actually mitigate rather than exacerbate mis-allocations. We consider some stylized examples of our model and show that the welfare implications of fiscal equalization are indeed ambiguous. Transfers reduce welfare in some constellations, but improve welfare in other cases. To investigate the effects of fiscal equalization in practice, we therefore take our model to the data.

This quantification is challenging, because the rules and details of the German equalization schemes are complicated and span over several governmental layers (Federal, States and local municipalities). No official statistics are available for net transfer rates of local jurisdictions. To construct empirical proxies, we exploit information on the volumes of generated taxes and available public funds at the local level in the year 2010. Our approach assigns taxes and expenditures to the 411 German districts (*Landkreise*), accounting for fiscal equalization within and between States as well as the allocation of public funds across government layers. The numbers suggest that the total volume of re-distribution is substantial, and amounts to 65.7 billion Euro per year or 12.4 % of the aggregate tax revenue. Large and productive cities in the West are the biggest net contributors. Frankfurt comes out on top with a transfer rate of 13.3 % of local gross domestic product (GDP), which is equivalent to 11,000 Euro per inhabitant that is paid to other jurisdictions via fiscal transfers. The main recipients are poor and remote locations, often located in East Germany, which receive support of up to 23.1 % of local GDP.

In our counterfactual scenario, where all fiscal transfers are abolished, we observe a major migration wave out of the former recipient and towards the former donor regions. In total, we calculate that roughly 3.2 million people would change their district of residence. Some East German cities would lose almost one quarter of their population, while big cities like Frankfurt, Munich or Düsseldorf would substantially grow. As the induced migration is from less to more productive regions, we observe substantial gains in aggregate output and productivity at the national level. In our benchmark specification, we calculate that abolishing transfers raises average labor productivity by 5.8% and real GDP per capita by 3.7%. Fiscal equalization therefore seems to imply an equity-efficiency trade-off: by retaining economic activity in the periphery, fiscal transfers limit productivity and income dispersion across space. But this comes at a cost, namely lower national output.

When turning to national welfare, however, we find that this trade-off may actually not exist. In our baseline counterfactual, welfare even mildly decreases by 0.05% when transfers are abolished. In alternative specifications we sometimes obtain welfare gains, but they are consistently an order of magnitude smaller than productivity and output gains. The reason is that the former donor regions are already over-congested in the initial equilibrium. When transfers are switched off, additional migration into those crowded cities is induced, and this makes the problem of congestion externalities even worse. In other words, abolishing fiscal equalization may increase national GDP but not welfare.

Our paper relates to various strands of literatures. First, it adds to recent quantitative trade models with factor mobility and exogenous local characteristics (e.g. Allen and Arkolakis, 2014, Behrens, Mion, Murata, Suedekum, 2017, and Redding, 2016). We contribute to this line of research by introducing inter-jurisdictional transfers that necessarily imply trade imbalances between locations (Dekle, Eaton, Kortum, 2007).

A second line of research focuses on the optimal design of fiscal transfer schemes dating back to at least Buchanan (1950). A main objective is to understand the effect of taxes and transfers on the migration decisions of workers (see Albouy, 2012, Albouy et al., 2017). Our approach explicitly accounts for costly trade and locational preferences of households in understanding the economic effects of fiscal equalization.[4]

Third, the paper adds to the literature on the existence and costs of factor mis-allocation (e.g. Hsieh and Klenow, 2009). A related paper by Hsieh and Moretti (2017) studies the extent of labor mis-allocation due to housing supply restrictions in the US. They find that these regulations have lowered economic growth by more than 50 % between 1964 and 2009. In our model, fiscal equalization also implies lower productivity and output at the national level, but it potentially also mitigates over-crowding in high-productive locations caused by negative congestion externalities. We therefore emphasize that aggregate implications for national output and welfare may be very different.

The paper is organized as follows. We introduce the spatial model with fiscal equalization in Section 2 and illustrate key economic mechanisms in Section 3. Section 4 explains how we quantify the model for Germany. The counterfactual analysis presented in Section 5 before we conclude in Section 6.

[4]Fajgelbaum and Gaubert (2018) develop a quantitative spatial model with costly trade to examine efficient spatial policies. Our paper places a specific weight on fiscal equalization.

2 A quantitative geography model with fiscal equalization

We consider an economy consisting of N regions. The economy is populated by a mass $\bar{L}$ of homogeneous workers, who are (imperfectly) mobile across regions. Governments in every region collect income taxes to provide local public goods, and a fiscal equalization scheme reallocates resources across jurisdictions.

2.1 Preferences

Households in region i derive utility from consumption of a private good $C(i)$ and public services $G(i)$ according to the following Cobb-Douglas preferences, where $0 < \gamma < 1$:

$$U(i) = u(i) \cdot \left(\frac{G(i)}{L(i)^\eta} \right)^\gamma \cdot C(i)^{1-\gamma}. \tag{1}$$

The parameter $\eta \in [0; 1]$ governs the degree of rivalry in public services, with $\eta = 0$ capturing the case of a pure local public good and $\eta = 1$ the case of fully rival per-capita transfers. The term $u(i)$ represents a local amenity including fixed features like scenery or climate, but also endogenous local characteristics such as congestion or housing prices. It will be discussed in greater detail in Section 2.5 below.

2.2 Production technologies

Every region i produces a unique variety of a differentiated intermediate good under perfect competition using labor as the sole input. Locations differ in productivity, such that every worker produces $A(i)$ units of this good. A final good $Q(i)$ is assembled from the continuum of intermediates according to the following CES aggregator:

$$Q(i) = \left[\int_N q(n,i)^{\frac{\sigma-1}{\sigma}} dn \right]^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

Here, $q(n,i)$ 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 intermediates. We assume that $\tau(n,i) \geq 1$ units must be sent from n for one unit to arrive in i, and we abstract from intra-regional transport costs ($\tau(i,i) = 1$). Final goods are not traded across regions, and assembly has no extra costs. The price of the final good in location i is therefore given by

$$P(i) = \left[\int_N p(n,i)^{1-\sigma} dn \right]^{\frac{1}{1-\sigma}}. \tag{3}$$

This final good $Q(i)$ can either be used directly for private consumption $C(i)$, or by local governments to provide public services $G(i)$. Thus, we have $Q(i) = C(i) + G(i)$. The aggregate demand for the variety from n in location i is given by

$$q(n,i) = \frac{p(n,i)^{-\sigma}}{P(i)^{1-\sigma}} E(i), \tag{4}$$

where $E(i)$ denotes overall (private and public) expenditure in i.

2.3 Profit maximization and inter-regional trade

As the differentiated varieties are produced under perfect competition, prices equal effective marginal costs including transport costs. That is, $p(n,i) = \tau(n,i)w(n)/A(n)$ for the intermediate produced in n and sold in i, where $w(n)$ is the wage in n. Using those prices in (3) and (4) we obtain total sales from n to i as follows,

$$X(n,i) = \left(\frac{\tau(n,i)w(n)}{A(n)P(i)}\right)^{1-\sigma} E(i), \tag{5}$$

and the CES price index in location i becomes:

$$P(i) = \left[\int_N \left(\frac{\tau(n,i)w(n)}{A(n)}\right)^{1-\sigma} dn\right]^{\frac{1}{1-\sigma}}. \tag{3'}$$

2.4 Taxes, public spending, and fiscal equalization

We now describe the public sector in this economy. Income is taxed at rate rate $t(i)$ in region i, which generates an overall tax revenue equal to $t(i)w(i)L(i)$. Assuming that the public budget is balanced, the level of local public goods is thus given by $G(i) = t(i)w(i)L(i)/P(i)$ when there are no inter-regional transfers. When a fiscal equalization scheme is in place, every region is either a net recipient of public funds from other jurisdictions, or respectively, a net donor. Net receipts are denoted as $\theta(i)w(i)L(i)$, where the transfer rate relative to local aggregate income is positive ($\theta(i) > 0$) for recipient and negative ($\theta(i) < 0$) for donor regions. Given those transfers, the effective budget that is available for local public goods provision in region i is given by

$$G(i) = [t(i) + \theta(i)]\, w(i)L(i)/P(i), \tag{6}$$

and aggregate spending becomes $E(i) = (1 + \theta(i))w(i)L(i)$.

This specification of the public sector is kept as simple as possible, but it is flexible enough for our purpose of taking the model to the data. Three comments are in order about our setup. First, the model abstracts from any optimizing behavior of governments in the setting of tax rates $t(i)$ or transfer rates $\theta(i)$, including strategic considerations such as horizontal tax competition.[5] Instead, we consider $t(i)$ and $\theta(i)$ as exogenously given

[5]Notice that local government in Germany have indeed little autonomy over tax rates, as less than 9 %

and recover them from the data. Starting from those observed *actual* choices, we then study the economic effects of fiscal equalization in a counterfactual analysis. Second, we abstract from a Federal government (or any other vertical structure) and from national public goods. In the empirical application below, however, we consider all layers of the public sector in Germany, and break down Federal and State tax revenue to the local level. This approach also allows us to include tax revenue from other sources (such as value-added or corporate profits) other than income taxes as featured in our model. Third, we abstract from progressive tax schedules and dead-weight losses of income taxation. However, although individuals supply labor inelastically, we will see later that they respond to regional differences in tax and transfer rates through migration. Local governments therefore do face a mobile tax base, as individuals choose their locations endogenously.

2.5 Indirect utility, agglomeration and dispersion forces

Using (2)–(6) in (1), we can write indirect utility in region i as follows:

$$W(i) = u(i) \cdot \frac{w(i)}{P(i)} \cdot L(i)^{\gamma(1-\eta)} \cdot \left[(t(i) + \theta(i))^{\gamma} (1 - t(i))^{1-\gamma} \right]. \tag{7}$$

The first two terms in (7) show that regions with better amenities $u(i)$ and higher real wages $w(i)/P(i)$ tend to be more attractive locations for households. Moreover, the third term indicates that larger regions are more desirable when there is some non-rivalry in public services (if $\eta < 1$), because more inhabitants can share public facilities.[6] Finally, the fourth term shows that an inflow of fiscal transfers (an increase of $\theta(i)$) increases indirect utility, ceteris paribus, because it allows governments to expand local public goods.

Apart from the sharing of local public goods, there is an additional agglomeration force in our model that operates via the local productivity level. More specifically, we follow Allen and Arkolakis (2014) and assume that $A(i)$ is given by:

$$A(i) = \bar{A}(i) L(i)^{\alpha}, \quad \text{with } \alpha \geq 0. \tag{8}$$

Here, $\bar{A}(i)$ represents a location-specific exogenous productivity, and the positive impact of $L(i)$ on $A(i)$ captures additional agglomeration economies such as knowledge spillovers. The strength of this force is measured by the elasticity α.

The dispersion force in our model works through the local amenity term $u(i)$. It, too, contains an exogenous component $\bar{u}(i)$, capturing scenery or climate, and an endogenous part that is negatively linked to local population size as follows:

of tax revenue comes from sources over which they have any discretion. See Section 4 for more details.

[6] In other words, local public goods provision establishes one agglomeration force in our model that is increasing in γ and decreasing in η.

$$u(i) = \bar{u}(i)L(i)^{-\beta}, \quad \text{with } \beta \geq 0, \tag{9}$$

where β governs the strength of that endogenous dispersion force.

This simple notation is a short-cut for several possible micro-foundations of local congestion effects. For example, it may capture higher housing prices or more traffic jams in larger cities. Allen and Arkolakis (2014) have formally established this isomorphism. First, defining $1-\delta$ as the income share spent on a fixed local factor, and setting $\alpha = 1/(\sigma - 1)$ and $\beta_0 = (1-\delta)/\delta$ renders this model isomorphic to Helpman (1998) and Redding (2016). The price of the immobile factor increases when workers migrate into a region, and this congestion externality runs through (9) in our setup.

It is also straightforward to incorporate idiosyncratic locational preferences into this model. Allen and Arkolakis (2014) show that this effectively scales up the endogenous dispersion force. More specifically, suppose that indirect utility of worker ω in location i features an additional term $v(i,\omega)$, which is additively separable in (7) and is drawn from a Frechet distribution with shape parameter k as in Redding (2016). Using (9), the first two terms in (7) can then be written as $\bar{u}(i) \cdot w(i)/P(i) \cdot L(i)^{-\beta}$, where $\beta = \beta_0 + 1/k$. Workers become imperfectly mobile across regions, as their location choices are now also affected by idiosyncratic tastes. This lower degree of mobility materializes in the model as if the local congestion force were stronger ($\beta > \beta_0$).

To keep our model parsimonious, we do not take a stance on specific micro-foundations, but use (8) and (9) as flexible reduced forms for agglomeration and dispersion forces, and we add sharing of local public goods as another agglomeration externality.

2.6 Equilibrium

A competitive equilibrium in this economy is defined by the following four conditions:

1. **Labor market clearing.**

$$\int_N L(n)dn = \bar{L} \tag{10}$$

2. **Goods market clearing.** Total labor income in region i, $w(i)L(i)$, must equal region $i's$ total sales to all locations $n \in N$:

$$w(i)L(i) = \int_N X(i,n)dn, \tag{11}$$

   where $X(i,n)$ is given by (5) and includes fiscal transfers across regions.[7]

[7]Note that fiscal transfers imply trade imbalances in equilibrium. Donor regions produce more than they consume, and thus run a current account surplus (also see Dekle, Eaton and Kortum, 2007). To see this formally, recall that total expenditure must equal local spending plus total imports, so $E(i) \equiv (1+\theta(i))w(i)L(i) = \int_N X(n,i)dn$. Comparing this expression with (11), we observe that the difference between exports and imports is given by $-\theta(i)w(i)L(i)$, while $\int_N (-\theta(n)w(n)L(n))dn = 0$.

3. **Balanced public budget.** The total amount of transfers paid must equal the total amount received:
$$\int_N \theta(i)w(i)L(i)dn = 0. \tag{12}$$
Moreover, every local government spends its available budget entirely on local public goods, $[t(i) + \theta(i)]\, w(i)L(i) = G(i)$, as imposed above in (6).

4. **Utility equalization.** Finally, free mobility of labor ensures that utility is equalized across all locations. That is, $W(i) = W(j) = W \quad \forall i, j \in N$.

To solve for the equilibrium, we first combine utility (1), bilateral exports (5), and goods-market clearing (11) to obtain

$$\begin{aligned} L(i)^{1-\alpha(\sigma-1)}w(i)^{\sigma} =& W^{1-\sigma}\bar{A}(i)^{\sigma-1}\int_N \tau(i,n)^{1-\sigma}\bar{u}(n)^{\sigma-1}\Theta(n)^{\sigma-1} \\ & (1+\theta(n))\, w(n)^{\sigma}L(n)^{1+(\sigma-1)[-\beta+\gamma(1-\eta)]}dn, \end{aligned} \tag{13}$$

where $\Theta(n) \equiv (t(n) + \theta(n))^{\gamma}(1 - t(n))^{1-\gamma}$. Second, combining (1) and (3') yields

$$\begin{aligned} w(i)^{1-\sigma}L(i)^{(1-\sigma)[-\beta+\gamma(1-\eta)]} =& W^{1-\sigma}\Theta(i)^{\sigma-1}\bar{u}(i)^{\sigma-1} \\ & \int_N \tau(n,i)^{1-\sigma}\bar{A}(n)^{\sigma-1}w(n)^{1-\sigma}L(n)^{\alpha(\sigma-1)}dn. \end{aligned} \tag{14}$$

Using data on tax rates $t(i)$, transfer rates $\theta(i)$, bilateral trade costs $\tau(i,n)$, wages $w(i)$, and population sizes $L(i)$ in the system (13) and (14) allows us to solve the model for the exogenous productivities $\bar{A}(i)$ and amenities $\bar{u}(i)$ up to a positive constant.[8]

In the subsequent analysis, we restrict our attention to cases with all regions populated in equilibrium. To do so, we impose the following assumption which is an extension of the parameter restriction for uniqueness and stability of the spatial equilibrium used by Allen and Arkolakis (2014):

Assumption 1: $\beta \geq \alpha + \gamma(1-\eta)$.

In words, the congestion force parameterized by $\beta \geq 0$ is at least as strong as the sum of the standard agglomeration force ($\alpha \geq 0$) and the sharing of public facilities ($\gamma(1-\eta) \geq 0$).[9] Notice that the net agglomeration externality is thus negative, $\alpha + \gamma(1-\eta) - \beta \leq 0$, so that an inflow of population into region i reduces indirect utility $W(i)$, ceteris paribus.

[8] Allen and Arkolakis (2014) have shown that for $\theta(n) = 0 \quad \forall n$ and $\Theta = 1$ it is possible to collapse the above system of two nonlinear integral equations into one equation providing a direct link between $w(i)$ and $L(i)$ for each location. In this case the equilibrium can be obtained as the uniform limit of a simple iterative procedure for specific parameter restrictions.

[9] If this parameter restriction was not satisfied, there would be equilibria where all workers concentrated in a single region. See Allen and Arkolakis (2014).

3 The impact of fiscal transfers: Examples

Before turning to the quantification we briefly illustrate our model with two simple stylized examples. In both cases we start from a scenario without fiscal transfers, and then introduce them in order to highlight their various economic impacts.

3.1 Income and size differences

Consider a setting with identical exogenous amenities $\bar{u}(i) = \bar{u}$, equal tax rates ($t(i) = t$) and without transport costs across all N regions ($\tau_{ij} = 1 \ \forall i, j$). We split regions into two groups with exogenous productivities $\bar{A}(i) = A_1$ in $n_1 \in [0; N/2]$ and $\bar{A}(i) = A_2 \leq A_1$ in $n_2 \in (N/2; N]$. In an initial equilibrium without fiscal transfers, all regions within a group are symmetric since geography plays no role. Moreover, the productive regions in group 1 are larger than the less productive ones in group 2 (i.e., $L_1 \geq L_2$). They also have higher wages ($w_1 \geq w_2$), higher output ($Q_1 \geq Q_2$), higher spending ($E_1 \geq E_2$), and more public services ($G_1 \geq G_2$). Those regional gaps are larger, the higher is the exogenous productivity difference $\mathcal{A} \equiv A_1/A_2 \geq 1$.[10] Yet, regions in group 1 have lower overall amenities ($u_1 \leq u_2$) due to the endogenous congestion forces.

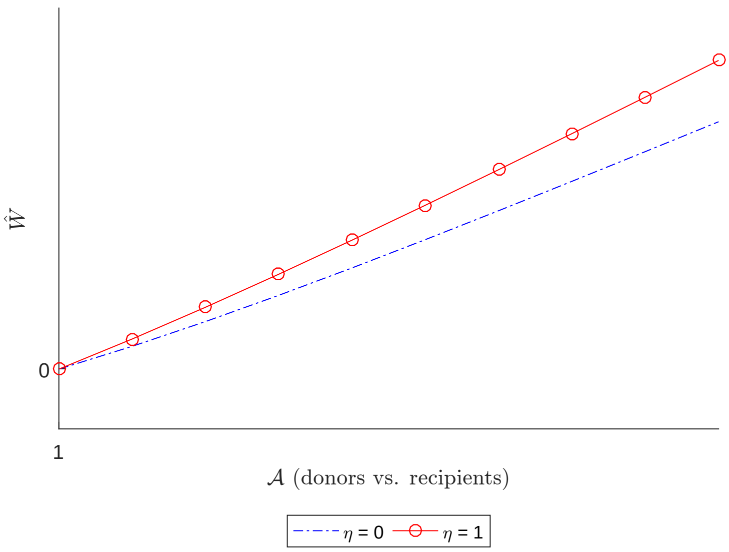
Now we introduce a small fiscal transfer from the rich to the poor regions, i.e., $\mathrm{d}\theta_2 w_2 L_2 = -\mathrm{d}\theta_1 w_1 L_1 > 0$. This transfer triggers migration towards group 2, because it allows for more local public goods there, which in turn makes the regions in group 2 relatively more attractive. As a consequence, the regional productivity gap partly closes in the new equilibrium, because inward migration endogenously raises productivity in group 2 and outward migration lowers it in group 1. At the aggregate level, however, the economy suffers an output and productivity loss, because the transfer effectively induces individuals to relocate from productive to unproductive regions.

Utility is, of course, equalized across all regions in the old and in the new equilibrium. But the common *level* of equalized utility in the economy (denoted $W = W_1 = W_2$) will differ before and after the small fiscal transfer is introduced. In Figure 1, we plot the percentage change in W resulting from the fiscal transfer against the size of the initial productivity gap $\mathcal{A}$. We observe that the transfer leads to an overall welfare gain in the economy, which is increasing in the magnitude of $\mathcal{A}$.

Why does fiscal equalization raise overall welfare in this example, although it lowers aggregate output and productivity? The intuition is that regions in group 1 are inefficiently large in the initial equilibrium. To see this, notice that single households neglect the impact of their private location decisions on other agents, which are transmitted via the local

[10] Notice that the overall productivity difference between the regions is even larger than $\mathcal{A}$ due to the endogenous agglomeration externality (8).

Figure 1: Fiscal equalization between productive and unproductive regions



Notes: The figure illustrates the welfare implications of introducing a fiscal equalization scheme. We rule out trade costs to isolate the effect of productivity (and thus income) differences between regions. The figure shows the association between the percentage change in welfare, $\hat{W}$, and the relative exogenous productivity parameter of donors versus recipients, $\mathcal{A} \equiv \bar{A}_1/\bar{A}_2 \geq 1$. We plot the results for $\eta = 0$ and $\eta = 1$ to highlight the importance of the rivalry in consumption of the local public good.

externalities including the price index, and migrate until average utilities are equalized ($W_1 = W_2$). A welfare-maximizing social planner, by contrast, would allocate workers so as to equate marginal utilities $\partial W_1/\partial L_1 = \partial W_2/\partial L_2$, and thereby fully internalize all externalities (also see Albouy et al. 2017).[11] Recalling that our model features a *negative* net agglomeration externality, since the congestion effect outweighs the sum of agglomeration effects, this implies that the *optimal* size of the regions in group 1 is smaller than their equilibrium size. That is, regions in group 1 are too large while those in group 2 are too small from a social point of view, and this problem is more severe the higher is $\mathcal{A}$.

The small fiscal transfer that we consider in our thought experiment partly offsets this distortion. It does, in general, not implement the optimal allocation in this economy.[12] However, given that the transfer is arbitrarily small, we can be sure that it moves the equilibrium closer to the optimum by triggering private incentives to move to group 2. Thereby it reduces the problem of over-congestion in the large regions in group 1.

Finally, notice from Figure 1 that the aggregate welfare gain from fiscal equalization is increasing in η, the degree of rivalry of local public goods. This is because the net agglomeration externality, $\alpha + \gamma(1 - \eta) - \beta \leq 0$, is less negative with a pure public good

[11]These authors compare equilibrium and optimal allocations in an urban system with heterogeneous sites and without transport costs. Our current example also assumes freely tradable goods, and is therefore a special case of their general model.

[12]Recall that the design of an optimal policy scheme is not the research question of this paper.

($\eta = 0$) than with rival per-capita transfers ($\eta = 1$). The initial equilibrium is less over-congested, hence, the transfer tackles only a smaller problem in the economy.

3.2 Trade costs and geography

Our second example focuses on trade costs. We place a discrete number of N locations at equal distances along a unit line, and assume that overall trade costs τ are proportional to the distance of shipment.[13] Obviously, regions in the middle of the line have a more favorable geography than regions on the edge. If exogenous productivities and amenities were the same everywhere, these central locations would thus be larger and pay higher wages in equilibrium (also see Allen and Arkolakis, 2014).

To focus on geography instead of size and income differences, which were discussed in the previous example, we impose different assumptions. In particular, we set the exogenous $\bar{u}(i)$ and $\bar{A}(i)$ such that initial population sizes $L(i)$ and wages $w(i)$, and therefore local GDPs, are the same everywhere in the initial equilibrium. In other words, regions become more attractive and productive towards the edges of the line, and this compensates for the unfavorable geography which materializes in a higher price index. The higher is τ, the stronger are the required compensating differentials for equal regional sizes and incomes.

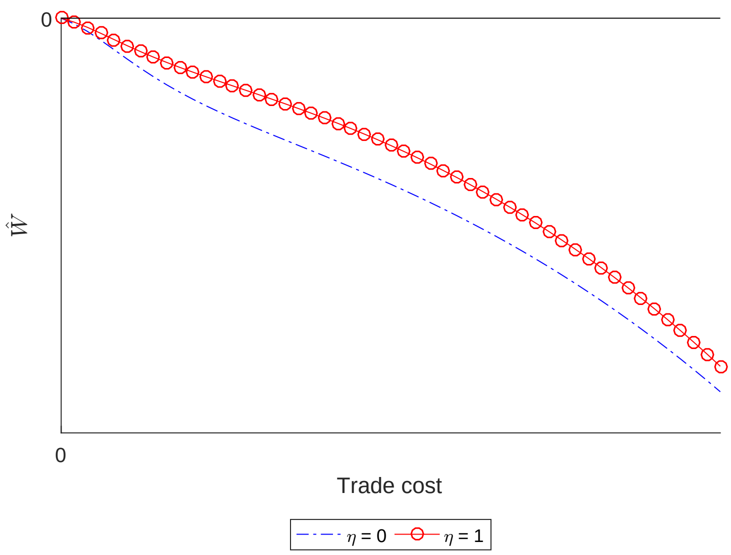
Starting from this scenario, we now introduce a small fiscal transfer that shifts resources from the center towards the edges, in proportion to individual positions on the line. Again, this triggers migration away from the donors and towards the recipients, so that more economic activity moves towards the periphery. As before, utility is equalized across regions in the old and in the new equilibrium, i.e., before and after the transfer.

Figure 2 illustrates the change in the economy-wide welfare level W for different levels of trade costs. When transport is costless ($\tau \to 1$), all regions are identical ex-ante as there are no geographical disadvantages that need to be compensated by exogenous productivity or amenity differences. Then, shifting resources via the transfer scheme has no aggregate welfare effects. At higher levels of τ, however, there are stronger ex-ante differences in regional characteristics $\bar{u}(i)$ and $\bar{A}(i)$ which are held constant in the counterfactual scenario.

We observe that the overall welfare implications of fiscal equalization turn negative, and the magnitude is stronger the higher is τ. Fiscal transfers now exacerbate transport losses in interregional trade, as they effectively shift economic activity from central to remote locations so that more output must be shipped over longer distances. Those transport losses are associated with an overall welfare loss in the economy, even if the peripheral recipient locations are inherently more productive and attractive.

[13] That is, trade costs are τ from one end of the line to the other, τ/N between any two nodes, etc.

Figure 2: Fiscal equalization between core and periphery



Notes: The figure illustrates the welfare consequences of introducing a fiscal equalization scheme. We assume that regions have the same GDP before equalization, but differ with respect to transport costs. Locations in the core have lower transport costs than locations in the periphery. The figure plots the reaction of welfare in percent, $\hat{W}$, when trade becomes more costly and recipient regions are located in the periphery. We plot the results for $\eta = 0$ and $\eta = 1$ to highlight the importance of the rivalry in consumption of the local public good.

3.3 Discussion

Summing up, the two examples suggest that the overall welfare implications of fiscal transfers are ambiguous. They may lead to lower output and productivity at the national level, if they induce people to locate in unproductive regions. They may also amplify transport losses when they provide incentives for households to move towards remote areas. On the other hand, fiscal transfers may tackle the problem of over-congestion in large cities that is inherent in our framework. Which forces dominate on balance is not obvious, a priori, and hinges on specific parameter constellations

In reality, all those aspects are likely to operate in parallel. Our aim is, therefore, to conduct a quantitative analysis of an economy with multiple asymmetric regions, in order to shed light on the various economic effects of fiscal equalization.

4 Quantification: Fiscal equalization in Germany

To bring our model to the data, we consider the case of Germany which operates a pronounced fiscal equalization scheme that shifts a substantial amount of resources across jurisdictions. Our calibration is for 2010, which is the most recent year for which all necessary information is available. We start with an overview of the institutional background before introducing the data and discussing parameter choices and estimation. Finally, in a counterfactual analysis, we simulate an extreme scenario when Germany were to completely abandon its fiscal equalization schemes.

4.1 Institutional background

Political power in Germany is divided between the Federal government, State governments (the Länder), and municipalities. Each of these authorities is autonomous and largely independent with respect to budgetary issues, but at the same time responsible for carrying out specific tasks on the expenditure side of the public budgets. The revenue side is formed by a combination of independent taxes set by the different government layers, and to the largest extent by the sharing of joint taxes.

Table 1 shows that the aggregate tax revenue summed up to 530.6 billion Euro in 2010, which is equivalent to 20.6% of GDP. Joint taxes account for approximately 70% of this amount, with income taxes (32 %) and the value-added tax (VAT, 34%) being by far the most important categories. Those revenues are shared between the three broad government layers according to specific formulas.[14] Additional taxes come on top whose revenues accrue exclusively to only one layer. Here, the Federal level accounts for 18.4% (e.g., excise duties), States for 2.3% (e.g., inheritance taxes), and the local level for 9% of the overall revenue. The latter include real property and excise business taxes (*Gewerbesteuer*), which are the only cases where municipalities have some discretion in setting tax rates.

Table 1: Tax revenues, 2010

	in billion Euro	in %
Joint	372.9	70.3
Federal taxes and tariffs	97.8	18.4
State	12.1	2.3
Municipality	47.8	9.0
Sum	530.6	100

Source: German Statistical Office (2011a).

[14] For example, income taxes are shared with shares 42.5% for the Federal, 42.5% for the State, and 15% for the local level. For the VAT, the respective shares are 52%, 45.5%, and 2.5%. See Federal Ministry of Finance (2016) for further details.

Starting from this initial distribution across the three broad layers of government, tax revenue must be allocated to the single States and municipalities. This is done according to a complicated set of rules that includes population and income shares, as well as various fiscal equalization schemes. Their constitutional basis is Article 72 of the German Constitution, which states that living conditions should be "equivalent" across the country. Both the formula-based Federal equalization scheme (*Länderfinanzausgleich, LFA*), and the municipal schemes within the single States (*Kommunaler Finanzausgleich, KFA*) are specific institutional frameworks derived from this goal.

Both schemes essentially organize the distribution of revenues from joint taxes, coupled with additional fiscal grants from higher- to lower-level government layers as well as horizontal transfers between jurisdictions on the same layer. All detailed rules are summarized in official documents by the German Federal Ministry of Finance (2015, 2016) and analogous documents by the State Ministries. Rather than repeating them here, we describe in the next subsection how we break down tax revenue to the local level and thereby back out the effective degree of fiscal equalization from official tax data.

4.2 Measuring fiscal equalization

Our unit of observation in this paper are the 411 German districts (*Landkreise* and *kreisfreie Städte*), which are administrative units roughly comparable to US counties. To bring our model to the data, we need to compute local tax revenue before and after redistribution, i.e., $t(i)$ and $t(i) + \theta(i)$ for every district i. This type of information is, unfortunately, not readily available from an administrative source. We therefore need to add some structure to the data, in order to construct empirical proxies.

We proceed in two steps. First, we compute total tax revenues generated per district. This step yields local average tax rates $t(i)$. Second, we compute the available local tax budgets after redistribution, which in turn allows us to recover the transfer rates $\theta(i)$.

Tax revenue before redistribution. A key data source for the first step is provided by the German Federal Statistical Office (2011a).[15] Each municipality is entitled to keep a certain percentage of income taxes (15%), VAT revenues (around 2%) and excise business taxes (varies between municipalities). Combining the absolute amounts of these taxes that are directly attributable to municipalities allows us to uncover the respective total volume of tax income in these categories. To this we add the local taxes that each municipality can keep entirely, and we are able to assign more than 70% of aggregate German tax revenue to the local level with this approach. The remaining 30 % comprise the exclusive Federal and State taxes, and the corporate taxes which are shared between the Federal

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

and the State level. We allocate the origin of those revenues across districts according to their shares in directly attributable tax income, as previously described. This captures the idea that districts with higher VAT and income tax revenue are characterized by higher economic activity in general, which in turn also leads to more revenues from other taxes. Finally, dividing tax revenues by local GDP as reported by the Federal Statistical Office yields the average tax rates $t(i)$.

It is worth emphasizing that local GDP is only a proxy for the local tax base, since income is taxed at the place of residence rather than at the workplace. Given that agglomerated areas, especially the main cities, are characterized by net inflows of commuters from adjacent districts, local GDP overestimates the tax base in rich locations and underestimates it in residential districts with less employment. As a result, our measure of the average tax rate provides a conservative approximation of the size of fiscal equalization, given that rich locations are net contributors.

Tax revenue after redistribution. Second, we compute local public budgets after redistribution. Here we directly draw on information from the Federal Statistical Office, which publishes data on municipal tax budgets including transfers from other jurisdictions.

The remaining task is to allocate the tax budgets of the upper layers, the Federal and the State level, to the districts. We do this by using information about the States' tax budgets after redistribution, and assign this amount to municipalities according to population shares.[16] We proceed in an analogous way for the remaining Federal tax budget. Combining collected taxes $t(i)$ from step one, and the available public budgets $t(i) + \theta(i)$ from step two finally delivers the transfer rates per districts, $\theta(i)$, which are expressed relative to local GDP.

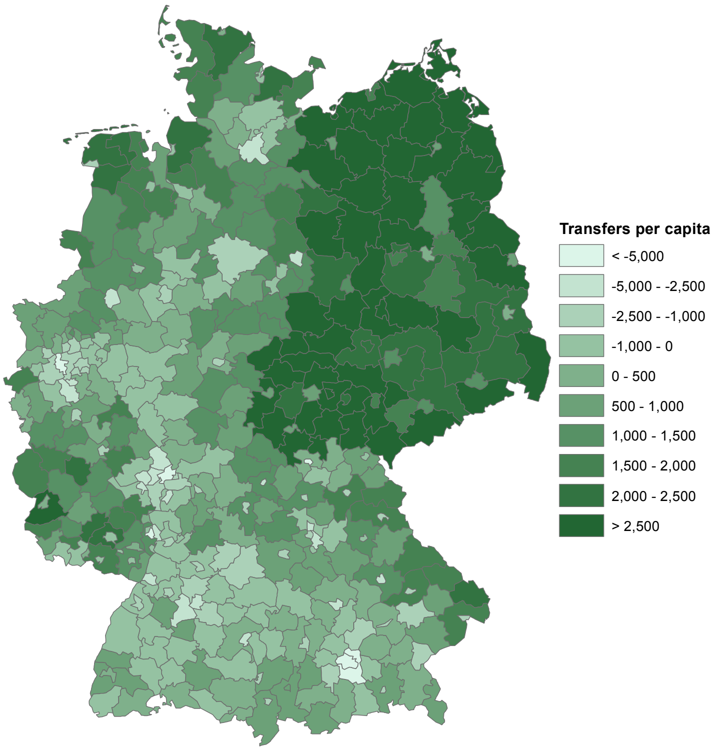
4.3 Descriptive overview of fiscal equalization

Figure 3 visualizes the per-capita fiscal transfers for all German districts. Darker colors indicate stronger net recipient positions, while donor regions are shown in lighter colors. Large German cities turn out to be major net contributors to fiscal equalization, while peripheral regions (especially in former East Germany) are the main recipients. Here, annual per-capita public transfers exceed 3,000 Euro in some cases. By contrast, Frankfurt is the biggest net contributor, with approximately 11,000 Euro donations per-capita, followed by Munich where the respective value is 5,700 Euro.

Panels (a) and (b) of Figure 4 illustrate that the transfer rates $\theta(i)$ are correlated with local wages and population sizes. Net donors are indicated by blue crosses, while red circles indicate net recipient regions. We observe that high-income locations are net

[16]This allocation by population shares captures the idea that citizens have similar fiscal needs that require similar public funds per capita.

Figure 3: Per-capita transfers (in Euro)



Notes: Darker areas indicate recipients, bright areas donors.

donors, that is $\theta(i) < 0$. More populated locations also tend to be net donors, although Berlin stands out as the major outlier, because it has the largest population but still receives fiscal transfers of around 5.4 % of its local GDP.[17]

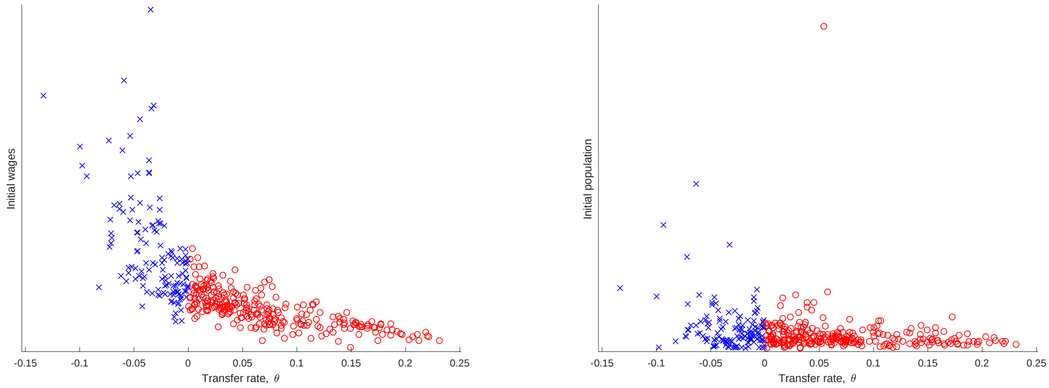
With this information at hand, we can also calculate the total amount of fiscal transfers that was shifted across districts in 2010. Specifically, recalling that net donations must equal net receipts by construction, we can sum up the absolute terms $\sum_{i=1}^{411} |w(i)L(i)\theta(i)|/2$ in order to construct a measure for the overall magnitude of fiscal transfers in Germany. This yields a considerable amount of approximately 65.7 billion Euro, or 12.4% of the aggregate tax revenue. Notice that this amount is substantially larger than officially documented figures for the Federal equalization scheme (LFA) as reported by the German Ministry of Finance. In Appendix Table A1, we illustrate the single steps of this scheme, which sum up to a transfer volume of only 26.5 billion Euro that is shifted across States. Our calculations suggest, however, that the actual volume of fiscal equalization is even larger, because we also take into account transfers across districts within States.[18]

[17]The 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.

[18]Notice that we abstract from additional (explicit or implicit) fiscal redistribution via other public budgets, e.g. the social security system, so our estimate may even be a lower bound.

Figure 4: Relationship of wages and population with the transfer rate

(a) Wages, $w(i)$ (b) Population, $L(i)$



Notes: Panel (a) links wages to transfer rates $\theta(i)$. Panel (b) plots the relationship of population with the transfer rate $\theta(i)$. Note 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).

4.4 Parameter choices and estimation

In this subsection, we discuss the choice of pre-determined parameters, our strategy to estimate bilateral trade costs $\tau(i,n)$ and further data needed to quantify our model.

Basic parameters. We choose baseline values for α, β, γ, η and σ by relating to available estimates from the empirical literature. First, we set $\alpha = 0.05$ as in Rosenthal and Strange (2004), who show that productivity increases by around 5% if population doubles. Second, our chosen value of β 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 in Germany amounts to roughly 25% in 2010, which in turn leads to a value of $\beta_0 \approx 0.33$.[19] In addition, as argued in Section 2.5, β may contain idiosyncratic locational preferences and the associated mobility frictions. If these preferences are distributed Frechet with shape parameter $k = 3$, as suggested by Bryan and Morten (2015), the overall value of β can be written as $\beta = \beta_0 + 1/k$, which rationalizes our choice of $\beta = 0.66$ as the baseline value for the congestion elasticity. Third, we need a value for γ, which describes the expenditure share on public goods given the assumed Cobb-Douglas utility function. With a balanced overall budget this is, in turn, equal to the average tax rate (before redistribution). Tax data for Germany thus suggest to set $\gamma = 0.2$ as our baseline. Fourth, we assume that local governments provide pure public goods, i.e. $\eta = 0$, but we also study the other extreme of a pure private transfer ($\eta = 1$) in the sensitivity

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

analysis. Independent of the value of η, notice that the chosen parameter values ensure that Assumption 1 is satisfied, i.e., $\beta \geq \alpha + \gamma(1-\eta)$. Finally, the elasticity of substitution σ plays a crucial role for the estimation of trade costs. We follow Simonovska and Waugh (2014) in choosing a value of $\sigma = 5$.

Data and estimation of the trade elasticity. Quantifying our model moreover requires data on inter-regional bilateral distances and trade flows, as well as data on population and labor income per district. Data for population sizes and aggregate income (GDP) for every district are readily available from Eurostat (NUTS3-level), and the German Federal Statistical Office. We compute the ratio of the two as a proxy for the regional wage level. Using GIS software, we furthermore obtain bilateral Euclidian distances between districts' centroids. This information is needed to estimate trade costs.

We use information on trade flows from the Forecast of Nationwide Transport Relations in Germany (Verkehrsverflechtungsprognose 2030) provided by the Clearing House of Transport Data at the Institute of Transport Research of the German Aerospace Center.[20] The data contain bilateral trade volumes in metric tons at the product level by transport mode (road, rail, water) between European regions, where one German region is either exporter, importer or part of the trade route in the year 2010.[21]

Our theoretical model requires trade *values* rather than *volumes*, so we convert the data by using unit values by product group available from COMTRADE at the 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. We finally aggregate trade flows across transport modes.

We follow the standard gravity literature (e.g. Head and Mayer, 2014) and estimate (5) with importer and exporter fixed effects in order to take multilateral resistance terms into account. We proxy bilateral trade costs by the Euclidian distance $dist(i,n)$ between the centroids of locations i and n according to

$$\tau(i,n) = dist(i,n)^{\epsilon}\tilde{e}(i,n), \tag{15}$$

where $\tilde{e}(i,n)$ is the error term. Log-linearizing (5) and substituting the parametrization of trade costs according to (15) yields the following gravity equation for the value of bilateral trade flows from i to n:

$$\log X(i,n) = \kappa(i) + \kappa(n) - (\sigma-1)\epsilon \log dist(i,n) + (1-\sigma)b'\mathbf{M} + \log e(i,n), \tag{16}$$

where $\kappa(i)$ and $\kappa(n)$ are exporter and importer fixed effects that control for wages, pro-

[20] The data can be accessed via http://daten.clearingstelle-verkehr.de/276/. It is similar to the US commodity flow survey.

[21] See Henkel and Seidel (2016) for further details about these data.

ductivity, population and the CES price index.[22] $\mathbf{M}$ collects standard bilateral control variables from the gravity literature,[23] and $\log e(i,n) = (1-\sigma)\log \tilde{e}(i,n)$.

Table 2 summarizes the regression results. Columns 3 to 4 refer to bilateral trade values, where unit values are applied to the volume data. Following Nitsch and Wolf (2013), we also explore results for trade volumes instead of values as the dependent variable in columns 1 and 2. Although this deviates from the theoretical model, these results provide important robustness checks, especially because dummy variables account for the product-specific price per ton that converts volume of exports into values.

Table 2: Estimated distance elasticities

	volumes		values	
log(distance)	-1.26***	-0.98***	-1.23***	-0.93***
	(0.002)	(0.004)	(0.003)	(0.005)
dialect sim.		0.23***		0.24***
		(0.013)		(0.015)
contiguity		0.52***		0.58***
		(0.010)		(0.011)
state border		-0.46***		-0.46***
		(0.005)		(0.006)
Exporter FE	✓	✓	✓	✓
Importer FE	✓	✓	✓	✓
Product FE	✓	✓	✓	✓
Constant	3.10***	3.56***	17.5***	18.0***
	(0.066)	(0.065)	(0.079)	(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. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We find that the point estimates for the distance effects range between -0.93 and -1.26. They are highly statistically significant, and firmly in line with available estimates from the gravity literature. Head and Mayer (2014) conclude that estimates of the trade-distance elasticity parameter ϵ in typical gravity equations cluster around -1.1, with a standard deviation of 0.41. Given our estimation results, we parameterize trade costs

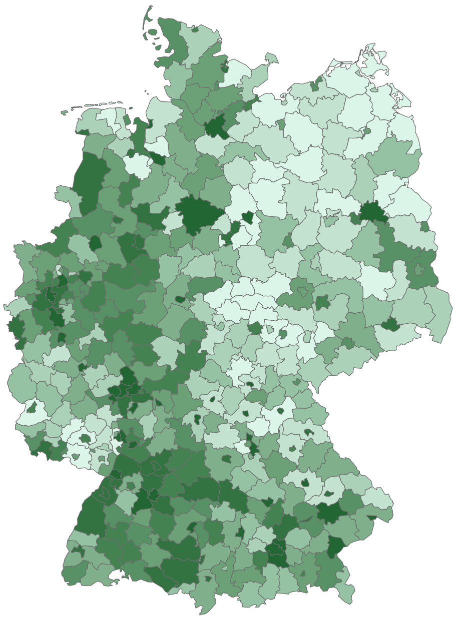
[22] We exploit variation across product groups when estimating the gravity equation and thus add product fixed effects.

[23] 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 states.

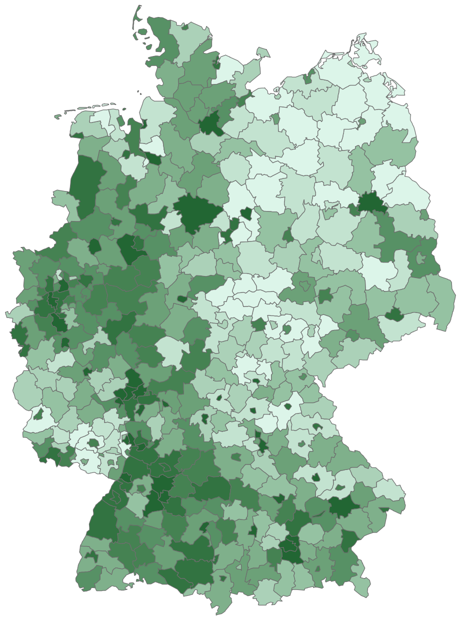
according to $\tau(i,n)^{1-\sigma} = dist(i,n)^{-1.23}$.[24]

Figure 5: Estimated exogenous productivities and amenities

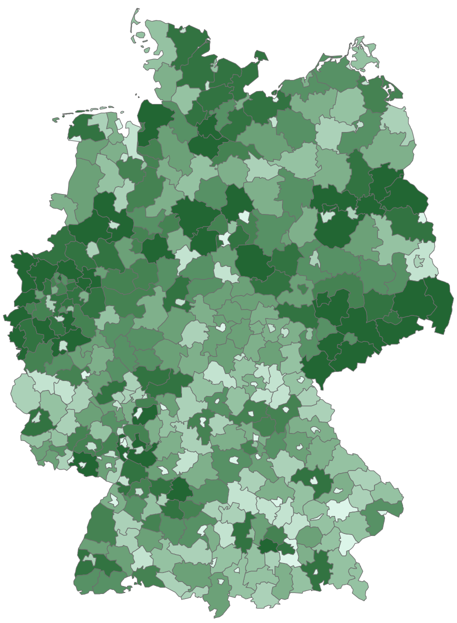
(a) Exogenous productivities



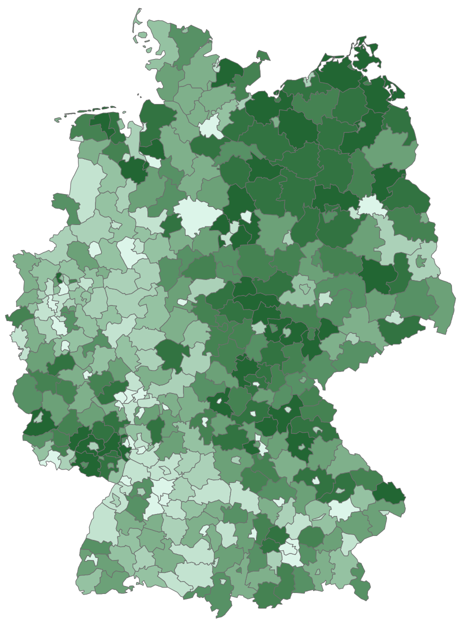
(b) Composite productivities



(c) Exogenous amenities



(d) Composite amenities



Notes: This figure plots the exogenous and composite productivities $\bar{A}(i)$ and $A(i)$, and the respective amenities $\bar{u}(i)$ and $u(i)$ for $\alpha = 0.05$, $\beta = 0.66$, $\gamma = 0.2$ and $\eta = 0$. A darker shading indicates higher values.

[24] Besides, we observe that historical ties (as measured by dialect similarity), contiguity, and administrative borders also affect trade flows between German regions. All of those findings are also consistent with previous results from the literature on regional trade flows.

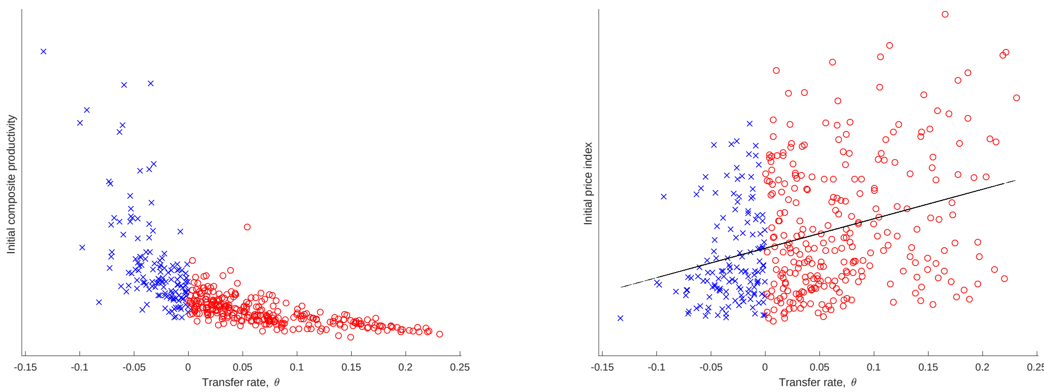
4.5 Amenities and productivities

Given our parameter choices and estimates for trade costs, the last step is to back out exogenous productivities $\bar{A}(i)$ and amenities $\bar{u}(i)$ for every district from the structure of our general equilibrium model. To do so, we plug in estimated trade costs $\tau(i,n)$ together with information on population $L(i)$, wages $w(i)$, tax rates $t(i)$, and transfer rates $\theta(i)$ into (13) and (14). This defines a system of 2×411 equations in 2×411 unknowns, and labor-market clearing pins down the equalized welfare level W in this system.

The map in panel (a) of Figure 5 shows the pattern of exogenous productivities $\bar{A}(i)$. It tends to be low in the East and high in the South-West of Germany as well as in the big cities. Combining this information with location-specific population delivers composite productivity $A(i) = \bar{A}(i)L(i)^{\alpha}$, which is shown in panel (b) and exhibits a similar spatial pattern. This productivity is positively correlated with regional per-capita income, and therefore negatively with the net receipts of fiscal transfers in the German equalization scheme. This is also shown in panel (a) in Figure 6, where we document the relationship between $A(i)$ and the local transfer rate $\theta(i)$.

Figure 6: LOCAL PRODUCTIVITY, PRICE INDICES AND THE TRANSFER RATE

(a) Composite productivity, $A(i)$ (b) Price index, $P(i)$



Notes: Panel (a) shows the level of the estimated composite productivity $A(i)$ in relation to $\theta(i)$. Panel (b) depicts the level of the price index in relation with the transfer rate.

Panels (c) and (d) in Figure 5 show the patterns of exogenous and composite amenities $\bar{u}(i)$ and $u(i)$, respectively. Composite amenities deviate from exogenous amenities due to differences in population levels. This leads to relatively low levels of $u(i)$ in the more densely populated West and South-West of Germany. Finally, we observe from panel (b) of Figure 6 that recipients are characterized by a higher price index, which can be interpreted as a measure of remoteness. In Appendix A.4 we focus on an alternative remoteness indicator following Baldwin and Harrigan (2011).[25] We find a similar pattern

[25]This proxy describes the income-weighted sum of an inverse power function of distance, according to

(see Figure A2). This evidence suggests that the German fiscal equalization schemes indeed tends to shift resources from the center to remote locations.

5 Counterfactual analysis: Abolishing fiscal equalization

To assess the various economic effects of fiscal equalization, we now perform a counterfactual analysis. We start from the initial spatial equilibrium described in the previous Section, which is influenced by the actual fiscal transfers that were observed in Germany in 2010. Then we simulate a scenario, where the entire fiscal equalization scheme is abandoned. This counterfactual corresponds to a situation where all local public goods must be financed by taxes levied upon local economic activity, but without any cross-regional fiscal transfers.[26] By comparing this counterfactual to the initial observed equilibrium, we analyze the impact of fiscal transfers on the location choices of individuals within Germany, the implied regional migration flows, the aggregate level and the distribution of productivity and output across regions, as well as on national welfare.

5.1 Setup of the counterfactual analysis

In the baseline version of our counterfactual analysis, we assume fixed values of the exogenous parameters[27] and the same local tax rates $t(i)$ and trade costs $\tau(i,n)$ as in the initial equilibrium. We also assume that the exogenous productivities $\bar{A}(i)$ and amenities $\bar{u}(i)$ remain unchanged (see panels (a) and (c) of Figure 5). We then impose zero fiscal transfers for all regions, $\theta(i) = 0 \ \forall i \in N$, and use our model (13) and (14) to solve for the new (counterfactual) equilibrium values of wages $w(i)$ and population $L(i)$ that are consistent with equalized utility across space.

Using those equilibrium values allows us, in turn, to compute the composite productivities and amenities, as well as all other endogenous variables (such as public goods, spending, and GDP) for all regions. Finally, it yields output and productivity at the national level, and the *change* in aggregate welfare from the old to the new equilibrium. This latter piece of information, denoted $\hat{W}$, is of crucial importance for our purpose, because it entails the overall welfare implication of the fiscal equalization scheme.

5.2 Location decisions and migration

We start the discussion of our results with the implied re-location decisions. The examples in Section 3 have clarified that the introduction of a fiscal equalization scheme creates

$R(i) = (\int_N (Y(n)/dist(i,n)^{1-\sigma})dn)^{-1}$.

[26] Alternatively, the counterfactual scenario may be thought of as one with balanced trade for all regions.

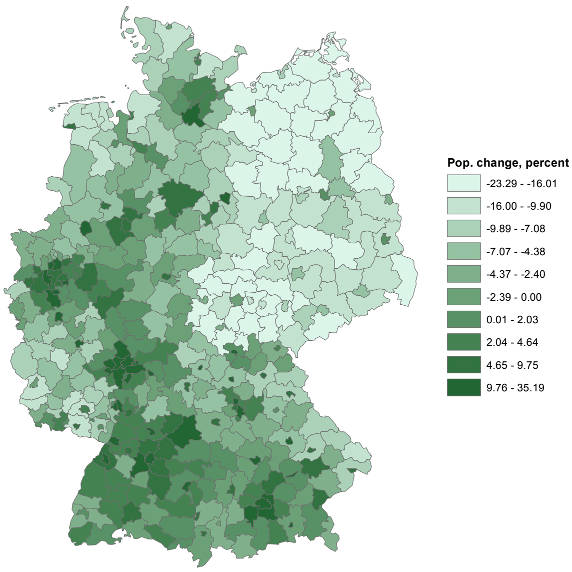
[27] That is, $\alpha = 0.05$, $\beta = 0.66$, $\gamma = 0.2$, $\eta = 0$, $\sigma = 5$, and $\epsilon = -1.23$. We conduct various robustness checks for those parameters below.

incentives for individuals to move towards the recipient regions, because the transfers allow for more public goods provision and thus make those regions relatively more attractive. Analogously, the abandoning of fiscal transfers should therefore induce people to leave the former recipient and move towards the former donor regions.

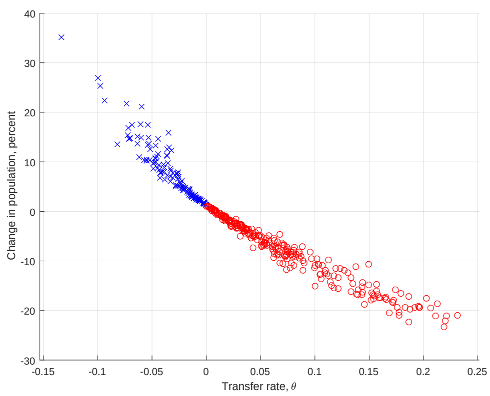
Figure 7 shows that our quantitative multi-region model exhibits exactly this pattern. The map depicts changes in local population sizes after switching off transfers. People leave East Germany and less densely populated districts in the West and move towards big cities (e.g., Frankfurt, Munich, Düsseldorf) as well as towards the South-Western part of the country. Some former recipient locations in East Germany lose almost a quarter of their population, while some donors receive an inflow of more than a third.

Figure 7: Changes in local population

(a) Geographical pattern



(b) Transfer rate and population change



Notes: Panel (a) shows pattern of population changes from the initial to the counterfactual equilibrium. Panel (b) relates population changes to the level of the initial transfer rate $\theta(i)$.

The relationship between the prevailing transfer rate $\theta(i)$ in the initial equilibrium, and the implied change in local population size after setting all transfer rates equal to zero, is shown in panel (b) of Figure 7. Former donors (indicated by blue crosses with $\theta(i) < 0$) indeed gain, while former recipients (the red circles with $\theta(i) > 0$) lose population.

At the aggregate level, abandoning fiscal transfers would induce 3.2 million individuals, that is 3.9% of the total German population, to change their district of residence. To put this number into perspective, notice that *actual* net migration across districts that was observed in the decade 2000–2010 amounted to only around 100,000 people per year who changed their district of residence (Federal Statistical Office, 2011). Abandoning fiscal equalization would thus increase regional migration by a sizable factor of 32.

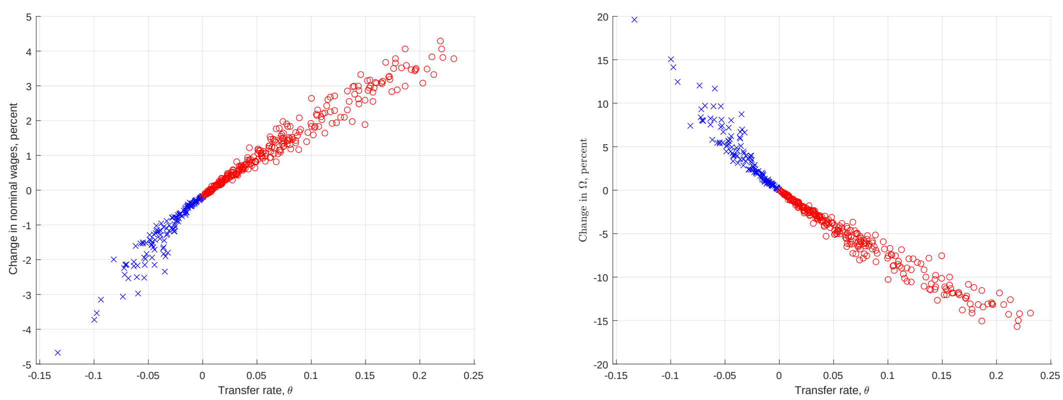
5.3 Local public goods provision

The abandoning of fiscal equalization directly affects government budgets and therefore local public goods provision across districts. It is decreasing in the former recipient regions which lose funding, and increasing in the former donor regions which now keep all of their tax revenues. In addition, there are two indirect effects because individuals are mobile across districts and wage levels are endogenous.

Figure 8: Changes in wages and local public services

(a) Wages

(b) Local public services



Notes: Panel (a) plots change in the local nominal wage against the initial transfer rate θ. Panel (b) shows changes in local public goods provision (adjusted for the local price level) and the initial transfer rate.

The implied migration responses mean that the tax bases erode (enlarge) in former recipient (donor) regions, which face outward (inward) migration. However, panel (a) of Figure 8 shows that local wage levels move into the opposite direction. Wages are increasing in the former recipient areas, because emigration reduces labor supply and thus location-specific intermediate inputs. The former donor regions become more populous, in turn, and goods market clearing implies falling prices for their local intermediates.

Summing up all three effects, we observe in panel (b) that former recipients (donors) of fiscal transfers end up with a decreasing (increasing) level of local public goods provision. For local tax bases, we conclude that the sum of the direct and the indirect migration effect seems to outweigh the indirect wage effect. Abandoning fiscal equalization therefore leads to a divergence in the quality of local public goods across districts.

5.4 Output and productivity

The induced migration responses trigger further changes in composite productivities across districts. In particular, the former donor regions which receive inward migration experience a boost via the endogenous agglomeration economies. The opposite happens in the former recipient regions which experience outward migration, hence falling productivity. Bearing in mind that the donors already had an edge in the initial equilibrium (see Figure 5) we thus find that regional productivity differences are amplified in the counterfactual.

Since a total of 3.2 million individuals move from less productive towards more productive areas when fiscal transfers are abandoned, we observe an increase in average productivity at the national level. In the baseline version of our counterfactual analysis this gain is equal to 5.8 %, and real GDP per capita grows by 3.7 % on average. Figure 9 shows analogous quantitative implications for different parameter settings. We depict the change in national average productivity (denoted $\hat{A}$) and the corresponding total number of individuals who change their location (denoted $\hat{L}$) for various constellations of α and β (the baseline is $\alpha = 0.05$ and $\beta = 0.66$). It is evident from panel (a) that productivity increases in all cases. The gain tends to be stronger the smaller is β, and the larger is α. Smaller levels of β imply lower levels of locational preferences and thus larger migration flows. These, in turn, translate into higher productivity, and this channel becomes stronger the higher the agglomeration elasticity α.

Put differently, with respect to output and productivity, there seems to be an equity-efficiency trade-off: the fiscal equalization scheme moderates productivity dispersion across space, but this comes at the cost of lower aggregate productivity at the national level.

5.5 Welfare implications of fiscal equalization

The migration responses triggered by the removal of fiscal transfers do not only lead to changes in composite productivity, but also in amenity levels across districts because of the endogenous congestion forces. In particular, composite amenities decrease in former donor regions, which receive inward migration and thus become even more crowded than they already were in the initial equilibrium. The former recipient regions, by contrast, lose population. This relaxes local congestion, and raises amenities in those areas.

Figure 9: Changes in aggregate productivity

(a) National productivity change

(b) Total migration

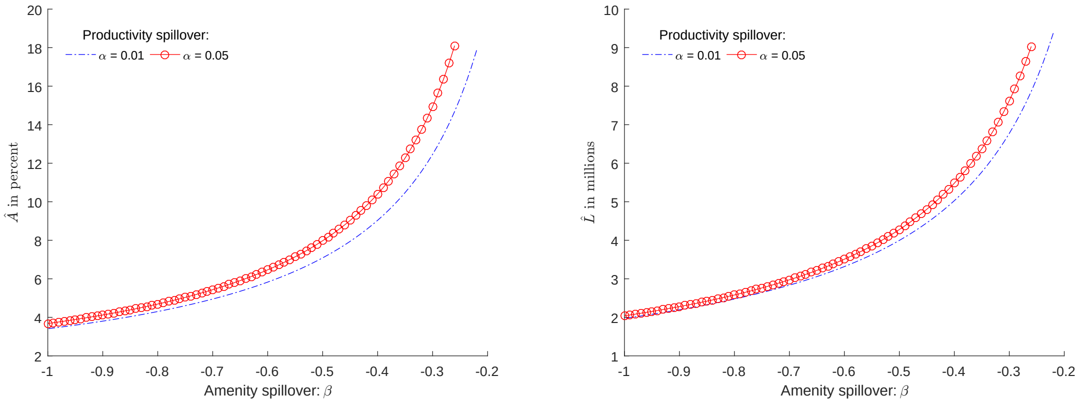
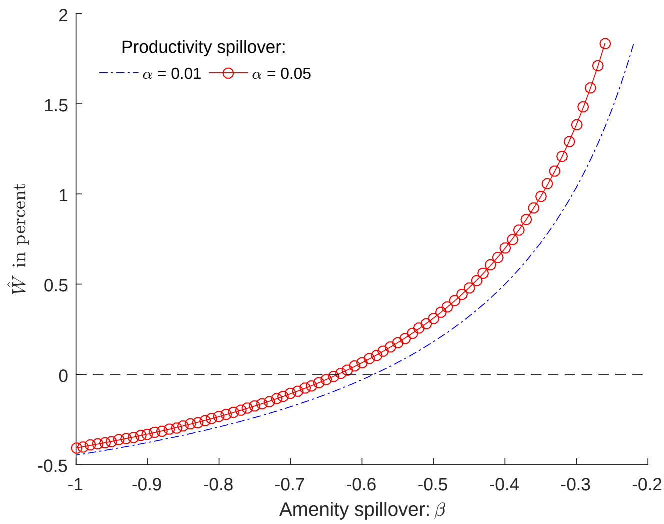


Figure 10: Aggregate welfare effects of fiscal equalization



Notes: Percentage change in equalized indirect utility across regions after abandoning fiscal equalization.

Those implied changes in local amenities are key to get at the aggregate welfare effects of the fiscal equalization scheme. It is clear that indirect utility is equalized across all districts in the old and in the new equilibrium, but the question is at what level. In our baseline case of the counterfactual analysis, this common welfare drops by 0.05 % after abandoning the transfer scheme. That is, $\hat{W} = -0.05$. In other cases, however, we do not find a welfare loss but an aggregate welfare gain from abandoning fiscal equalization. Figure 10 plots $\hat{W}$ for the same parameter constellations of α and β as in Figure 9 above. As can be seen, depending on parameters the change in overall welfare can be positive or negative, but in all cases it tends to be an order of magnitude smaller (in absolute terms) than the implied change in aggregate productivity.

Stated differently, even though the removal of fiscal equalization always leads to a notable output and productivity gain at the national level, it may or may not be welfare enhancing. What is the intuition of this important result? Recall from Assumption 1 above that our model exhibits a negative net agglomeration externality, i.e., dispersion forces are stronger than agglomeration forces at the margin, in order to rule out a degenerate equilibrium where the total population collapses into a single city. Endogenous amenities decline substantially in locations that experience inward migration, and this decline is stronger than the productivity gains arising from endogenous agglomeration forces and the benefits from sharing public facilities. In other words, the former donor regions of the equalization scheme become more productive, but also much more congested.

We can also relate the findings from Figure 10 to the insights of the stylized examples that were discussed above in Section 3. There we have shown that the introduction of fiscal transfers may decrease national welfare if it provides an incentive for individuals to move to remote locations, thereby exacerbating transport losses. However, introducing fiscal transfers may also increase welfare, because they work against the inherent tendency that productive cities tend to be "too large" from a social point of view. In our quantified multi-region model, where we consider the *abolition* of transfers as our counterfactual exercise, we are likely to face all of those channels in parallel. The actual fiscal equalization scheme in Germany tends to shift resources towards regions that are both remote and small. A priori, it is therefore not clear if removing transfers increases or decreases welfare. The quantitative pattern in Figure 10 echoes this general point.

More specifically, abandoning fiscal equalization leads to a stronger welfare loss if β is large and α is small. Thus, by analogy, this means that the introduction of an equalization scheme implies a stronger welfare gain in those cases. The reason is that net agglomeration externality is then strong, which in turn leads to a higher degree of over-congestion. The fiscal scheme therefore tackles a larger problem in those parameter constellations.

5.6 Preferences for public services and their rivalry

We finally explore the sensitivity of our results with regard to the importance of public services in individuals' preferences, γ, and the degree of rivalry in consumption, η. So far we have kept $\gamma = 0.2$ in all simulations, and we have assumed pure (fully non-rival) local public goods by setting $\eta = 0$.

In Table 3 we report the counterfactual responses of welfare, productivity and migration for different parameter settings. Reducing γ to a value of 0.15 reduces agglomeration forces ceteris paribus, so the over-congestion without transfers becomes stronger relative to the baseline in welfare terms. As we observe from the first row in Table 3, abolishing fiscal equalization leads to a more pronounced welfare loss of -0.15 %. The migration response is weaker, however, with higher net congestion forces and so is the increase in productivity. A similar reasoning applies when we turn public services into private transfers by setting $\eta = 1$. The agglomeration force from sharing public services as a pure public good vanishes altogether, causing a stronger welfare loss of -0.3 %. Again, a lower migration response leads to a smaller productivity growth in the counterfactual.

Table 3: Importance and rivalry of public services

η	γ	$\hat{W}$ *in %*	$\hat{A}$ *in %*	$\hat{L}$ *in millions*	$\hat{L}$ *in %*
0	0.15	-0.15	3.96	2.20	2.69
0	0.2	-0.05	5.81	3.17	3.87
1	0.2	-0.30	4.33	2.39	2.92

Notes: This table reports changes in welfare, average real wages, average labor productivity and migration (in millions and in % of the total population) for $\sigma = 5$, $\alpha = 0.05$, $\beta = 0.66$ and different parameter values of η when income redistribution between locations is abolished.

6 Conclusions

Fiscal transfers between jurisdictions shape the spatial economy. We use a general equilibrium model with trade and labor mobility to carve out aggregate effects of fiscal equalization on welfare, productivity and labor mobility. Welfare effects of fiscal equalization are ambiguous from a purely theoretical point of view. Externalities cause inefficiently large cities in our model, so that transfers from rich to poor places partly mitigates this misallocation of labor. However, costly trade implies that transfers reduce welfare if recipients are located in the remote periphery and, thus, have a higher price index.

In our quantitative exercise we calibrate the model for Germany. Abolishing fiscal transfers completely leads to regional migration from poor (low-productive) to rich (high-productive) locations raising average labor productivity and output. However, negative congestion externalities tend to be stronger at the margin, and effectively the abolition of transfers may even cause a welfare loss. Stated differently, fiscal transfers across jurisdictions may be costly in terms of output and productivity, but still they can make the residents of the country better off in total.

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.

Albouy, D., K. Behrens, F. Robert-Nicoud, and N. Seegert. 2017. The optimal distribution of population across cities. University of Illinois. Unpublished manuscript.

Allen, T. and C. Arkolakis. 2014. Trade and the topography of the spatial economy. *Quarterly Journal of Economics* **129(3)**, 1085-1139.

Austin, B., E. Glaeser and L. Summers. 2018. Saving the heartland: Place-based policies in 21st century America. *Brookings Papers on Economic Activity.* BPEA Conference Drafts, March 8-9, 2018.

Baldwin, R., and J. Harrigan. 2011. Zeros, quality, and space: Trade theory and trade evidence. *American Economic Journal: Microeconomics* **3(2)**, 60-88.

Behrens, K., G. Mion, Y. Murata and J. Suedekum. 2017. Spatial frictions, *Journal of Urban Economics* **97(1)**, 40-70.

Blöchliger, H., O. Merk, C. Charbit and L. Mizell. 2007. Fiscal equalisation in OECD countries, OECD Working Papers on Fiscal Federalism, No. 4, OECD Publishing, Paris.

Bryan, G. and M. Morten. 2015. Economic development and the spatial allocation of labor: Evidence from Indonesia, Stanford University, unpublished manuscript.

Buchanan, J. 1950. Federalism and fiscal equity. *American Economic Review* **40(4)**, 583-599.

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.

Dekle, R., J. Eaton and S. Kortum. 2007. Unbalanced trade. *American Economic Review* **97(2)**, 351-355.

Ehrlich, M. von and T. Seidel. 2018. The persistence effects of place-based policies. Evidence from the West-German Zonenrandgebiet. *American Economic Journal: Economic Policy*, forthcoming.

Fajgelbaum, P.D. and C. Gaubert. 2018. Optimal spatial policies, geography and sorting. University of California, Berkeley. Unpublished manuscript.

Federal Ministry of Finance. 2015. Bund-Länder-Finanzbeziehungen auf der Grundlage der Finanzverfassung, Berlin.

Federal Ministry of Finance. 2016. The federal fiscal equalisation system in Germany, Berlin.

German Statistical Office. 2011a. Fachserie 14, Finanzen und Steuern. Wiesbaden.

German Statistical Office. 2011b. Fachserie 1, Bevölkerung und Erwerbstätigkeit. 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. Gravity equations: Workhorse, toolkit, and cookbook. *Handbook of International Economics*, Elsevier. Gita Gopinath, E. H. and Rogoff, K. (Eds.), **Vol. 4**, 131-195.

Helpman, E. 1998. The size of regions. In: Topics in Public Economics: Theoretical and Applied Analysis, (ed.) D. Pines, E. Sadka and I. Zilcha, 33-54. Cambridge: Cambridge University Press.

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**.

Hsieh, C.-T. and P.J. Klenow. 2009. Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics* **124(4)**, 1403-1448.

Hsieh, C.-T. and E. Moretti. 2017. Housing constraints and spatial misallocation. Unpublished manuscript. University of California, Berkeley.

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* **16(3)**, 290-306.

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.

Polyanin, A. and Manzhirov, A. 2008. Handbook of Integral equations. London: Chapman and Hall/CRC.

Redding, S. J. 2016. Goods trade, factor mobility and welfare. *Journal of International Economics* **101**, 148-167.

Rodríguez-Pose, A. 2018. The revenge of the places that don't matter (and what to do about it), *Cambridge Journal of Regions*, Economy and Society **11(1)**, 189-209.

Rosenthal, S. S. and Strange, W. C. 2004. Evidence on the nature and sources of agglomeration economies. *Cities and Geography*, Elsevier. Henderson, J. V. and J.-F. Thisse (Eds.), **Vol. 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.

Zabreyko, P., A. Koshelev, M. Krasnosel'skii, S. Mikhlin, L. Rakovshchik, and V. Stetsenko 1975. Integral equations: A reference text. Leyden: Noordhoff International Publishing.

A Appendix

A.1 Solving the system of non-linear equations

We employ a method of successive approximations to solve for the equilibrium of the system of non-linear equations (see Zabreyko et al., 1975). In the following, we briefly describe the steps of the iterative procedure. First, we choose an arbitrary vector of non-negative starting values for the endogenous variables in equations (13)-(14). Next, we simultaneously solve the system of equations (13)-(14) for a given parametrization of trade costs and parameter values to obtain new vectors of solutions for the endogenous variables. To ensure convergence, we normalize each new vector to sum up to one. We then update the starting values according to a weighted average of previous starting values and solutions of the previous iteration. Finally, we iteratively solve the system of equations until the metric distance between the starting values and solutions of the endogenous variables becomes sufficiently small.

Existence and uniqueness theorems for non-linear equations are described by Polyanin and Manzhirov (2008). Under the condition that the sequence of convergence is an element of a complete metric space it will also converge to a limit point. Hence, the system of non-linear equations has at least one continuous solution.

A.2 Federal fiscal equalization scheme

Table A1 shows the volume of redistribution at each stage of the process. In sum, this amounts to 26.5 billion Euro or 5 % of tax revenues. On a per-capita basis, Berlin leads the lists of recipients with 1,611 Euro per citizen and year. Hesse and Bavaria pay most in net terms with more than 400 Euro per year.

Table A1: Volume of redistribution, 2010

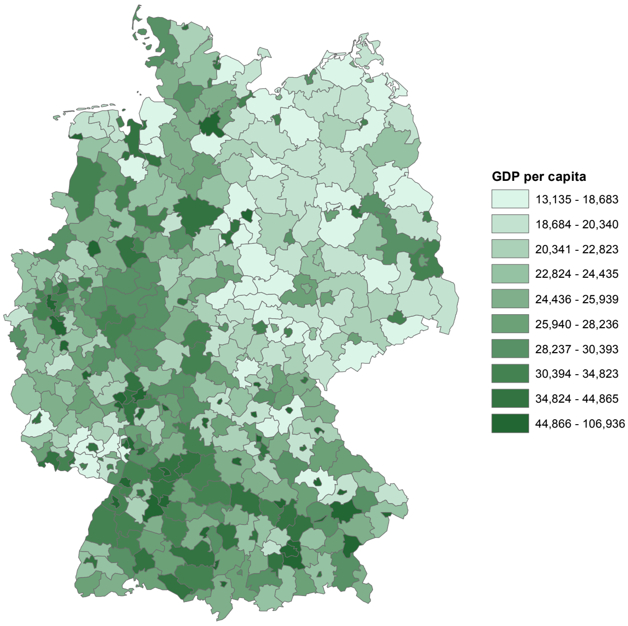
	VAT redistribution (million Euro)	Horizontal equalization (million Euro)	General grants (million Euro)	Special grants (million Euro)	Per capita transfers (Euro)
Bavaria	-1,545	-3,511	0	0	-403
Baden-Württemberg	-1,327	-1,709	0	0	-282
Berlin	58	2,900	912	1,706	1,611
Brandenburg	864	401	176	1,498	1,174
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).

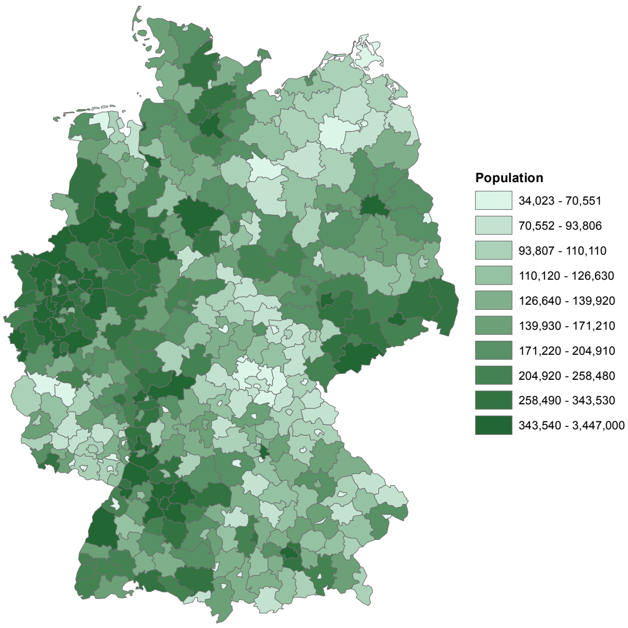
A.3 GDP per capita and population density

Figure A1: Distribution of GDP per capita and population density in 2010

(a) GDP per capita



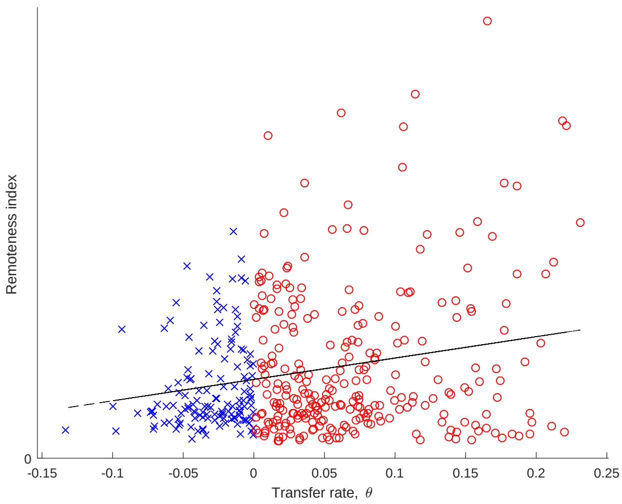
(b) Population



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.

A.4 Remoteness

Figure A2: Remoteness index and the transfer rate



Notes: This figure depicts the level of the remoteness index against the transfer rate θ.