Municipal Mergers and Economic Activity

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Abstract

In this paper, we make use of large-scale municipal mergers in Germany to study the effect of local border changes on the distribution of activity in space. To allow for a comparison of economic activity within unique geographical units over time, we use geo-coded light data as well as local land-use data. Applying a difference-in-differences approach on entropy-balanced data, we find evidence that municipalities absorbing their merger partners and hosting the new administrative center experience a significant increase in local activity, while the municipalities that are being absorbed and are losing the administrative center experience a decrease in such activity. The difference between the gains in activity from absorbing municipalities and the losses from absorbed ones appears positive. These previously undocumented results point to the importance of distance to the administrative center as a determinant of the spatial distribution of economic activity.

Keywords: Border effects, centripetal forces, nightlight data, administrative center, municipal mergers.

JEL classification: H7; R11; R12

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1 Introduction

The way administrative borders influence the distribution of economic activity in space is subject to an increasing body of literature.[1] Various determinants of economic activity such as language, tax and tariff policies, norms, and commercial law change at national borders, which implies that economic activity exhibits some discontinuity at borders. In terms of geographical scope, national borders are only the tip of the iceberg. The majority of countries are divided into local jurisdictions with a multitude of borders due to the decentralization of policy responsibilities or administrative duties. Local borders, such as municipal borders, differ from national ones. Municipalities or other local administrative units typically operate in a homogeneous socio-economic environment with a common language, set of norms, and commercial law, which implies that these determinants of economic activity do not change at local borders. Based on this reasoning, local administrative borders are possibly expected to be irrelevant for the spatial distribution of economic activity. However, although borders of sub-national jurisdictions typically do not invoke sharp socio-economic discontinuities, they entail discontinuities with respect to the type and the location as well as the distance to the responsible administrative authorities.

In this paper, we provide evidence that local borders matter for the spatial distribution of economic activity and that the administrative center attracts economic activity. The role of borders and the question of whether the administrative centers follows economic activity or attracts economic activity are central to the analysis of urban and rural structures, but are hard to identify and quantify.[2] Most notably, borders and the distance to authorities rarely change, which brings about a risk of bias from confounding, time-invariant factors. Border changes due to mergers might serve as a quasi-experiment, as they imply changes of the typically stable distance to the authorities (of voters as well as firms), while leaving other determinants of economic activity constant. Germany has experienced an unusually large number of border reforms and adjustments, which makes it a natural case to study the question at hand. Municipal amalgamations are central to policy discussions in Germany. The number of municipalities has dropped considerably in former West Germany from 23,629 in 1970 to 8,502 in 1980 and

[1] See, e.g., Anderson and van Wincoop (2003), Egger and Lassmann (2015) and Pinkovskiy (2017) for contributions in this field.

[2] The spatial effects of administrative centers make an early appearance in Christaller's Central Place Theory (Christaller, 1933; Fujita, 2010), a concept that is core to urban planning and economic geography. Therein, the 'centrality' of a geographic unit is determined by, e.g., the political and administrative functions that have been assigned to it. More recently, the spatial effects of administrative centers (as measured by public employment levels) are analyzed in Faggio and Overman (2014) and Becker, Heblich, and Sturm (2018), for instance. A more detailed discussion of the literature will be provided below.

again in re-unified Germany from 16,177 in 1991 to 11,237 in 2013. We exploit the associated time variation in the geography of borders by using large-scale municipal border reforms due to municipal amalgamations that took place in Germany after the reunification in 1990. Such changes allow us to control for unobserved determinants of economic activity in a straightforward, but unprecedented way.

Despite their policy relevance, the implications of municipal border changes for economic activity and the inherent role of the distance to the administrative center are largely unexplored in earlier work.[3] Presumably, the lack of empirical evidence on this issue is related to the lack of adequate data. Local data are typically reported for the administrative unit and the reporting adjusts to the change in the geography of the administrative unit. The spatial distribution of economic activity within a municipality is seldomly available in official statistics and this restriction also applies to countries with developed statistical reporting. All this makes it impossible to universally trace economic activity and the distance to the relevant administrative center for a given municipality over time and to measure the geography of economic activity before and after local border changes. In this paper, we propose a novel approach to bypass the shortcoming. We measure economic activity at the local level by using geo-coded light data. Such data are recorded by satellites and published by the Earth Observation Group at the National Centers for Environmental Information. The use of light data allows us to circumvent the problem of lacking administrative data and to trace the economic activity of geographic units smaller than a municipality over time. We build these geographical units by overlaying all yearly German municipal maps between 1998 and 2013. This results in the universe of the smallest unchanged spatial units in the investigation period. We assess the quality of geo-coded light data as a proxy for economic activity at the local level by providing evidence that both measures are strongly and linearly correlated at the local level using municipal data. Also, to identify the source of light radiation we make use of the Digital Landscape Model (DLM) of the German Federal Agency for Cartography and Geodesy. The DLM describes the topographic features of the German landscape with an accuracy of ±100 meters and allows us to extract the areas

[3] Spatial effects are feared by potentially losing municipalities, but intended by merger policy. For instance, the opposition against the merger between the two German municipalities of Giessen and Wetzlar (in Hesse) was motivated by "the fear that Wetzlar [...] would become an industrial suburb of Giessen" according to mayor Hans Görnert (Frankfurter Rundschau, 30.7.2009, Auflösung der Lahn-Stadt vor 30 Jahren, http://www.fr.de/rhein-main/giessen-wetzlar-aufloesung-der-lahn-stadt-vor-30-jahren-a-1092346; authors' own translation). At the same time, the merger guidelines in Brandenburg stipulated that one goal of the reform is to "enable the development of a single living and economic area through coordinated planning and management of infrastructure" (Starke Gemeinden für Brandenburg – Leitlinien der Landesregierung für die Entwicklung der Gemeindestruktur im Land Brandenburg, 2000, p.3; authors' own translation).

occupied by housing in every year.

The different German Länder imposed merger guidelines, which required municipalities to merge with their neighbors, within a short time frame and to reach a high-enough minimal population threshold after merging. In some cases, the guidelines also fixed the number of merging partners. Hence, a municipalities' choice of merging partners was strongly restricted. However, the non-randomness of local border changes might still be a concern to the identification of their effects. The decisions to merge and with whom to merge may be correlated with unobservables. As an example, a poorly performing municipality based on some unobserved dimension might be more likely to merge, and to do so with a better performing one. To address these issues of endogeneity, we first apply a difference-in-differences approach where we compare the difference in outcome before and after treatment between the treated and the control municipalities. Treated municipalities are municipalities involved in a merger whereas control municipalities are those never involved in a merger within our sample period. The approach accounts for unobservable time-fixed effects and fixed effects at the micro unit at which we observe light data (which is smaller than a municipality and uniquely assigned to pre-merger municipalities such that municipality fixed effects are accounted for as well). Still, applying a difference-in-differences approach on balanced or matched data leads to estimates closer to those from an ideal experiment (Blundell and Dias, 2009; Ferraro and Miranda, 2014). Pre-balancing or pre-matching the data helps tackling problems such as time-varying unobservables correlated with treatment or invalid counterfactual trends that still pose a threat to identification when using a "naive" difference-in-differences approach. Such pre-processing methods help us retrieve a causal effect when, for example, the performance of merging municipalities (and not of control ones) was worsening as the merger approaches, which is a typical concern to identification in the case of municipal merger. The pre-processing ensures that we compare merging and non-merging municipalities that exhibit similar behavior prior to the merger period. This improves upon existing studies on the effects of mergers to tackle issues of endogeneity and thereby to uncover causal effects of local border changes, as more firmly discussed below.

As a pre-processing method, we apply entropy balancing as proposed by Hainmueller and Xu (2013) to the universe of municipalities in Germany.[4] Thanks to the use of geo-localized data, we are able to enforce the balancing of pre-treatment trends at the level of the merging partners, which we can then follow after the merger. This could not be done using municipality-level data due to the problem of lacking administrative data. As discussed above, the pre-merger units

[4] We chose entropy balancing over propensity-score (and other) matching methods for reasons detailed in Section 4.

disappear in the official data after the merger such that a pre-merger unit cannot be traced over time to infer the way the re-location of the administrative center shapes economic activity in space.

Moreover, we differentiate the impact of administrative border changes between municipalities that absorb others and host the new administrative center, and municipalities that are absorbed and lose the administrative center. In line with the anecdotal evidence cited above, we find that municipalities absorbing their merging partners experience a significant increase in local activity, while municipalities being absorbed experience a decrease in such activity. Overall, the net effect of the reform appears positive and relatively important. The average merger generates a night-light increase which is equivalent to an overall 2% GDP growth.[5] Absorbing places experience a 4% GDP growth, whereas absorbed places face a 2% decrease in GDP. We present evidence that the geographical location of the new administrative center, which correlates with the centroid of the new municipality, rather than population or size differentials, explains the heterogeneity in the estimates to a large extent. The findings suggest that local border changes result in a spatial re-organization of municipal economic activity. The centripetal forces towards the administrative center are blocked by borders and change with their restructuring. Intuitively, mergers alter the distance to the relevant economic and social center of a municipality, due to the redirected usage of common social services and thereby the incentives of firms and households within a municipality to exert economic activity closer to the center. The finding that the absorbing municipality, which is generally the larger of the merging municipalities, gains in terms of economic activity, relative to absorbed municipalities, is consistent with the notion that urban areas gain at the expense of rural areas, as frequently documented in the urban economics literature without unraveling the inherent role of administrative centers.[6] Additionally, we observe that all merging municipalities experience a concentration of local activity compared to non-merging municipalities.

The paper proceeds as follows. In Section 2, we present a detailed discussion of the related literature. Then, in Section 3 we describe the municipal border reforms in Germany after the reunification in 1990 followed by a description of the identification strategy in Section 4 and the data set in Section 5. We present the main empirical findings and robustness analyses in Section 6 and offer some concluding remarks in Section 7.

[5]The correspondence between night-light growth and GDP growth is based on the elasticity of 0.3 obtained by Henderson, Storeygard, and Weil (2012).

[6]Desmet and Henderson (2015) provide a review of the relevant literature.

2 Literature review

The paper contributes to the literature in various ways. As stated above, we use light data to address the existing shortcomings in statistical reporting. Light data offers the double advantage of being available within administrative units and its reporting unit does not vary with border changes. Thereby, the paper contributes to the recently evolving literature that uses light data in instances where outcomes of interest are difficult to measure with existing administrative data, such as Henderson et al. (2012) analyzing city dynamics; Burgess, Hansen, Olken, Potapov, and Sieber (2012) studying natural resource usage; Hodler and Raschky (2014) looking at the allocation of infrastructure projects in developing countries; and Alesina, Michalopoulos, and Papaioannou (2016) isolating the effects of ethnic inequality.[7] Combining border effects and light data, Pinkovskiy (2017) analyzes discontinuities in economic activity (as proxied by light data) at country-level borders. However, in this literature, variations in borders and their implication for economic activity in space (and not only at borders) are not analyzed.

Municipal mergers are frequently analyzed with a focus on their fiscal and political effects at the local level (Hinnerich, 2009; Reingewertz, 2012; Hyytinen, Saarimaa, and Tukiainen, 2014; Saarimaa and Tukiainen, 2015; Blesse and Baskaran, 2016). Given the data issues discussed above, perhaps it comes as no surprise that neither border-related adjustments in economic activity and its spatial distribution within municipal boundaries nor the associated role of administrative centers are addressed in this literature. Additionally, with micro units as time-invariant units of analysis, we improve upon existing studies to tackle issues of endogeneity of mergers, which helps to uncover the causal effects of local border changes. Existing studies do not use differences-in difference analysis for a given geographical unit and nor do they use matching procedures to create comparable treated and untreated geographical units that are constant over time. To address the problem of lacking administrative data, it is common practice in the merger literature to create control groups based on post-merger boundaries. Thus, the choice of control units is endogenous to the post-reform behavior of treated municipalities. The economic relevance of national administrative border effects has been documented in other strands of work, though.[8] There, administrative borders serve as a proxy for various institutional and socio-economic factors that change at national borders. In the present paper, we show that, even after controlling for these conventional factors as well as for unobserved factors given the

[7] See Donaldson and Storeygard (2016) for a review of the literature.

[8] Most notably, the issue has received prominence in the trade literature. See, e.g., Anderson and van Wincoop (2003) who analyze the importance of border effects for trade flows and Rossi-Hansberg (2005) who provides a theoretical modeling of border effects.

use of local border changes, borders have an effect.[9] The empirical findings documented here point to the role of centripetal forces towards the administrative center in organizing economic activity. These effects are restrained by borders and unfold once local borders are removed.[10] Centripetal forces are well understood from a theoretical perspective, but empirical work identifying how borders affect these forces and thereby change the spatial organization of economic activity is scarce.[11] The findings of this paper might be informative for future work on local spatial structures. The empirical evidence is in line with the idea that central facilities serve as a coordination device for the location of economic activity and help to select between multiple-steady-state spatial distributions of economic activity, which are inherent to many models of new economic geography (Krugman, 1991). As shown previously, the location of a central facility such as an airport hub might well serve as a focal point (Redding, Sturm, and Wolf, 2011). In our context, the central facility is the administrative center whose location changes due to a municipal merger. Thereby, administrative centers might have an effect in these models above and beyond the displacement effect of public employment on private sector employment, as emphasized in Faggio and Overman (2014) and Becker et al. (2018), for instance. They look at the relocation effects of public employment across local labor markets. In our setting, the relocation of public employment is only local, occurring within a local labor market. As such, the effects of administrative centers on economic activity that we identify in the analysis are complementary to the effects reported in Faggio and Overman (2014) and Becker et al. (2018).

[9] Redding and Sturm (2008) and Nitsch and Wolf (2013) use local border changes in their empirical work, but with a different focus. They use such changes as a shock to market access to estimate the impact on city growth and trade flows, respectively.

[10] The change in the administrative center might be a first-round effect on the spatial allocation of economic activity that is reinforced by economic agglomeration forces thereafter. In the new steady state and for a given structure of administrative centers, the economic forces might be sufficiently strong that it is difficult to observe effects of local boundaries in the data. The reasoning is consistent with Rozenfeld, Rybski, Gabaix, and Makse (2011) who, based on a bottom-up algorithmic approach in tracing city structures rather than on legally-defined administrative borders, find that Zipf's law holds for population quite well.

[11] Theoretical research on the determinants of centripetal forces is summarized in Duranton and Puga (2004) and Behrens and Robert-Nicoud (2015), for instance. The corresponding empirical literature is smaller, but steadily growing and reviewed in Duranton and Kerr (2015). Border changes and the associated change in centrality of spatial units, presumably initiated due to the relocation of public administrative infrastructure, is not addressed empirically (nor theoretically).

3 Changes in municipal administrative borders in Germany, 1990-2013

In this section, we describe the large-scale municipal border reforms that took place in Germany since the country's reunification in 1990.

Both the former Federal Republic of Germany (FRG; Old Länder) and the former German Democratic Republic (GDR; New Länder) have experienced large-scale administrative border reforms since 1970. The number of municipalities in the FRG shrank to almost one-third between 1970 and 1980 (from 23,629 in 1970 to 8,502 in 1980; see Figure 1). Following an effort to rationalize the operation of municipalities, this reform particularly reduced the number of small municipalities. Over the mentioned decade, the share of municipalities with less than 500 inhabitants decreased from 44% to 21% (see Figure 1b).[12] Since 1980, both the number of municipalities as well as the share of small municipalities in the ex-FRG remained constant until now. Due to the political organization of the GDR, such a reform did not take place there prior to the reunification. Hence, in 1990, the share of municipalities with 500 or less inhabitants was 2.4 times higher in the GDR than in the FRG (49% to 20%; see Figure 1b).

– Figure 1 about here –

Upon reunification, municipalities in the New Länder were granted the same economic and political power as municipalities in the Old Länder. This situation pushed the New Länder, in turn, to implement large-scale merger reforms. The first New Länder to implement such reforms were Saxony and Thuringia in 1994, while the last state to do so was Saxony-Anhalt in 2009-2010. Overall, the number of municipalities decreased from 16,177 in 1991 to 11,237 in 2013 all over reunified Germany. Except for Berlin, which is only one municipality, this decline happened all over the New Länder. E.g., the number of municipalities in Saxony-Anhalt decreased from 1,012 in 2008 to 220 in 2011. Figure 2 shows how the number of municipalities evolved with the different merger reforms since the mid-1990s.

– Figure 2 about here –

With the administrative border reforms in the focus of this paper, the average local economic effects as well as the heterogeneity of the effects are of interest. With regard to the latter, it will turn out to be useful to distinguish two types of merging entities which we dub *absorbed* and *absorbing*. We refer to a spatial entity as *absorbed*, if it is absorbed by another one; and

[12] According to the authors' own calculations based on the "Statistisches Jahrbuch" of both East and West Germany before the reunification, and on the German Federal Statistical Office after the reunification.

as *absorbing*, if it absorbs others. The classification in two groups follows the one made by the German Federal Statistical Office (DEStatis). The *absorbed* municipalities are involved in a merger with an *absorbing* municipality and called "dissolved" by DEStatis; the *absorbing* municipalities are simply involved in a merger with at least one *absorbed* municipality.[13] Note that some merging municipalities cannot be assigned to any of the two types. We classify them as *other*. This third category is made of municipalities that are all involved in a merger, but that do not fulfill the requirements to be classified in one of the two previous categories. The most common case that leads a municipality to be classified as *other* is the one where all municipalities of a merger are qualified as "dissolved"; hence, we can not identify among them the one absorbing the others. In Section 6.2, we use alternative geography based classifications which can include all merging municipalities. Results using these classifications are not significantly different from the ones using the DEStatis classification. *Absorbing* municipalities are those municipalities that will become the center of the post-merger municipality. It will contain the political center of this new municipality. *Absorbed* municipalities, on the other hand, lose their old center as it is displaced to the *absorbing* municipalities. Consequently, *absorbed* municipalities experience a sharp increase in the distance to the municipal center. [14]

The border reforms also included a few municipal separations. A separation occurs when part of a municipality becomes independent or merges with another municipality. For the sake of clear identification, we restrict our analysis to pure mergers, i.e. merger process that did not include any municipality involved in a separation.

Figure 3a illustrates this classification using the border reform that took place in Saxony-Anhalt in 2009. We observe that *absorbing* places (light green) are larger and surrounded by in-merging *absorbed* ones (dark blue). We also see that *other* municipalities (dark green) are generally spatially dislocated from *absorbing* municipalities. Lastly, Figure 3b shows characteristics of the border changes that took place in 2009. We observe that mergers tended to involve more than two municipalities. Over the 1998-2013 period, mergers involved on average 3.1 municipalities, with the largest merger having involved 22 municipalities.

– Figure 3 about here –

[13] A merger type is attributed to a spatial entity and remains the same within a merger process. A merger process is defined as the set of all mergers that involve at least one same spatial unit within a three-year period. This means that, if municipality A absorbs municipality B in a first year (i.e., A is an *absorbing* type, and B an *absorbed* type), and if in a second year the new municipality made out of A and B absorbs municipality C, the type of B remains *absorbed*, even though it co-absorbed C as part of A plus B.

[14] In 72,3% of the mergers, *absorbing* municipalities contained the centroid of the post-merger municipality; hence, *absorbing* municipalities are more centrally located than *absorbed* places.

When analyzing municipal mergers, one commonly faces a fundamental identification problem: micro-regional economic accounting and statistical data collection are associated with municipal borders. Counts and borders of municipalities change with mergers. For that reason, it is common practice in the merger literature – pertaining to spatial units as well as to firms that merge – to create pre-merger artifacts which correspond to post-merger boundaries, or vice versa. However, creating pre-merger artifacts has two disadvantages. First, it mechanically introduces a bias as we end up comparing a group of independent units (pre-merger) to a single larger unit (post-merger). Second, it forbids the analysis of any variation within post-merger boundaries (both pre- or post-merger).

We approach this problem as follows. First of all, we track municipalities and their borders annually between 1998 and 2013, and overlay these borders for all years together.[15] This results in the universe of the smallest spatial units, which we refer to as *places*, of which there are 17,613 all over (unified) Germany in the investigation period. Any municipality's area can be expressed in terms of a set of such places at any point in time between 1998 and 2013, and boundaries of places do not have to coincide with administrative boundaries in all years. Figure 4 shows all place and all municipal borders (in 2010) around Berlin. Changes in municipal borders are well defined in terms of a shedding or accumulation of places. Of course, the object of interest to this study are places which change the association with a municipality as well as municipalities whose set of places changes. The task is then to find observable characteristics which are measured at the level of places so that the evolution of characteristics can be tracked in response to the changing association of places. Doing so permits measuring merger-related consequences which are beyond the reach of administrative data.

– Figure 4 about here –

Across all New Länder, the municipal merger reforms took place in two steps. First, municipalities were encouraged to merge with whom they wanted, as long as the proposed merger followed strict guidelines given by the state parliament. The guidelines required primarily municipalities to merge with their neighbors within a specific time frame (generally around three years), they were geared towards reaching a high-enough minimal population threshold after merging (between 3,000 inhabitants in Thuringia and 10,000 inhabitants in Saxony-Anhalt). In some states, a certain target number of merging partners was given (e.g., Brandenburg made to merge three to six municipalities into a new one). Additionally, the guidelines encouraged the center of the newly created municipality to be located centrally to minimize the maximum

[15] Exact information on municipal border maps for each year is available from the German Federal Agency for Cartography and Geodesy.

distance from all places to the center. As almost 50% of the municipalities in the New Länder had less than 500 inhabitants in 1990, such requirement meant that municipalities would have had to merge either with many small neighbors or with a larger one (if available). Even though municipalities were free to choose their merging partners, we call the mergers in the first step semi-voluntary because the political encouragement of merging following strict requirements was strong. Except for Mecklenburg-West Pomerania, this first step of the reform was followed by a second one in which the different states enforced further mergers among some municipalities. This second step aimed at merging any remaining small municipalities that had not moved forward with merging (semi-)voluntarily in the first step. We refer to the mergers in the second step as compulsory. Any merger effect is likely to be different between (semi-)voluntary and compulsory mergers as this last group can be seen as regrouping the "left over" municipalities which could not find merging partners in the first stage of the reform.

4 Study design and identification strategy

The present paper interested in identifying the causal effect of local border reforms on local economic activity. Even though the different German Länder imposed merger guidelines that left little leeway to the municipalities as detailed in Section 3, the decision to merge might still not be random and observed control variables might not account fully for unobservables correlated with treatment. This also holds for the decision on the merging partners as well as the type that each municipalities adopts when merging. To address these concerns, we employ a difference-in-differences approach where we compare the difference in outcome before and after the merger in treated versus non-treated places. The use of this approach is further motivated by the fact that pre-treatment trends in the control and treated groups appear quite parallel, as shown in Section 5.

Unobservable municipal characteristics that are correlated with treatment can still pose a problem to identification when using a simple difference-in-differences approach. Applying the approach on pre-balanced or pre-matched data leads to estimates closer to those from an ideal experiment (Blundell and Dias, 2009; Ferraro and Miranda, 2014). Bearing this in mind, we pre-balance our data using entropy balancing following Hainmueller and Xu (2013), which we prefer over standard matching methods such as propensity-score matching as the balancing of covariates between the treated and the untreated units is assumed but not ensured, there. Entropy balancing explicitly imposes balancing constraints on the different observable characteristics which reduces the risk that the treatment and control group systematically differ apart from the treatment status (see Hainmueller and Xu, 2013; Zubizarreta, 2015). [16]

In what follows, we detail our identification strategy. We will refer to a year by $t = 1998, ..., 2013$ and to a phase in a 10 year window centered around a merger event by $s = -5, ..., 4$, the latter being zero in the very year of a merger activity ($s = 0$). Let us use indices $m = 1, ..., M$ and $p = 1, ..., P$ to index the universe of municipalities and places, respectively, in Germany over the period 1998-2013. We refer to places as the smallest regional aggregates that had been unchanged over time. For instance, for a municipality m whose borders did not change during the period of investigation, this municipality m corresponds to one specific p. If a municipality merged with parts or the whole of another municipality, it would represent some p at the beginning of the period of investigation and a conglomerate of several places p at the end of it. For instance, municipality $m = 1$ might consist of $p = 1$ and $p = 2$ in 2013, while $m = 1$ consisted of only $p = 1$ and $m = 2$ consisted of $p = 2$ in 1998. $p = 1$ is then an *absorbing* places, while $p = 2$ is an *absorbed* place.

For the empirical analysis, it is useful to quadruple-index the data so that any generic variable v is indexed as v_{mp}^{st}. The data-set which is used in the empirical analysis then has the following structure. First of all, all years t are considered in which a change in administrative borders had happened. For simplicity, let us pick one specific such year and refer to it as t'. Now, we take all the available data within the sample period with (up to) 5 observations prior to and after t'. Ultimately, t takes on every integer value between 1998 and 2013, since there was some administrative merger activity in each and everyone of the years. Let us use $\mathscr{A}_1^{t'}$ to refer to the set of places p which were involved in some merger activity in year t', and let us use $\mathscr{A}_0^{t'}$ to refer to the set of places p which were never involved in any merger or separation activity centered around t'. Then, the total set of units at t' is $\mathscr{A}^{t'} = \mathscr{A}_1^{t'} \bigcup \mathscr{A}_0^{t'}$.[17] Clearly, by that design, the

[16] Precisely, both propensity-score (and other) matching estimators and entropy balancing estimators can be portrayed as to belong to the class of weighting estimators for binary endogenous treatment effects models (see Wooldridge, 2007; Hainmueller and Xu, 2013). As is generally the case with nonparametric estimators invoking conditional mean independence, consistent estimation requires that the vector of covariates is balanced (i.e., the moments are the same) between the treated and the untreated. In case of covariate balancing, propensity-score-based estimators and entropy balancing both will deliver consistent average-treatment-effect estimates. In absence of covariate-balancing, propensity-score-based estimates may be severely biased, inter alia leading to a potentially large gap between the average treatment effect and the average treatment effect of the treated. This problem is avoided by explicitly imposing balancing constraints under entropy balancing.

[17] Altogether, there are only 382 separations in the data (where only in 4 cases a shedding place became an administrative municipality and in the remaining cases places merge with existing municipalities). These cases are too few in comparison to the other merger types to warrant an analysis of their own, and we discard the respective data from the analysis. Moreover, we discard observations, where places and municipalities were involved in more than a single merger after a three-year time window around a merger event. We consider all

tuples $\{pt\}$ which uniquely identify place-time observations may be repeatedly observed in two sets $\mathscr{A}^t$ and $\mathscr{A}^{t'}$. This overlap leads to non-zero off-diagonal entries in the variance-covariance matrix of the disturbances, which can be taken care of through clustering at the place level. Moreover, it should be noted that not all phases s are observed for each specific time period t', depending on its location in the interval 1998-2013. Overall, this design leads to 1,289,396 observations which enter the econometric analysis, while there are only 17,613×16=281,808 unique $\{pt\}$-tuples in the data.

With this notation, we may write the empirical model for outcome Y^{st}_{mp} and any specific type of merger treatment which is used for identification of the phase-specific response to a specific type of merger activity as

$$Y^{st}_{mp} = \alpha^s D^{st}_{mp} + X^{st}_{mp}\beta^s + \mu^s_{mp} + \lambda^{st} + u^{st}_{mp}, \tag{1}$$

where D^{st}_{mp} is a binary indicator variable that is unity in all phases $s \leq 0$ if unit p was involved in some type of merger activity at t and zero otherwise, X^{st}_{mp} is a vector of control variables, α^s is the average treatment effect associated with one of the merger types of interest here – *absorbing* or *absorbed* in phase s –, β^s is the phase-specific vector of parameters on the control variables, μ^s_{mp} and λ^{st} are *smp*- and *st*-specific fixed effects, and u^{st}_{mp} is a disturbance term. By this design, the specification in (1) corresponds to a conditional (on X^{st}_{mp}) difference-in-differences estimation approach with multiple phases (see Bertrand, Duflo, and Mullainathan, 2004). As an alternative to the specification in equation (1), we estimate pooled effects by merger type for phases $s \in \{0, ..., 4\}$ after the merger relative to phases $s \in \{-5, ..., -1\}$ prior to the merger.

For any type of merger of interest here, any place that was never involved in a merger is an independent municipality and forms part of the control group. Since the size of the treatment group varies by merger type and over time, the samples the parameters are estimated from differ in size. The total number of observations used for the regressions for *absorbing* and *absorbed* mergers are 5,864 and 15,674, respectively.

5 Descriptive statistics on outcome and control variables

As indicated above, investigating the effect of municipal border changes using places requires outcome data to be recorded at the place or smaller level, consistently over time, and independently of administrative borders. To measure local economic activity at such a geographical

merger activities of a municipality within a three-year time window as a single event, even though places may have merged in a staggered way during this time spam. If further places had merged after such a three-year time window and within 15 years after the merger event, we discard such observations as well for the sake of better identification of the treatment effects of interest.

level, we use night-light-intensity data recorded on an annual basis. Such data are recorded by satellites and published by the Earth Observation Group at the National Centers for Environmental Information.[18] The spatial unit in these data are 30 arc second grids, spanning -180 to 180 degrees of longitude and -65 to 75 degrees of latitude. The cloud-free nighttime light data are recorded annually in 64 integer levels of radiance between 0 and 63. We employ the top-coded version of the data for two reasons. First, the top-coded data are available and reliable for a longer time period. Second, they are more accurate at recording low light intensity levels, which is crucial to our analysis, as the average night-light intensity over all places and years is 10.99 watts/cm2/sr/um (see Table 1). We extracted the data using geographic-information-system (GIS) tools. By overlaying the annual nighttime-light data with the map containing the boundaries for all 17,613 places in the data, we may extract statistics such as the average, minimum, maximum, standard-deviation, and the Herfindhal index of the night-light intensity within a particular place and year, and we can track these statistics for a given place over time.

The usage of night-light data enables us to overcome the problem of lacking administrative data to analyze local border reforms. However, for this solution to be successful, night-light data must constitute a good proxy of local activity. We detail below the three main concerns that arise when using night-light in our context and how we overcome them:

We use night-light data as a proxy to economic activity in general. To show that night-light performs well at capturing economic activity in general, we plot the average night-light intensity against three measures of local activity at the municipal level using data from 2009 and 2013: population, number of workers living, and number of workers working in a particular municipality. As shown in Figure 5, we observe an almost linear relationship along the 45 degree line for all three measures of local activity. Figure 5 additionally reports the results of an OLS regression of each measure on the night-light intensity. In all three cases, the estimated parameters are positive and highly significant. This documents a high degree of correlation between administrative data and nightlight data, and it makes us confident that the later may be used as a proxy of activity where the former is not available. Still, various concerns might exist why night-light data does not constitute a good proxy for economic activity. One concern might be that changes in street lighting might generate changes in nightlight that does not

[18] Precisely, we employ the Version 4 of the Defense Meteorological Satellite Program - Operational Linescan System (DMSP - OLS). We used the stable-light version of three different satellites to cover the period 1998-2013 (F14 for 1998-2003, F16 for 2003-2009 and F18 for 2010 and onwards). The night-light intensity is measured in Watts/cm2/sr/um. The stable-light version insures that the light recorded is emitted by a stable source, i.e. not including traffic, and that the data are not distorted by meteorological conditions such as fire, lighting, clouds or rain.

correspond to changes in economic activity. Street lighting was governed by the German DIN 5044-1 guidelines until 2011 and by the European EN 13201 guidelines afterward. These rules apply in the same way across the whole country.[19] Hence, no differences across treated and untreated places should be observed for similar streets. Further, as we use relatively small places, a blooming effect (i.e. spillover of light across places) might bias our results. To account for such potential effect, we introduce covariates from neighbor municipalities in our estimation strategy. As shown later on, the results with and without such covariates are very similar, suggesting that the blooming effect is not overly present in our data. Finally, the nightlight data is top coded, i.e. data points whose values are above an upper bound are censored. Changes in economic activity might not equally translate into nightlight changes (as observed in the data) at all levels of economic activity. The version 4 of the Defense Meteorological Satellite Program (DMSP - OLS) is top coded at 63 lumens. In Germany, very few places emit high levels of light as can be seen on Figure 5. Only 1% of all grids emit light above 60 lumens, whereas the average municipalities emits 11 "only" lumens (see Table 1). This suggests that top coding should not be an issue in our context.

– Figure 5 about here –

To identify the source of light radiation, we make use of the Digital Landscape Model (DLM) of the German Federal Agency for Cartography and Geodesy. The DLM describes the topographic features of the German landscape with an accuracy of ±100 meters. For the purpose of this paper, we extract the areas occupied by housing every year. The rest of the landscape is composed of industry areas, vegetation areas, water bodies, mountains, and agricultural areas.[20] Figure 6 shows the distribution of housing areas around Berlin in relation to place borders. Housing areas occupy a large share of land in Berlin and in neighboring places. Other land uses become more important as we move away from Berlin. Over all Germany, we observe 9,320 housing areas in 2013 (for a total of 11,237 municipalities in that year).

– Figure 6 about here –

Finally, when combining the three sets of maps mentioned above – pertaining to places, nightlight intensity, and land use – we can identify the average light coming mainly from housing areas

[19] Motivated by environmental considerations, Germany introduced a law in 2015 which had important effects on the technology used to lit streets from 2017 onwards. As our dataset covers the period 1998-2013, this legal change should not impact our results.

[20] The small number of recorded industry areas (750 for 11,237 municipalities) and the concentration of such areas in large urban centers prevent us from analyzing light emitted by industry areas.

in a particular place and year. Figure 7 presents this information for places around Berlin in 2013.

– Figure 7 about here –

Moreover, we augment the data with ones available at the administrative, municipal level provided by the Statistical Offices of the different states (1995-2007) and by the German Federal Statistical Office (2008-2013). This includes detailed data on municipal finance, taxes, land use, land coverage, unemployment, and demography. However, such data are not available at the finer-grained regional level of places.

Table 1 describes key characteristics of places by treatment status and merger type. We use the structure of the stacked data to describe the average change in the outcome variables for both control and treated places before and after the mergers. The outcome variables in Table 1 describe both the intensity of the local activity and the concentration of such activity within a place. To measure the concentration of night-light intensity within a place, we compute the Herfindahl index about night-light intensity across pixels within a place as follows:

$$H_{pt} = \sum_{j=1}^{N_p} l_{pjt}^2 \quad \text{with} \quad l_{pjt} = \frac{x_{pjt}}{\sum_{j'=1}^{N_p} x_{pj't}},$$

where H_{pt} is the concentration index for place p in year t, j represent a pixel in a place p, N_p is the number of pixels in place p (which is constant because place borders are fixed), x_{pjt} represents the light intensity of a pixel j located in place p at year t, respectively. The Herfindahl index can be described as the squared sum of the shares of each pixel in the overall light intensity of a place p. One key issue when analyzing satellite night-light data is to identify which activity is emitting the light. To address this problem, we also study how administrative borders impact the light intensity from housing within a place.

Table 1 is organized vertically in two panels. Panel A provides averages of outcome variables (or around-merger-event changes thereof) for all places on average (*Total*), for control places on average (*Control*), and for merging or treated places on average (*Treated*).[21] Panel B provides averages of outcome variables (or around-merger-time changes thereof) for both types of merging places (i.e., all of those are treated): *absorbed*, i.e. places not hosting the new administrative center, and *absorbing*, i.e. places hosting the new administrative center. Horizontally, Table 1 is organized in three headed columns. The first and the second ones (entitled *Average* and *S.d.*) contain, respectively, the average and the standard deviation of outcome variables in all years

[21] We refer to treated places for brevity. Rigorously speaking, treated places are ones located in a merger-treated municipality. Control places are ones not located in a merger-treated municipality.

and phases covered. The third column (entitled *Avg. pre-post change*) reports the difference between (in three years; i.e., in $t-3$ to $t-1$) before and (in three years; i.e., in t to $t+2$) after the merger for each outcome variable.

Over the period of study, we observe that treated places have a lower average night-light intensity compared to control places (8.17 to 11.06; see Panel A of Table 1). Note that such average level of light intensity indicates that sensor saturation is not an important concern in our application. This difference is also observed when looking at the luminosity coming from housing areas in such places. The main difference between treated and control places seems to be that luminosity in treated ones is much more concentrated (across the pixels within a place). Notice that the Herfindahl index of luminosity is almost seven times higher in treated places than in control places.

The second column of Table 1 displays the average unconditional difference in outcomes around the time of a merger. A positive number implies that, on average, a variable's value increased in the post-merger period relative to the pre-merger period. It appears that, except for the Herfindahl index of the luminosity of pixels within places, the outcome variables grew unconditionally faster in treated places than in untreated ones.

– Table 1 about here –

Panel B of Table 1 discerns levels and unconditional changes in outcome variables by merger type. Two points stand out from this analysis. First, the average night-light radiance and average night-light radiance from housing increased in all places around the time of mergers. Second, the Herfindahl index of night-light radiance increased around the time of mergers for absorbing places, whereas it declined in absorbed places.

– Table 2 about here –

Table 2 presents place-frequency-weighted first moments of municipal-level covariates. Characteristics of a generic municipality m in year t are attributed to all places that lie in m at time t. By definition, places in treated municipalities should experience a jump in their population and area between the time before and after the merger. This is what we observe. Table 2 shows that the municipal population (municipal area) rises by a factor of around 9 (7) in *absorbed* places, but only by 1.1 (1.4) in *absorbing* places.[22] This simply follows from the fact that *absorbing*

[22] In the empirical analysis, to avoid that these jumps in municipal covariates artificially capture some of the merger effect at the place level, we weight the covariates post merger depending on their importance pre merger relative to a place's merger partners.

municipalities are generally larger in population and area compared to *absorbed* ones. Also note that, relative to their total area, *absorbed* places have a larger agricultural area.

Table 2 also shows that a number of covariates such as population or area are significantly different in treated places from the average place. For the estimation of average treatment effects of municipal mergers, this may pose a problem. As outlined above, a prerequisite of consistent estimation and identification of the treatment effect under conditional mean independence is that the covariates conditional on which the average treatment effect is estimated are balanced – i.e. they follow the same statistical distribution. If this is not the case, the difference in outcome may be mis-ascribed to merging when in fact it is due to nonparametric differences in moments of the observables.

To avoid this problem, we employ entropy balancing as proposed by Hainmueller and Xu (2013). We enforce balancing of the first and second moments of the covariates for every specific sample and treatment group studied. Specifically, we calculate weights which applied to the pre-merger control group lead to the pre-merger treated and the pre-merger control groups to be balanced. To obtain time constant weights, we take the average by area across years of these weights and apply it, for each control area, to all years.

Table 3 displays the consequences of entropy balancing for all covariates when considering all mergers. The table is vertically organized in lines, where one line pertains to a particular covariate. Horizontally, the table is organized in three pairs of headed columns: the first pair (labelled *Pre-treatment group*) provides first and second moments of the covariates for all treated places; the second one (labelled *Pre-treatment control group: Unbalanced*) provides first and second moments of the covariates for all untreated places without entropy balancing; the third one (labelled *Pre-treatment control group: Balanced*) provides first and second moments of the covariates for all untreated places with entropy balancing. The results suggest that without entropy balancing there is a large gap in the first and second moments of the covariates between the treated and the control places which may lead to confounded treatment-effect estimates. Entropy balancing starkly reduces if not eliminates this gap. Figure 8 provides a compact illustration of the consequences of entropy balancing across all four treatment types considered in the subsequent analysis: it displays the normalized distribution of first and second moments by dividing the first and second moments for all covariates for the control places by the respective first and second moments of the treated places across all merger types. This is done with the data without balancing (blue curve) and with balancing (red curve). The fact that the red curve (with entropy balancing) in Figure 8a is fixed at 1 indicates that the entropy balanced covariates of the control group match (almost) perfectly those of the treated group. The second moments exhibit less dispersion after balancing, c.f. Figure 8b.

– Table 3 and Figure 8 about here –

Perhaps a more intuitive way of understanding the role of entropy balancing in our application is displayed in Figure 9. Unobservables correlated with treatment or invalid pre-treatment trends can still pose a threat to identification when using difference-in-differences approach. Figure 9 shows that pre-treatment trends are already parallel without balancing. However, as balancing helps us to match even the level of the outcome variable pre-treatment, it further reassures us that some unobservables that are potentially correlated with treatment do not bias our results. This helps to address the concern that mergers are often seen as a result of differences in economic trends across municipalities. Still, expectations to experience different economic trends might not fully show up in pre-reform covariates, which poses a threat to a causal interpretation of our findings. We show that merger policies help to address this concern. As explained above, small municipalities are expected to merge and merger guidelines stipulate population thresholds, which differ across states. Municipalities above or below the respective thresholds experience different exposure to merger policies, while presumably not systematically differing in the expected economic trend. This together with the possibility to compare treated municipalities also with control municipalities in other states that have a different threshold or implement no merger policies suggests that expected differences in economic trends are not overly correlated with treatment, if at all.

– Figure 9 about here –

6 Empirical results

Before turning to a discussion of the specific results, let us emphasize that all of the results reported below enforce a balancing of the first and second moments of the covariates for each specification so that conditional mean independence is ensured provided the rest of the assumptions. Moreover, we condition on two sets of fixed effects: one pertaining to places by phase and one to years by phase.[23] Finally, we always cluster the standard errors by place.

6.1 Main results

Table 4 summarizes the main results regarding average treatment effects of municipal mergers on two measures of local activity. The results in the table are organized in three horizontal

[23]This is to distinguish between factors that are specific to a pre- or post-merger phase for any place and to pre- or post-merger phases depending on the year they are pertaining to.

blocks pertaining to three different treatment-group configurations (*all* places; *absorbed* places; and *absorbing* places) and in two vertical blocks in each of which we analyze two different outcomes (Avg. night-light radiance, Avg. luminosity; Light concentration (among the pixels within a place)). The first vertical block presents our main results, while the second accounts for a possible "blooming effect" which we discuss below.

The main results suggest that there is a negative impact on the level of luminosity for the average merger. Moreover, there is systematic heterogeneity about the level effect. First of all, the night-light radiance appears to decline on average in *absorbed* places but to increase in *absorbing* ones.[24] Second, *absorbed* places tend to see an increase in the concentration of luminosity in their territory, which is not the case in *absorbing* places. A coefficient of, say, -0.94, for average night-light luminosity as an outcome means that the outcome – which takes on values of 0 to 63 – declines by this magnitude. The same applies for the other coefficients. To put these numbers in quantitative perspective, it is useful to take the average levels and standard deviations of the outcomes into consideration (see Table 1).

One general concern about using night-light data at a fine grid level is what has been called the "blooming effect," i.e., the fact that light diffuses into neighboring cells. To tackle this issue, let us first note that the use of stable light areas in the Version 4 DMSP/OLS Nighttime Lights Time Series dataset (which we use here) already corrects for this effect. As Huang, Yang, Gao, Yang, and Zhao (2014) put it, the stable-light dataset "records spatial brightness variation within stable light areas and helps minimize the blooming effect...". However, as a robustness check, we estimate model 1 including the average across all neighboring places of each covariate in order to control for the activity in neighboring places and, hence, possible diffusion. The results, presented in the second vertical block of Table 4, are very similar to those in the first block. This suggests that the blooming effect does not introduce a significant bias in our estimations.

– Table 4 about here –

The results in Table 4 were estimated as averages of five phases after a merger relative to five phases prior to the merger. Such an analysis might conceal some adjustment within the post-merger period. In order to address this issue, we provide estimates of the same effects as in Table 4 for each post-merger phase between 0 and 3, keeping the average year prior to the merger as the benchmark. We summarize the corresponding results in Table 5, which is organized horizontally in two panels. Each one of the two panels pertains to one of the two outcomes discussed in Table 4. For each outcome, we have the same structure as in the earlier table, but we report phase-specific average treatment effects of municipal mergers horizontally.

[24]We obtained the same results when excluding the control variables.

Using this structure, not surprisingly, we observe the same general pattern of effects on average as in Table 4: *absorbing* merging places come out as winners and *absorbed* ones as losers on average, when measuring economic consequences in terms of night-light radiance. The effect on *absorbed* places by phase is, however, not significant. What is particularly interesting here is that the negative effect on *all* and *absorbed* places is strong already in the very year of the merger. A similar picture is observed when looking at the effect on the concentration of night-light radiance in *all* and *absorbed* places.

– Table 5 about here –

With the municipal mergers in the data, as indicated in Section 3, one should consider that the process leading to a merger differs depending on whether the merger decision is enforced by a larger jurisdiction (a German State or Land), or not. As discussed in Section 3, the merger guidelines established by the different German States lead to two stages in the reform. In the first stage, which we called "semi-voluntary", municipalities could merge with any partner they wanted as long as the basic population and distance criteria were met. In the second stage, which we called "compulsory," the remaining municipalities were forced by the Land to merge. One could expect a systematic difference in the merger effects between the two groups as the remaining municipalities were potentially the ones left over. Using the same structure as in Table 4, Table 6 displays the results for those municipalities which were forced to merge, and for whom one or several merger partners were fully determined by the respective State or Land (compulsory mergers). As expected, we observe a larger adverse effect on all three merger groups in Table 6 than in Table 4. This is particularly relevant for *absorbing* places, for which the effect becomes strongly negative. The finding is consistent with the interpretation that places merging at a late stage differ from places merging at an early stage. This result is also interesting in comparison to our main results as it indicates that the results observed in Table 4 cannot be solely a public administration effect (i.e. light emission due to the relocation of public administration). If this was the case, we would observe the same heterogeneous pattern for compulsory mergers.

– Table 6 about here –

6.2 Net effect of mergers and interpretation

As seen in Table 4, there is systematic heterogeneity about the level effect of administrative border reforms. Places absorbing gain, while places being absorbed lose in local activity measured by night-light radiance. To compute the net effect on a merged set of places, one needs to take into account that absorbed places are more numerous but smaller in area than absorbing ones.

We use p to refer to any place in the set of all places P, in the set of all *absorbing* places G, and in the set of all *absorbed* places D. N_G and N_D refer to the number of *absorbing* and *absorbed* places, respectively. Using the average treatment effect for both *absorbing* and *absorbed* groups, α_G^{ATE} and α_D^{ATE}, respectively (Table 4), as well as their average area, the net effect per square kilometer (E_{sq}) can be computed as follows:

$$E_{sq} = \frac{\sum_{p \in G} area_p \times \alpha_G^{ATE} + \sum_{p \in D} area_p \times \alpha_D^{ATE}}{\sum_{p \in P} area_p} \tag{2}$$

Consequently, the total net effect on the average merger (E_m) can be obtained by the product of the net effect per square kilometer and the combined area (in square kilometers) of the average merger partners ($\bar{M}$).

$$E_m = E_{sq} \times \bar{M} \tag{3}$$

Considering all merging places, we observe a positive average net effect per square kilometer of 0.51 watts/cm2/sr/um; which leads to a total effect of 56.02 for the average merging municipality. As an illustration, this is equivalent to the light emitted by the municipality of Großseifen in Rhineland-Palatinate in 2013 which had 603 inhabitants and an area of 1.52 km^2. Using the elasticity of 0.3 obtained by Henderson et al. (2012), this implies a 2% growth in GDP for the average merger, which is divided between a 4% GDP growth in absorbing places and a 2% decrease in GDP in absorbed places. The implied overall net effect of the border reforms appears significantly large when considering that more than 2000 mergers took place between 1998 and 2013.

In the remainder of this subsection, we focus on understanding the mechanism behind the treatment effects estimated above. First, let us note that daily commuting from absorbed to absorbing places are unlikely to be driving the heterogeneous effects. This mechanism should lead to an increase in commuting activity also in absorbed places. The comparison of the magnitude of the net effect to the magnitude of the average treatment effect on *absorbing* and *absorbed* places offers a more promising interpretation for our results. It reveals that the gains from absorbing places are slightly more important than the losses of absorbed places. Migration of local activity across merging partners naturally comes to mind to explain why this is the case. To test for the role of migration across merging partners, we look at the evolution of the night-light emitted by land devoted to housing, as well as the corresponding land size.[25] Both dimensions

[25]Note that housing areas are by construction dominated by pure residential areas, but these areas are also likely to include small retail businesses. Hence, the observed migration across merging partners concerns both residential as well as small business migration.

can be affected by migration across merging partners. Table 7 summarizes the results for the treatment effect on the average night-light emitted by housing area (Column I) as well as on the share of land devoted to housing (Column II). In *absorbed* places, the share of land devoted to housing decreases, while the average night-light from housing remains unaffected. Hence, for these places, the overall negative effect observed in Table 4 appears to be due to a loss in activity in more peripheral areas. The picture is reversed for *absorbing* places. Table 7 shows that the area remains unaffected whereas the average light from housing increased. Hence, the overall gains in *absorbing* places appear on the intensive margin. These two effects hint at migration in general, but also at migration between peripheral locations in *absorbed* places to more central locations in *absorbing* places. Hence, even within places, more central places appear to be better off following the border reforms.

– Table 7 about here –

Furthermore, it appears necessary to scrutinize on the question of whether the heterogeneity pertains to mere area or population size or to other differences between *absorbing* and *absorbed* places. Aside from area and population size of places prior to the merger, the location of the centroid of the municipality after the merger is a strong candidate to explain the heterogeneity. Choosing the place that includes the centroid as the absorbing place can be rationalized as minimizing the distance to the center across the merging partners. In pursuit of this question, and in contrast to the previous analysis, we reclassify places as *absorbing* versus *absorbed* in terms of population and, alternatively, of area size, but also whether they include the centroid of the municipality after the merger. Hence, we abandon the institutional notion of *absorbing* and *absorbed* to adopt a mere geographic- or size-related one.[26] While we know from Table 2 that *absorbing* places tend to be bigger (in terms of both population and area) than *absorbed* ones, it will be interesting to see how the merger effects on the outcomes turn out after conditioning on the characteristics in Table 2.

Table 8 summarizes the results of the estimations with this new delineation of merger types. Interestingly, the results suggest that relative size in terms of population and area is not the main driving mechanism of the effects observed (Panel B and C). The results in all four cases are similar to those obtained in Table 4 when looking at all places. However, the location of the centroid captures better the heterogeneity in the treatment effects (Panel A). This result is in line with the recommendations given in the merger guidelines by the German Länder. Hence, it

[26]This allows us to also analyze those places that could not be attributed to any types based on institutional data.

appears that the minimization of the distance was an important factor of the decision of which places would be *absorbing* and which ones would be *absorbed*.

– Table 8 about here –

The result that the location of the centroid is crucial in explaining the findings points to the role of centripetal forces in local geography.[27] They appear to induce a relocation of economic activity away from the *absorbed* places. The forces are blocked by administrative borders and unfold once they are removed, implying that the *absorbed* places tend to lose in terms of economic activity due to border changes.

6.3 Extensions

After having presented and discussed our main results, we report additional findings and robustness checks that further help us understand the effect of border reforms on economic activity.[28] First, we look at the sensitivity of our results to the distance between *absorbing* and *absorbed* places. Second, we study the interaction of municipal tax rates and the effect of the merger. Finally, we investigate the presence of potential anticipation effects between the announcement and the implementation of the merger.

Adjacent vs. non-adjacent places: The earlier part of the text summarized the results from a pooled analysis of the merger effects for different types of places (*absorbing* and *absorbed*). In what follows, we assess the question whether merger results differ between adjacent and non-adjacent merging places by type. The reason for such a distinction is that citizens might feel particularly alienated to their responsible government or administration depending on whether this government or administration moved far away relative to its original address. The results pertaining to this analysis are summarized in Table 9. While adjacency does not seem to matter for *absorbing* places, the adverse effect on *absorbed* places is larger for places that are more distant from the new center. This indicates that the strength of the centripetal forces at hand is also a function of distance for *absorbed* places.

– Table 9 about here –

[27] The finding that centripetal forces operate towards the centroid, which in our setting primarily locates in the larger of the merging municipalities, is consistent with theoretical research on agglomeration forces and on the urban-rural divide. See Duranton and Puga (2004) and Desmet and Henderson (2015), for instance.

[28] Merger reforms at the county level (Kreis) took place in Germany between 2006-2008. To test whether these reforms bias our results, we exclude all mergers that took place within these years and estimate (1) on the remaining years. Results appear unchanged. The results of this robustness test are available upon request.

Heterogeneity with regard to pre-merger business tax rates: A peculiarity of Germany is that business tax rates – not personal income tax rates, which are chosen by the federal government – can be set by the local government (see, e.g., Egger, Koethenbuerger, and Smart, 2010). In fact, the local business tax rate – apart from fees charged by the municipality – is one of the few sources of revenues that municipal governments can directly influence. A low business tax rate could indicate that a municipality can afford to provide a tax-saving environment and aggressively targets the location of businesses. Conversely, a low business tax rate could indicate that a municipality needs to charge a low business tax rate to attract any businesses (due to its bad location, etc.). If two places in a merger – and these places tend to be located in a certain geographical vicinity – applied very different business tax rates prior to the merger, it should be taken that the places had experienced very different needs of these tax rates prior to the merger. Table 10 assesses whether we see a difference in the effects of mergers depending on the gap in pre-merger business tax rates between *absorbing* and *absorbed* places.

– Table 10 about here –

When taking the precision of the estimates into account, it turns out that no significant heterogeneity of the merger effects among the *absorbing* places and among the *absorbed* places due to pre-merger business-tax differences is observed. This is further evidence that entropy balancing performs well at balancing the treated and control groups.

Anticipation effects: An important consideration with difference-in-differences treatment effects is the appropriate pre-supposition of the timing of effects. While the phase-specific average treatment effects in Table 5 allude to the question of sluggish adjustment, another concern is the anticipation of effects which might lead to a down-ward bias of the magnitudes of the estimates.

We shed light on this matter by considering a pre-merger placebo timing of treatment by three years in Table 11. We choose a pre-treatment phase of three years as mergers are generally announced between one and three years prior to the actual merger date. Table 11 summarizes the placebo-treatment results for average nigh-light luminosity and its concentration within places. We suppress the results for places devoted mainly to housing, since the respective data are not available for the earlier years of the data. The results in Table 11 indicate some anticipation effects on average night-light luminosity and concentration prior to treatment in *all* and *absorbed* places. We see the effect starting from two years prior to the merger date. No anticipation effect is observed in *absorbing* places.

– Table 11 about here –

7 Conclusion

This paper analyzes how administrative border reforms in general and the relocation of the administrative center in particular affect local activity. To do so, we exploit the large scale municipal merger reforms that took place in Germany after the reunification in 1990. The reforms entail border changes in homogenous socio-economic environments where conventional determinants of economic activity stay constant in space. To allow for the comparison of the same units over time, we track municipalities and their borders annually between 1998 and 2013 and overlay these borders for all years. This results in the universe of the smallest spatial units, which we refer to as *places*. As administrative level data is not available at this fine geographical level, we combine remote-sensing light data and geo-localized land-use data to measure local activity at the place level. We, thereby, overcome the data limitations that previously prevented an empirical analysis of this issue and a causal interpretation of the findings.

In the empirical analysis, we applied a difference-in-differences approach to entropy balanced data (Hainmueller and Xu, 2013) in order to retrieve the causal effect of local border changes on economic activity. The key results of the analysis are the following. First, *absorbing* places, which host the new administrative center, gain in local activity, while *absorbed* places, which lose the administrative center, experience a decline. However, the net effect is positive. Second, the comparison of the gains and losses, as well as the effect of mergers on housing areas, hints at migration within new municipalities from *absorbed* to *absorbing* places, which reflects the wish to be located centrally.

Multiple implications emerge from our analysis. The findings are in line with the notion that redrawing local borders effects a change in the centripetal forces, directing them towards the new administrative center. To the best of our knowledge, this is the first empirical test of these forces. Thereby, the analysis is informative as to whether spatial units lose or gain in terms of economic activity following (local) border changes, an issue that is central to political discussions on border reforms. The expectation of losing economic activity generates political opposition to local border changes in smaller jurisdictions and, as in the German New Länder, might be the prime reason for centrally initiating border reforms in an attempt to increase overall economic activity (as compared to a situation without border changes). Our empirical findings are consistent with this reasoning, and provide an empirical underpinning for such centralized policies. Furthermore, while local (municipal) border changes are frequently analyzed in terms of their fiscal and political consequences, our analysis adds a new dimension to this debate. The overall level and geographic distribution of economic activity are endogenous to border reforms, implying that the consequences might well go beyond the effects suggested in the existing research on municipal mergers. Finally, the role of administrative centers (or the location of administrative infrastructure) has not received much attention in the urban economics literature, wherein, urban areas are found to attract economic activity at the expense of rural areas. Given that administrative infrastructure is typically located in urban areas, the location decision might well provide an additional channel underlining the centripetal forces documented in the literature. Our analysis provides an empirical foundation for the relevance of this channel. Disentangling the role of administrative infrastructure from other agglomeration forces is an interesting agenda that we leave to future research.

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Figure 1: Number of German municipalities over time (1960-2010)

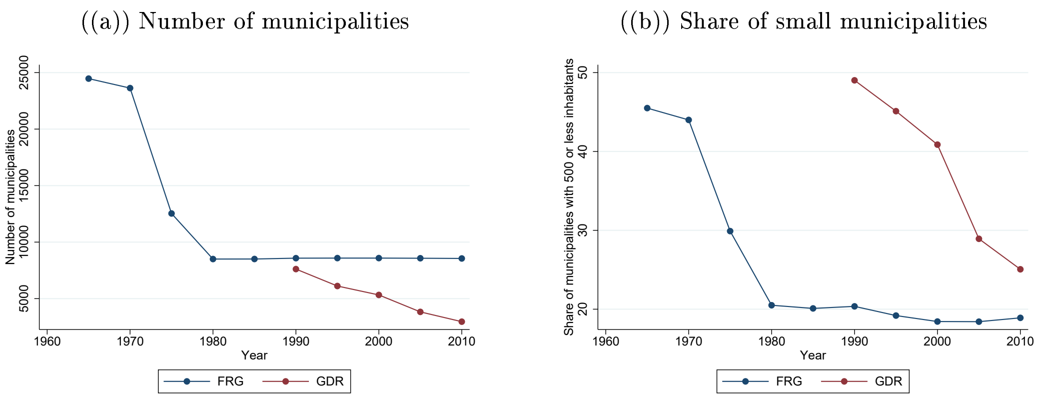


Figure 2: Municipalities and mergers over time

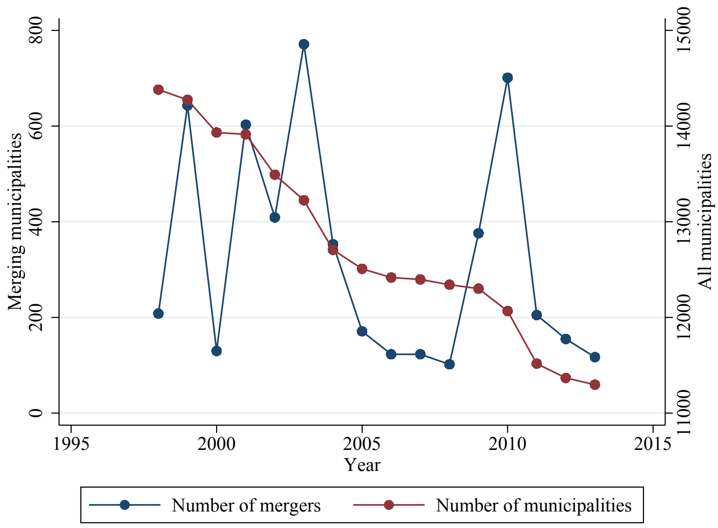
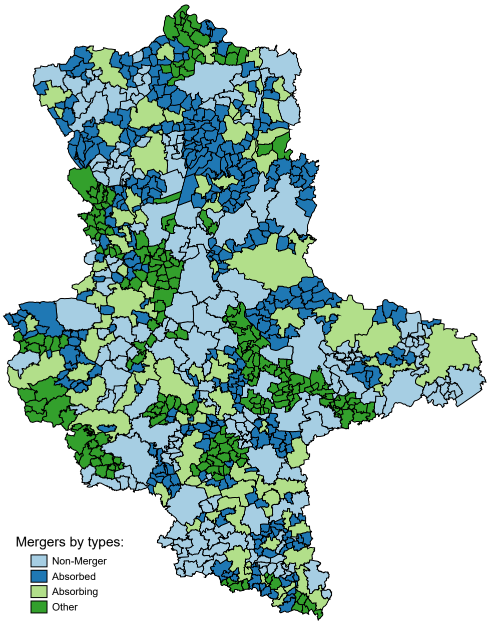


Figure 3: Municipal mergers in Saxony-Anhalt in 2009

((a)) Municipalities by merger types



((b)) Municipalities one year later

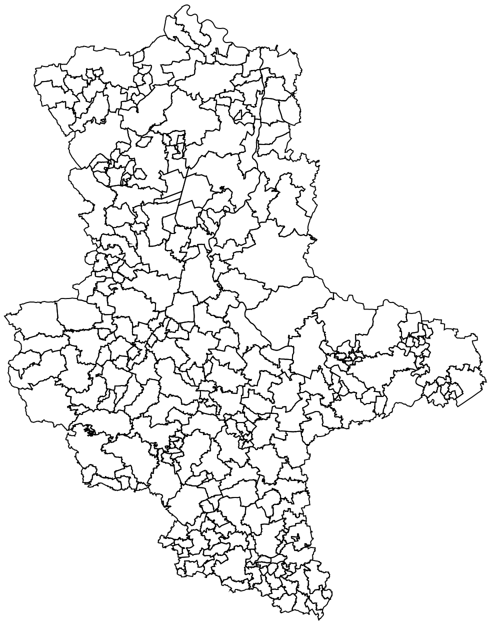


Figure 4: Micro-regions and municipalities around Berlin (2013)

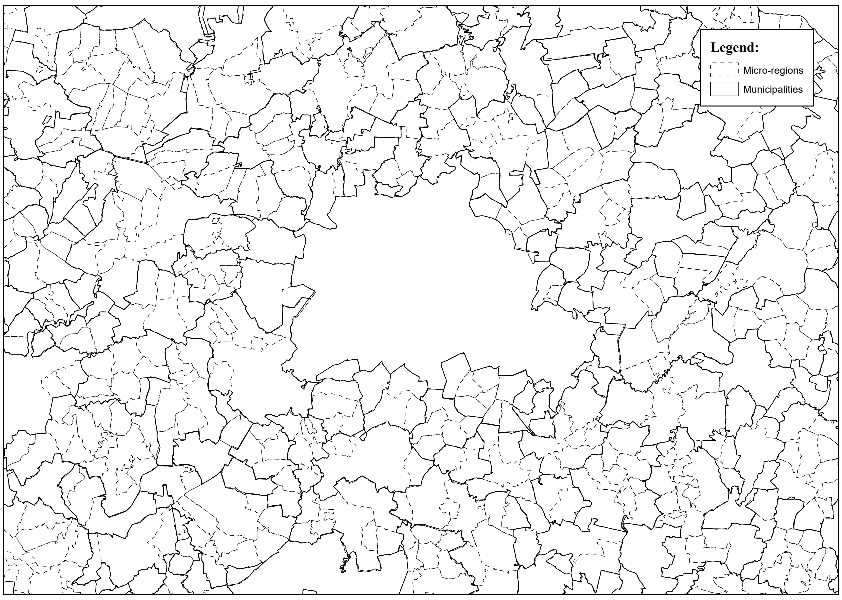


Figure 5: Night-light intensity and local activity (2009-2013)

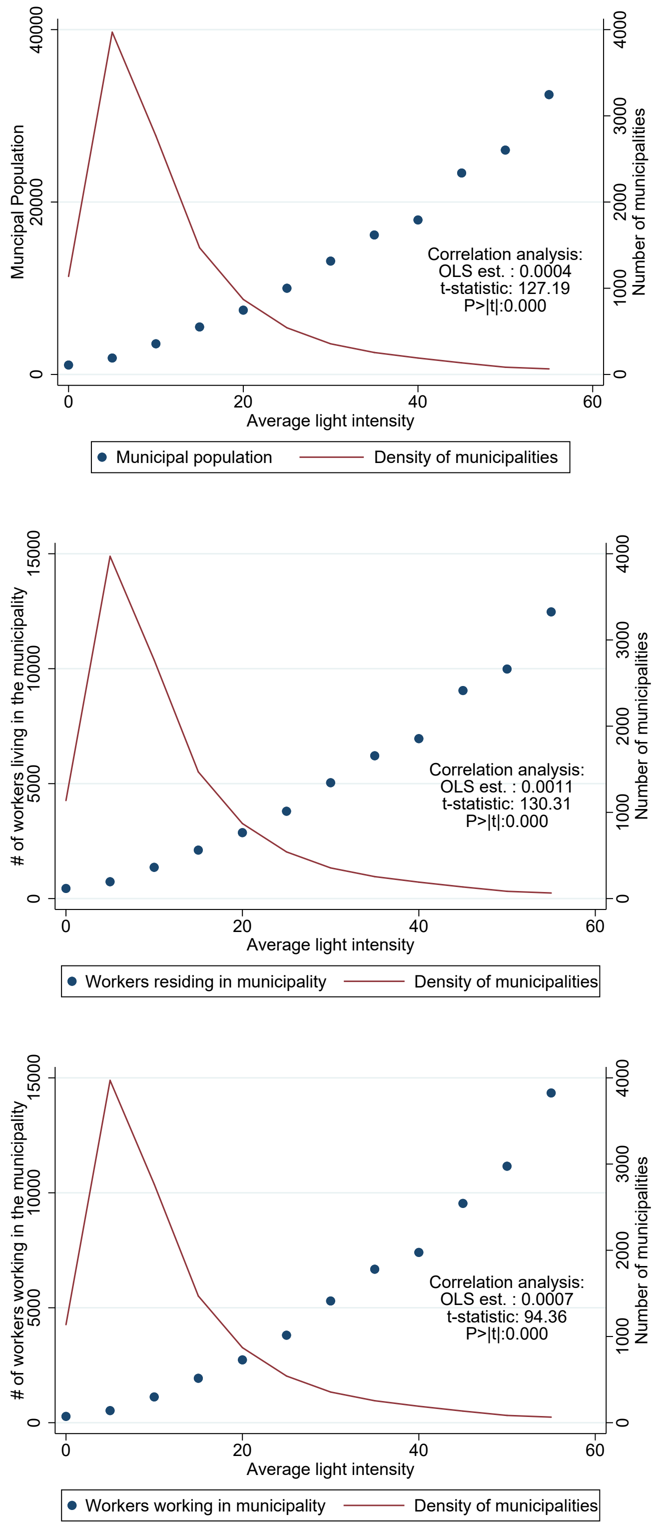


Figure 6: Places and land use around Berlin (2013)

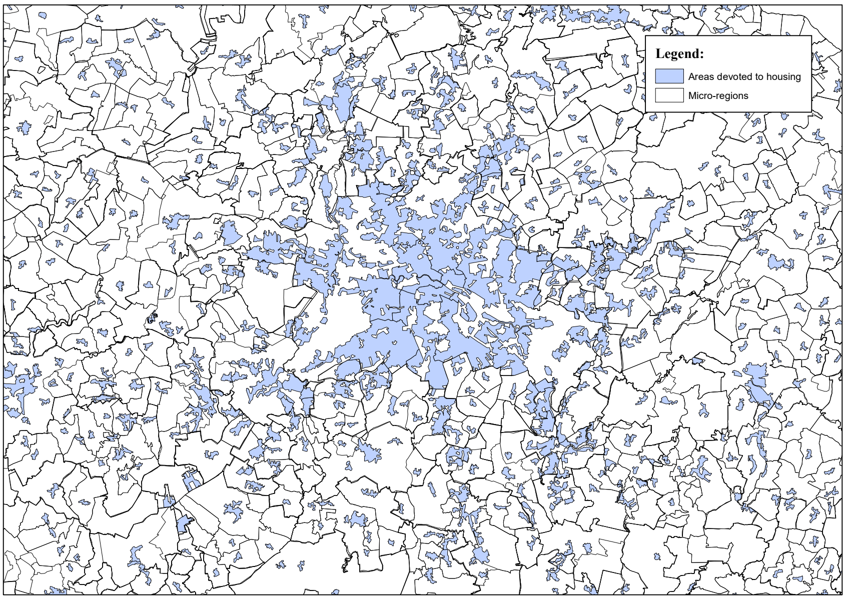


Figure 7: Distribution of light intensity and land use around Berlin (2013)

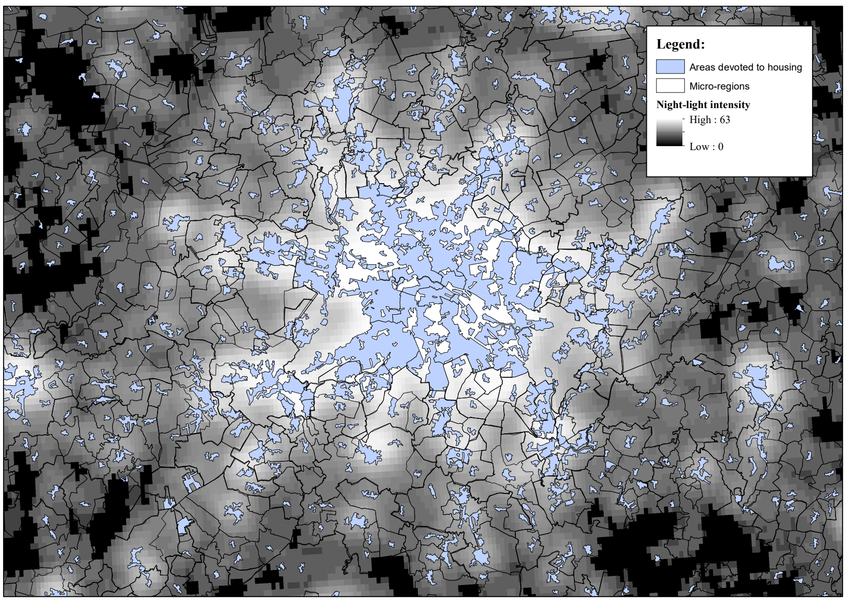


Table 1: Summary statistics: Outcome variables (place level, stacked data, 1998-2013)

		Average	S.d.	Avg. pre-post change
Panel A: Summary statistics by treatment status				
Total	Average night-light (level)	10.99	8.62	1.161633
	Herfindahl index	9.81	29.64	-.0104445
	Avg. night-light from housing	19.76	12.66	1.262658
	obs.	1,289,396		
Control	Average night-light (level)	11.06	8.62	1.134178
	Herfindahl index	8.61	27.94	-.008332
	Avg. night-light from housing	19.82	12.66	1.237114
	obs.	1,256,386		
Treated	Average night-light (level)	8.17	8.02	2.513595
	Herfindahl index	55.51	49.66	-.1144707
	Avg. night-light from housing	15.55	11.41	2.832634
	obs.	33,010		
Panel B: Summary statistics by merger type				
Absorbed	Average night-light (level)	7.78	7.81	3.026821
	Herfindahl index	65.90	47.37	-.2094239
	Avg. night-light from housing	13.45	10.39	3.237948
	obs.	15,674		
Absorbing	Average night-light (level)	11.07	9.15	1.031792
	Herfindahl index	37.65	48.43	.0957395
	Avg. night-light from housing	20.06	12.19	2.704103
	obs.	5,864		

Notes: Averages are reported for all listed variables over the all period, as well as before and after the merger. The year in which the merger takes place is considered as the first post year. Average housing light is only available on the period 2009-2013.

Figure 8: Normalized density of covariates' first and second moments with and without entropy balancing

((a)) First moment ((b)) Second moment

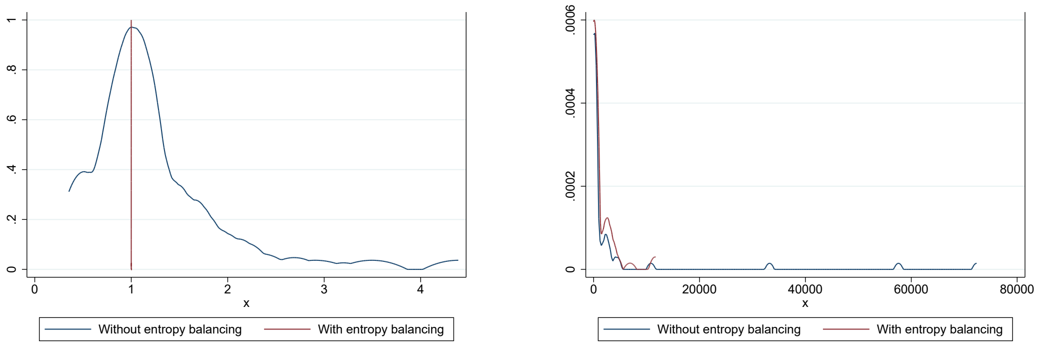


Table 2: Summary statistics of municipal covariates before and after the merger (municipal level, stacked data, 1998-2013)

	Total	Treated	Absorbed		Absorbing	
			Before	After	Before	After
Population	4258.43	6282.01	1203.22	10929.02	6915.32	7547.51
Area	2680.38	8206.90	1918.81	13465.24	4844.97	6515.89
Industry area	18.82	60.24	11.17	114.59	48.94	53.70
Housing area	69.63	112.53	26.50	187.01	105.48	105.62
Agricultural area	1492.69	4770.93	1172.68	7807.45	2775.98	3746.13
Street area	109.59	248.21	56.05	413.82	160.82	210.05
Forest area	777.19	2400.08	511.81	3922.22	1319.64	1865.63
Water bodies area	56.11	195.04	33.65	281.91	127.86	148.89
Pop. female	0.50	0.50	0.49	0.50	0.50	0.50
Pop. over 60yo	0.25	0.27	0.26	0.28	0.28	0.27
Land tax A rate	287.16	269.73	276.99	271.91	260.15	267.88
Land tax B rate	317.99	333.52	328.60	343.12	325.64	336.32
Business tax rate	329.35	318.97	314.44	327.54	321.17	327.33
Unemployment	0.04	0.08	0.09	0.08	0.08	0.08

Notes: Averages are reported for all listed variables. To the place in a particular year, we attributed the municipal data of the municipality in which the place was lying in that particular year.

Figure 9: Pre-treatment trends with and without entropy balancing

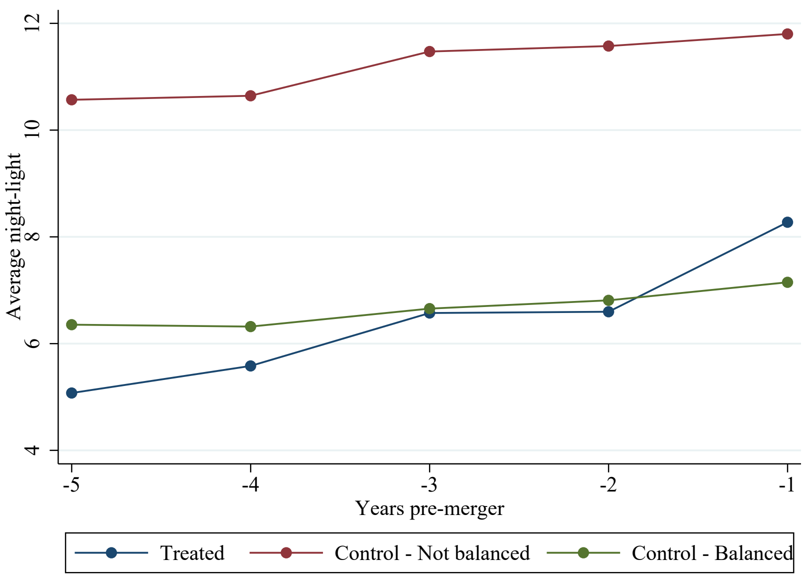


Table 3: Entropy balancing of municipal covariates for all places (1^{st} and 2^{nd} moments)

	Pre-treatment treated group		Pre-treatment control group			
			Unbalanced		Balanced	
	Mean	Variance	Mean	Variance	Mean	Variance
Population	2251	2.59e+07	4539	7.48e+07	2251	2.59e+07
Area	2359	1.00e+07	2555	8093657	2359	1.00e+07
Industry area	17.45	2657	17.21	1762	17.46	2657
Housing area	41.77	7175	71.42	15211	41.78	7176
Agricultural area	1417	3326056	1397	2711161	1417	3326382
Street area	72.73	10548	111.9	18596	72.74	10551
Forest area	627.1	1421697	757.2	1288746	627.1	1421915
Water bodies area	50.8	21621	46.11	12087	50.8	21621
Pop. female	.4967	.0004447	.501	.0007418	.4967	.0004447
Pop. over 60yo	.2613	.002123	.2528	.002921	.2613	.002123
Land tax rate A	274.1	2490	290.7	3012	274.1	2490
Land tax rate B	328	1289	314.3	1819	328	1289
Business tax rate	315.6	1855	333	996.8	315.6	1855
Unemployment	.08447	.001068	.0356	.0004733	.08447	.001068

Notes: We report the first and second moments as these moments are set as the balance constraints for all covariates. The tolerance level is the default value of 0.01.

Table 4: Merger effect on average night luminosity and light concentration

	I	II	III	IV
Outcome	Avg. night-light	Light concentration	Avg. night-light	Light concentration
	MAIN RESULTS		ACCOUNTING FOR LIGHT BLOOMING	
	All places			
Treat	-0.94***	0.03***	-0.85***	0.05***
	(0.18)	(0.00)	(0.18)	(0.00)
Observations	1,154,613	1,154,613	1,154,613	1,154,613
R-squared	0.78	1.00	0.80	1.00
	Absorbed places			
Treat	-0.49**	0.03***	-0.44**	0.06***
	(0.21)	(0.00)	(0.21)	(0.01)
Observations	1,151,826	1,151,826	1,151,826	1,151,826
R-squared	0.77	1.00	0.80	1.00
	Absorbing places			
Treat	1.24***	0.00	0.67**	0.01***
	(0.36)	(0.00)	(0.33)	(0.00)
Observations	1,147,320	1,147,320	1,147,320	1,147,320
R-squared	0.86	1.00	0.87	1.00
Place-phase FE	YES	YES	YES	YES
Year-phase FE	YES	YES	YES	YES
Place cluster	YES	YES	YES	YES

Notes: Satellite controls included.

Table 5: Mergers results by phase

	I	II	III	IV	V	VI	VII	VIII
Year post merger	0	1	2	3	0	1	2	3
	Average night-light				Light concentration			
	All places				All places			
Treat	-2.75***	-1.28***	-1.71***	-1.53***	0.02***	0.04***	0.04***	0.04***
	(0.32)	(0.29)	(0.30)	(0.33)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	602,257	602,749	593,888	585,008	602,257	602,749	593,888	585,008
R-squared	0.79	0.79	0.79	0.78	1.00	1.00	1.00	1.00
	Absorbed places				Absorbed places			
Treat	-1.89***	0.09	-0.75**	-0.96***	0.02***	0.04***	0.04***	0.03***
	(0.28)	(0.33)	(0.33)	(0.34)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	601,680	601,891	593,027	584,142	601,680	601,891	593,027	584,142
R-squared	0.76	0.77	0.77	0.76	1.00	1.00	1.00	1.00
	Absorbing places				Absorbing places			
Treat	0.01	0.01	0.40	0.30	-0.00*	0.01	-0.00	-0.01*
	(0.49)	(0.66)	(0.65)	(0.70)	(0.00)	(0.01)	(0.00)	(0.00)
Observations	600,165	600,180	591,310	582,439	600,165	600,180	591,310	582,439
R-squared	0.84	0.84	0.84	0.84	1.00	1.00	1.00	1.00
Place-phase FE	YES	YES	YES	YES	YES	YES	YES	YES
Year-phase FE	YES	YES	YES	YES	YES	YES	YES	YES
Place cluster	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Satellite controls included.

Table 6: Compulsory mergers

	I	II
Outcome	Avg. night-light	Light concentration
	All places	
Treat	-2.27***	-0.01
	(0.28)	(0.01)
Observations	284,249	284,249
R-squared	0.82	1.00
	Absorbed places	
Treat	-1.87***	-0.00
	(0.24)	(0.01)
Observations	284,163	284,163
R-squared	0.81	1.00
	Absorbing places	
Treat	-6.33***	-0.02***
	(1.54)	(0.01)
Observations	282,433	282,433
R-squared	0.84	1.00
Place-phase FE	YES	YES
Year-phase FE	YES	YES
Place cluster	YES	YES

Notes: Satellite controls included.

Table 7: Merger effects on night-light from housing and housing area

	I	II
Outcome	Avg. night-light from housing	Housing area
	All places	
Treat	-0.17	-0.03***
	(0.81)	(0.00)
Observations	156,865	156,865
R-squared	0.53	0.46
	Absorbed places	
Treat	-0.07	-0.03***
	(1.11)	(0.01)
Observations	156,690	156,690
R-squared	0.53	0.47
	Absorbing places	
Treat	1.93*	0.00
	(1.14)	(0.01)
Observations	156,432	156,432
R-squared	0.53	0.47
Place-phase FE	YES	YES
Year-phase FE	YES	YES
Place cluster	YES	YES

Notes: Satellite controls included.

Table 8: Determination of the location of the post merger center

	I	II
Outcome	Avg. night-light	Light concentration
Panel A: Centroid		
	Places which include the centroid of the post merger municipality	
Treat	0.21	0.00
	(0.25)	(0.00)
Observations	1,149,076	1,149,076
R-squared	0.84	1.00
	Places which do not include the centroid of the post merger municipality	
Treat	-1.04***	0.04***
	(0.22)	(0.00)
Observations	1,153,858	1,153,858
R-squared	0.75	1.00
Panel B: Population		
	Places in most populous municipality pre merger	
Treat	-0.44*	0.02***
	(0.24)	(0.00)
Observations	1,133,212	1,133,212
R-squared	0.82	1.00
	Places in non-most populous municipality pre merger	
Treat	-1.18***	0.03***
	(0.28)	(0.01)
Observations	1,134,295	1,134,295
R-squared	0.78	1.00
Panel C: Area		
	Places in municipality with larger area pre merger	
Treat	-0.49**	0.02***
	(0.25)	(0.00)
Observations	1,133,296	1,133,296
R-squared	0.82	1.00
	Places in municipality with non-larger area pre merger	
Treat	-1.48***	0.03***
	(0.28)	(0.01)
Observations	1,134,211	1,134,211
R-squared	0.78	1.00
Place-phase FE	YES	YES
Year-phase FE	YES	YES
Place cluster	YES	YES

Notes: Satellite controls included.

Table 9: The role of adjacency of absorbing and absorbed merging places

	I	II
Outcome	Avg. night-light	Light concentration
	Absorbed places neighboring an absorbing place	
Treat	-0.38	0.04***
	(0.32)	(0.01)
Observations	1,132,241	1,132,241
R-squared	0.78	1.00
	Absorbed places non-neighboring an absorbing place	
Treat	-3.78***	0.01
	(0.66)	(0.01)
Observations	1,129,453	1,129,453
R-squared	0.81	1.00
	Absorbing place absorbing only neighboring absorbed places	
Treat	0.85**	-0.00**
	(0.42)	(0.00)
Observations	1,126,054	1,126,054
R-squared	0.85	1.00
	Absorbing place absorbing also non-neighbors absorbed places	
Treat	0.82*	-0.00*
	(0.42)	(0.00)
Observations	1,092,774	1,092,774
R-squared	0.85	1.00
Place-phase FE	YES	YES
Year-phase FE	YES	YES
Place cluster	YES	YES

Notes: Satellite controls included.

Table 10: Mergers and taxation

	I	II
Outcome	Avg. night-light	Light concentration
	Absorbed places with a *higher* tax rate than its absorbing partner	
Treat	0.14	0.03***
	(0.44)	(0.01)
Observations	1,130,774	1,130,774
R-squared	0.78	1.00
	Absorbed places with a *lower* tax rate than its absorbing partner	
Treat	0.06	0.03***
	(0.33)	(0.01)
Observations	1,132,073	1,132,073
R-squared	0.77	1.00
	Absorbing places with a *higher* tax rate than the average of its absorbed partners	
Treat	1.14**	-0.00*
	(0.45)	(0.00)
Observations	1,130,154	1,130,154
R-squared	0.86	1.00
	Absorbing places with a *lower* tax rate than the average of its absorbed partners	
Treat	-0.06	-0.02***
	(0.66)	(0.00)
Observations	1,129,463	1,129,463
R-squared	0.85	1.00
Place-phase FE	YES	YES
Year-phase FE	YES	YES
Place cluster	YES	YES

Notes: Satellite controls included.

Table 11: Pre-treatment results

	I	II	III	IV	V	VI
Year pre-treatment	t-1		t-2		t-3	
	ANL	LC	ANL	LC	ANL	LC
	All places					
Treat	-1.97***	0.03***	-1.51***	0.02***	-0.01	-0.00
	(0.33)	(0.01)	(0.29)	(0.01)	(0.23)	(0.00)
Observations	429,958	429,958	420,682	420,682	411,505	411,505
R-squared	0.79	1.00	0.81	1.00	0.81	1.00
	Absorbed places					
Treat	-1.51***	0.02*	-1.15***	0.02*	0.34*	-0.01***
	(0.33)	(0.01)	(0.27)	(0.01)	(0.20)	(0.00)
Observations	429,546	429,546	420,303	420,303	411,135	411,135
R-squared	0.79	1.00	0.80	1.00	0.80	1.00
	Absorbing places					
Treat	0.25	0.00	-0.77*	-0.00	-0.11	-0.01*
	(0.62)	(0.00)	(0.47)	(0.00)	(0.35)	(0.00)
Observations	428,258	428,258	419,068	419,068	409,896	409,896
R-squared	0.83	1.00	0.84	1.00	0.84	1.00
Place-phase FE	YES	YES	YES	YES	YES	YES
Year-phase FE	YES	YES	YES	YES	YES	YES
Place cluster	YES	YES	YES	YES	YES	YES

Notes: Satellite controls included. ANL stands for average night-light and LC for light concentration.