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Measuring and mapping the existence of phantom borders at a local scale: example of Sudetenland in Czechia

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ABSTRACT

This study presents an innovative methodological approach for quantitatively measuring and mapping the existence of phantom borders. Phantom borders are former political borders that have not existed for decades, but their presence is still visible in current socio-geographical differentiation. The visualisations based on spatial statistical analysis of territorially detailed data enables revealing and assessing potential heterogeneous border effects at a local scale. The approach is demonstrated on an example of a phantom border of Sudetenland in Czechia using data for two different phenomena of demographical and social nature. Given the detailed local data, the presented maps assist with interpretation and analytical conclusions. Two main maps show the effect size of the phantom border and its variability in space and time. Four additional maps visualise the results of hot spot analysis and their relationship to the phantom border.

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Phantom borders; border effects; Sudetenland; Czechia; municipal level; hot spot analysis

1. Introduction

It may seem that state borders are no longer important in today's hyperconnected world where capital, goods and people move without many barriers. However, borders in their various forms still matter and have a significant impact on everyday lives. Traditionally, borders were conceived as static institutions intended to protect territory (O´Dowd, 2002). During the past decades, the conceptual understanding of borders has undergone major changes toward a more complex and dynamic view of borders and their various functions (Cooper & Perkins, 2012; Newman, 2006). Borders are conceived as temporal constructs and dynamic institutions, the nature of which may change over time and space (Berg & Ehin, 2006) and which shape space through social and historical processes (Hirschhausen et al., 2019). Historic borders, e. g. former political borders, which have lost their legal status, serve as perfect documentation of these dynamic changes. This study deals with phantom borders, a specific type of historic borders, which still shape reality and are visible in current socio-geographical differentiation in statistics and maps (Hirschhausen et al., 2015, 2019). Phantom borders underlying the current spatial patterns of voting behaviour are a relevant research topic in electoral geography in Central and Eastern Europe (Hirschhausen et al., 2015; Jańczak, 2015; Jelen & Dostál, 2017; Šimon, 2015). Although the effect of phantom borders is often mentioned when interpreting contemporary spatial patterns of various phenomena, empirical evidence demonstrating the significance and persistence of the border effects over longer periods is lacking.

The main aim of this study is to propose and test an innovative methodological approach for quantitatively measuring and mapping the existence of phantom borders. The existence of linear borders and its effects can manifest as an edge when visualising social phenomena in thematic maps. To capture and isolate the effects of phantom borders on socio-geographical differentiation, territorially detailed data is needed. Using local data, we aim to answer the following research questions: Is there a significant effect of phantom borders on current socio-geographic differentiation, i.e. is the existence of a phantom border confirmed? How has the border effect evolved in time depending on the nature of the socio-economic phenomena? Are there any heterogeneous effects of the phantom border in relation to different historical and spatial contexts?

In this study, all mapping and analysis procedures are demonstrated on the historic Czech-German ethnic border in Czechia which serves as a great example of a phantom border (Daněk, 2000; Guzi et al., 2021; Korčák & Netrdová, 2022; Šimon, 2015; Testa, 2021). This border was established almost a century ago in

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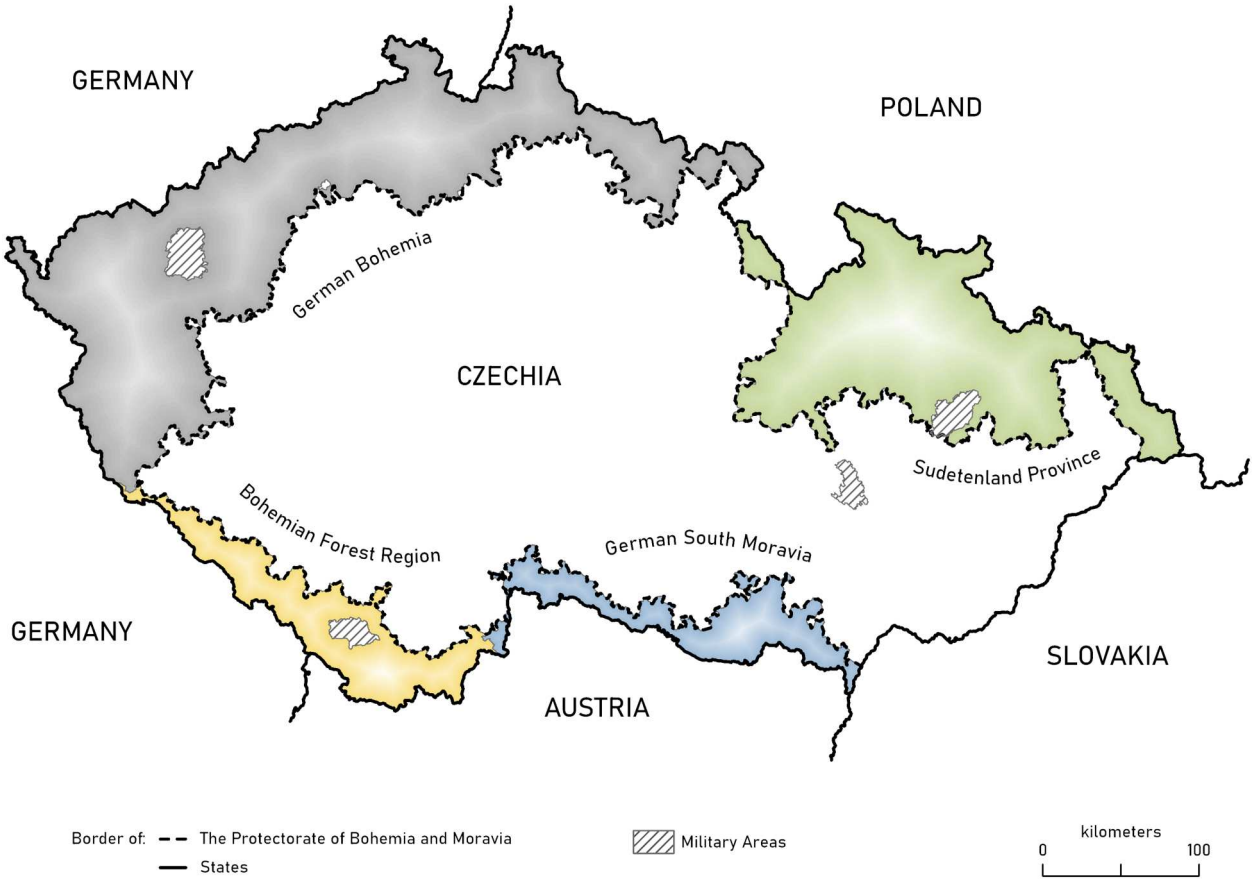

Figure 1. Delimitation of the Czech Sudeten border and its segments.

the era of the Protectorate of Bohemia and Moravia (1939–1945) to demarcate the Sudetenland, four former autonomous historical provinces with a predominantly German-speaking population. Two population shocks, the forced emigration of Czech Germans and the subsequent controlled resettlement, were associated with this border area after the Second World War. In total, some three million Germans were displaced or left the region voluntarily (Houžvička, 2015). These transfers of population completely reconfigured the population of Sudetenland and substantially transformed population structures. With a nearly complete replacement of the population, the long-term cultural and social continuity was interrupted, and a new socio-geographical organisation had to be formed. The previously homogeneous population composition was replaced by a highly heterogeneous society with no shared traditions or values, causing a certain degree of social instability (Guzi et al., 2021; Testa, 2021).

Due to the very detailed spatial level (municipal), we can precisely isolate and assess the effects of the phantom border. This is an important innovative aspect of this research, as historical borders have previously been delimited based on former political districts, different from recent administrative regions, and suitable data for analysis is missing. Moreover, having detailed municipal data at our disposal, we can use GIS and advanced spatial analysis techniques to produce novel results.

2. Data

For quantitative measuring and mapping the existence of phantom borders, detailed spatial and statistical data is needed. Only by focusing on the immediate vicinity of borders can we isolate the effect of phantom borders on socio-geographic differentiation.

The first task is to identify the delimitation of the phantom border in the contemporary regional structure of statistical (administrative) units. The Czech Sudeten border is most commonly delimited according to the prevailing Czech/German nationality based on a 1930 census and corresponds to a former language border (Kučera & Chromý, 2012; Kučera & Kučerová, 2012). However, the result of this approach is not a single continuous border, but a partially discontinuous territory with enclaves and exclaves. In this study, the official historical border of the Protectorate of Bohemia and Moravia (RIGTC, 2020) is fitted into the current municipal structure (6258 municipalities in 2021). The fit is not perfect, as there were some administrative changes in municipal delimitation (especially in the case of large cities), but the differences are only minor, and do not have a significant impact on our research goals. Figure 1 shows

the resulting delimitation of the phantom border under study. However, the Sudetenland region marked out by the border has never been a homogeneous territorial unit due to its perforated shape with an absence of a significant centre (Hampl, 2000; Chromý, 2004). The four autonomous provinces declared by the German ethnic minority in 1918 to protest the creation of Czechoslovakia – German Bohemia, Province Sudetenland, Bohemian Forest region and German South Moravia – illustrate this heterogeneity (Houžvička, 2015). The phantom border is thus further divided according to its historical context into four heterogenous border segments as well (see Figure 1).

The second task involves the operationalisation and quantification of socio-geographical differentiation using indicators available at the municipal level in a long-time series. For this purpose, the population census seems to be a perfect source of data providing comparable indicators with a consistent definition and methodology. Moreover, after a recalculation, data from all population censuses are available in the current municipal structure in 2021 (as a basis for the delimitation of the phantom border). The municipal and other territorial layers were excerpted from the Register of Census Districts and Buildings (CSO, 2022) provided by the Czech Statistical Office.

The choice of indicators for the analysis is based on the theoretical assumption that if the former Sudeten German border has an impact on the current socio-spatial differentiation, this should be most evident in demographic and social structure of population. While changes in age structure are a direct consequence of massive population transfers (displacement and resettlement of the Sudetenland by younger population), changes in social structure are indirect consequences related to transforming regional identity, social stability and human capital. Previous research on the effect of the Sudeten German border as a whole, based on the analysis of a large number of indicators, has shown that this phantom border still has an impact on contemporary socio-geographical differentiation, although its intensity varies (Korčák & Netrdová, 2022). In this study, the effort was to select the most synthetic indicators to describe the demographic (age) and social (education) structure of the population. Therefore, proportions of sub-populations, such as certain age groups or groups by education level, were not used, but aggregate indicators capturing the whole structure were constructed. The demographic structure of the population is described by the mean age calculated within 5-year age groups. The social structure is represented by educational level measured by the mean years of schooling (primary and incomplete education has a weight of 7, secondary education without matriculation 11, secondary education with matriculation 13, and higher education 18). Both indicators are available for five censuses (1980, 1991, 2001, 2011 and 2021) and thus cover a period of forty years (CSO, 2023).

3. Methods

The existence of a phantom border can be demonstrated in several ways. The simplest is via cartographic visualisation through a choropleth map. The border and its effect on socio-geographical differentiation may be partially visible, but hard to interpret. Besides choropleth maps, local clusters can be identified along and across phantom borders based on various local spatial autocorrelation statistics (Anselin, 1995; Spurná, 2008). This approach enables us to detect the spatial patterns more precisely and to assess how the identified hot spots and cold spots correspond with the delimited border.

We have used hot spot analysis quantified by the Getis-Ord G* statistic (Getis & Ord, 1992; Ord & Getis, 1995) with distance-based spatial weights with a 10-kilometre threshold distance. As the choice of criteria for the definition of spatial weights does not significantly affect the final outcome (Netrdová & Nosek, 2020), it should respect the geographical characteristics of the study area. For the territorial structure of Czech municipalities, a threshold distance of 10 kilometres appears to be the most appropriate, based on statistical robustness analysis using different spatial weights (Blažek & Netrdová, 2009). A randomisation procedure was used to assess the significance of the Getis-Ord G* statistic against a null hypothesis of no spatial autocorrelation. The results of the hot spot analysis for both phenomena under study are visualised in four additional maps. These visualisations demonstrate the effect of a phantom border on socio-geographic differentiation, including its tendencies over time and heterogeneity in space. Although the border effect is now more apparent, the effect size remains vague, and without its quantification the interpretation is difficult.

The proposed methodological approach for quantitatively measuring and mapping the existence of phantom borders is based on a descriptive and inferential statistical analysis of the phenomena under study on both sides of the phantom border. To detect the impact of the phantom border on socio-economic differentiation, it is necessary to define the phantom borderland where the possible border effect should be observable. The approach we found suitable was to define several buffer zones along the border in both directions to measure whether the effect of the phantom border diminishes in space. The bandwidth of each buffer zone depends on the regional structure and the area of regional units used for the delimitation of the border. For analysis purposes, additional buffer

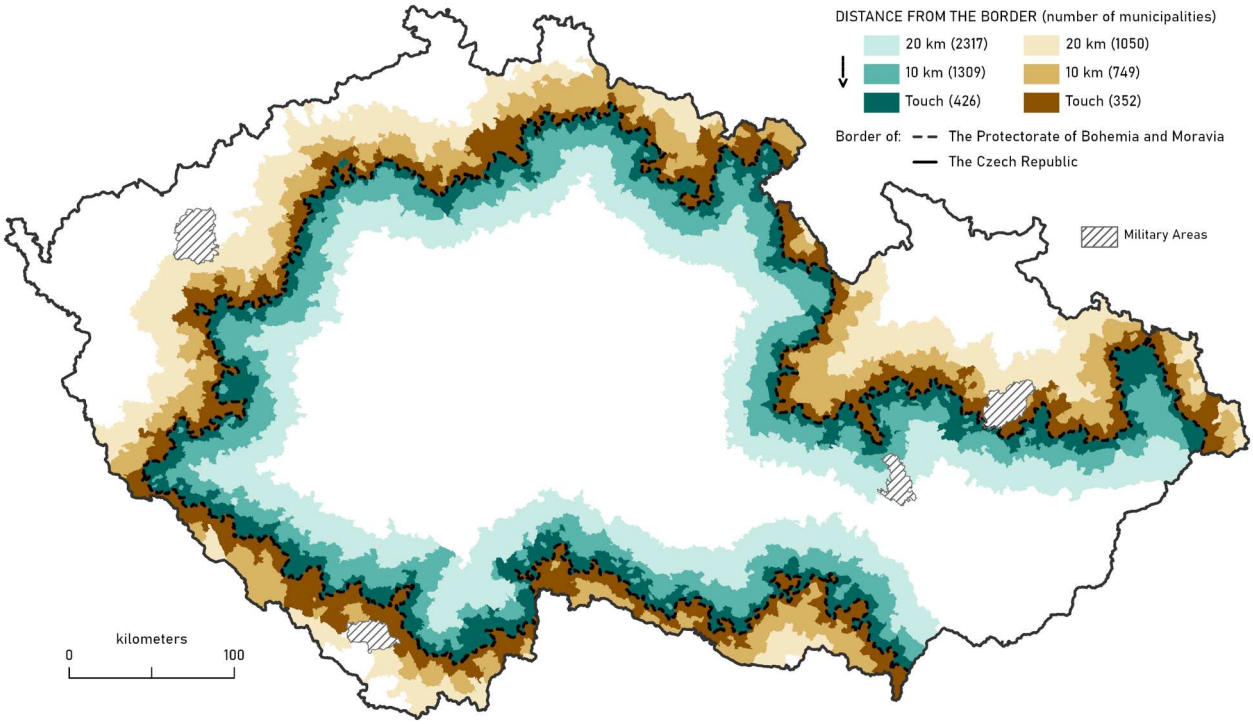

Figure 2. Buffer zones along the Czech Sudeten phantom border.

zones are created cumulatively by adding more municipalities to previous ones. In our case, three buffer zones are delimited based on a distance from the border of 0 (only municipalities that touch the phantom border), 10 and 20 kilometres (all municipalities within 10 or 20 kilometres of the phantom border). The delimited buffer zones are shown in Figure 2.

The possible border effect can be quantitatively measured and tested by an independent samples t-test comparing the differences between the mean values of the studied phenomena in the defined buffer zones on both sides of the border. In our case, the closest buffer zone, which includes municipalities directly adjacent to the border, contains a total of 426 municipalities in the inland and 352 municipalities in the Sudetenland. Out of a total of 6258 municipalities, this is a sample on which it makes sense to apply both descriptive and inferential parametric statistical procedures. While an independent samples t-test determines the statistical significance of the differences in mean values on both sides of the border, the substantive relevance can be revealed by measuring the effect size using Cohen's d (Cohen, 1988). Conducting the same analysis in each buffer zone allows us to identify the inherent border effect and its possible amplification with increasing distance from the Sudeten German border in either direction.

The disadvantage of this statistical analysis is that the results in the form of a single number quantify the average border effect along the whole border which may hide potential spatial variations (Fotheringham et al., 2000). The existence of heterogeneous effects is confirmed by hot spot analysis, which indicates the need of further detailed investigation. The simplest way is to divide the phantom border into discrete segments and perform the analysis separately in these segments. This discrete approach is reasonable in the case of a priori assumptions about the existence of border segments, grounded in theory, as is in our case involving the four German provinces (see Figure 1). The main maps show the visualisation of the change in the size effect of border through individual bar charts for each border segment.

In addition, the heterogeneous effects can be examined in space continuously without the division into segments a priori. In this continuous approach, the phantom boundary is divided into points and a statistical analysis is computed for each point based on data from its neighbourhood. The decision on the number of points, spatial lag between them, and the definition of neighbourhood depends on the regional structure under study and the assumption of a certain minimum number of units for performing an inferential statistical analysis. Based on the median size of a Czech municipality (eight square kilometres) and the requirement for a minimum of 15 units in the sample for a two-sample t-test, the neighbourhood should be 50 kilometres along the border and up to 25 kilometres from the border in our case. The use of a smaller neighbourhood would result in greater statistical error, while the use of a larger neighbourhood would hide possible local variation in differences. The neighbourhoods should overlap by half to ensure continuity and reveal possible local variations, corresponding to the location of points along the border at a distance of 25 kilometres. Therefore, in our case, 121 points

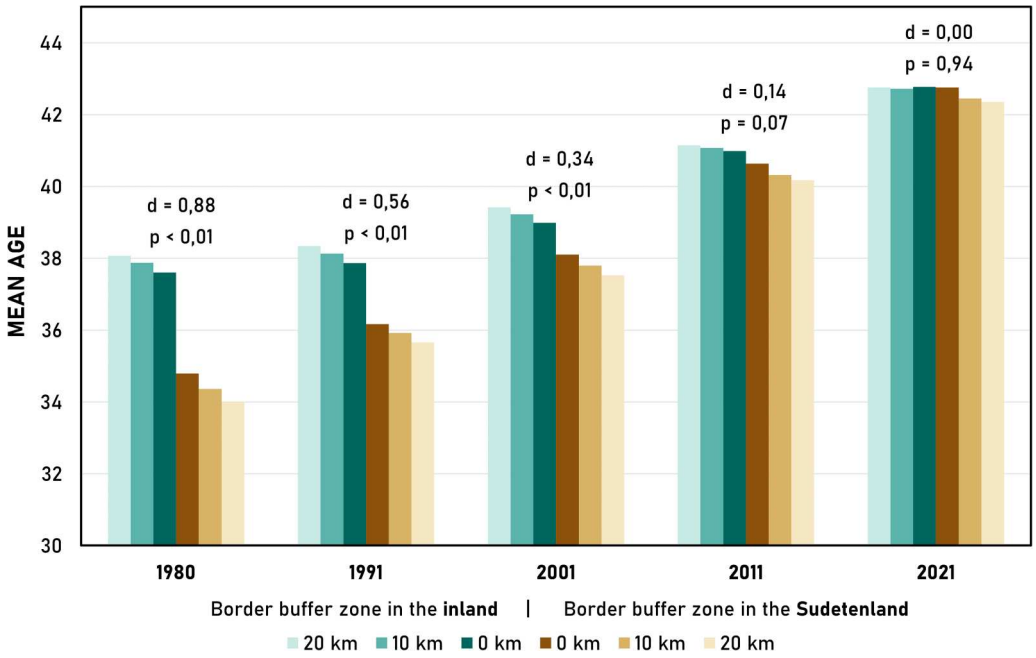

Figure 3. Differences between mean age in the border buffer zones.

with spatial lag of 25 kilometres were used and their neighbourhood was defined based on Euclidean distance with threshold of 25 kilometres. The main maps show the visualisation of the size of the border effect by the border thickness, categorised according to values of Cohen's d into four intervals (Cohen, 1988): none (<0.2), weak (<0,5), medium (<0,8) and strong (≥0,8).

4. Results

The studied phantom border, the historic border of the Protectorate of Bohemia and Moravia, witnessed extensive historical changes in the distribution of population in Czechia in the twentieth century (Topinka, 2005). With the expulsion of the Germans and the resettlement of a predominantly young population, the demographic structure of the Sudetenland changed almost immediately. This can be documented by the results of the mean age (see Figure 3). The absolute value of Cohen's d is at its maximum in 1980 (0.88), indicating large differences between the two buffer zones and thus a large border effect. Over the years, the demographic differences have diminished, and the effect of the border has gradually shrunken. This is also apparent from the age pyramids related to censuses held in 1980 and 2021 that serve as a supplement to the presented maps.

The heterogeneity of the phantom border according to mean age is shown in the main maps. The fading tendency of the border effect is visible almost throughout the whole border length, but the range of the Cohen's d values substantially differs among the four segments. A significant gap is apparent especially in the first two censuses in analysis, when the border effect along former Bohemian Forest region is almost twofold compared to two northern border segments. A more detailed interpretation of the results can be seen in the continuous approach which brings evidence of some more recent processes that influenced the demographic structure. For instance, a probable explanation for the relatively high values of Cohen's d in 1980 along the Bohemian Forest region is its direct adjacency to a typical inner periphery characteristic of population ageing (Perlín et al., 2010). Another example is the suburbanisation process that could have weakened the border effect in the area north of Prague.

The expulsion of Czech Germans after 1945 and the subsequent resettlement of borderland is a potentially important factor also in the current socio-economic situation and development (Bernard, 2012; Korčák & Netrdová, 2022; Testa, 2021). The extensive displacement process broke the bonds between local residents and territory, reshaping the social structure of population in Sudetenland. Hence, the results for the social indicator showing the mean years of schooling display an opposite trend than the demographic indicator (see Figure 4). The newly established social structures in the borderlands are cumulatively reproduced through the spatial pattern of educational level, and the socio-economic differences between the populations on either side of the phantom border continue to widen.

The discrete approach of average school attendance confirms the stagnating or growing effect of the phantom border along all four former German provinces (see main maps). As in the case of mean age, there are considerable discrepancies in the values of Cohen's d in time according to a particular border segment. The social scissors opened up most in the

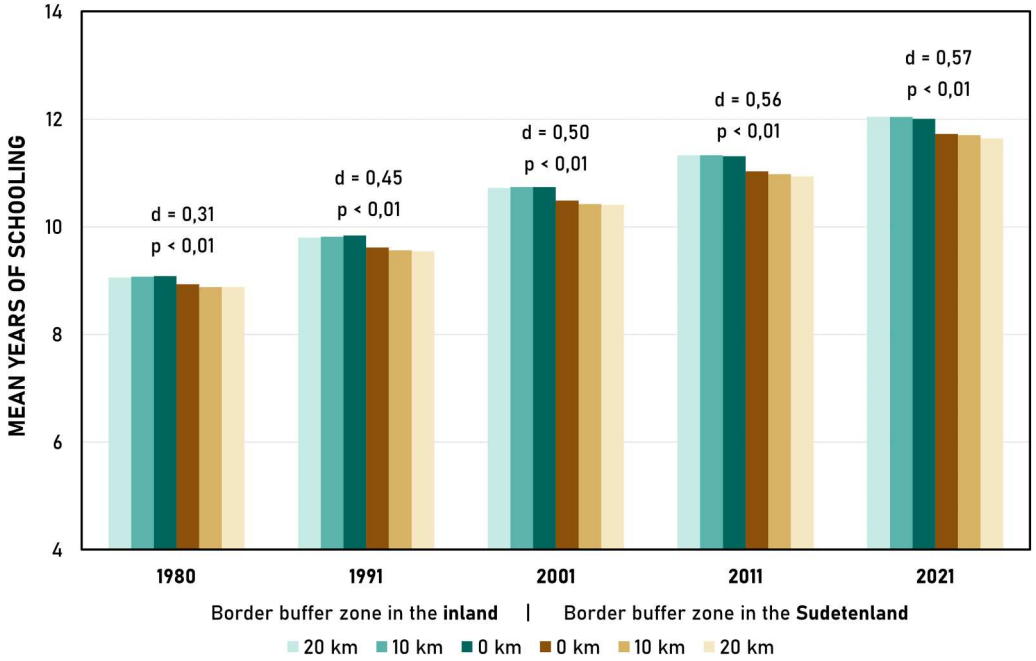

Figure 4. Differences between mean years of schooling in the border buffer zones.

former Bohemian Forest region during the period under review, while in the two northern segments the phantom border was already visible in the 1980s, so growth there was not as strong. If we assess the results with the continuous approach to measuring border effects, the polarisation between urban and rural regions as a key factor comes to the surface.

Results for both characteristics confirm the existence of phantom border. However, the significance and evolution in time are different. Demographic differences are shrinking, which indicates a process of homogenisation. On the contrary, social differences are persistent in time or even increase in size. Moreover, spatial heterogenous effects among the four border segments were identified in line with the theoretical assumptions considering their distinct historical and spatial context.

5. Conclusions

The proposed methodological approach for quantitative measuring and mapping the existence of phantom borders enables us to evaluate their importance and significance as a factor influencing socio-geographical differentiation. While visualisations and spatial hot spot analysis reveal spatial heterogeneity and local border effects that may significantly vary across space, statistical analysis provides global results that generalise the overall border effect in the studied area. It is the combination of these approaches that provides new insights and understanding of the effects observed. By carrying out the analysis with spatially detailed data while comparing differences between neighbouring territorial units on both sides of the studied phantom border, the possible effect of other factors is minimised. This allows for the importance and significance of the border effect to be quantified. The benefits of the proposed approach can be documented on the example of phantom border in Czechia where new innovative conclusions can be drawn.

First, the existence of a phantom border was confirmed by both a demographic and a social indicator. The significant effect of borders on socio-geographic differentiation was identified for each year. At the beginning of this period, the phantom border was manifested in the demographic structure of the population, nowadays it is primarily formed by social differences. While changes in demographic structure in Sudetenland can be seen as a direct consequence of political decisions and institutional changes, changes in social structure are indirect.

Second, the importance of the phantom border is changing over time. While the demographic indicator tends to homogenise in the two border zones divided by the phantom border, the social indicator tends to differentiate with the negative values concentrating in Sudetenland. Thus, both processes of disappearance (demographic structure) and reproduction (social structure) of phantom borders are documented and quantified. In general, the demographic heterogeneity was gradually replaced by socio-economic heterogeneity. Unfortunately, no methodologically comparable census data is available since the actual act of expulsion of the Germans, so it is not possible to show the development during the whole period of the establishment of the new socio-geographical organisation in the Sudetenland. Nevertheless, the results correspond with other case studies dealing with impact of the expulsion of Germans and following resettlement of borderlands (Guzi et al., 2021; Testa, 2021).

Third, heterogeneous effects of the phantom border due to different historical and spatial contexts were identified. On the one hand, the continuous view of the phantom border helps reveal additional spatially contingent processes that affect socio-geographic differentiation, such as current migration flows, ongoing globalisation of commodity flows or some important economic and political developments triggered by European Union programmes. The advantage of this approach is the ability to identify various segments in terms of the uneven effect size of the phantom border. On the other hand, the discrete approach allows us to compare the border effect in a priori delimited segments and thus confirm some theoretical assumptions based on distinct historical or spatial context. In addition, the significance of phantom border can be evaluated within the current administrative structure, therefore bringing important new policy implications.

The phantom border usually hinders regional development in its surroundings and the success of the process of its deinstitutionalisation (Zimmerbauer & Paasi, 2013) is dependent on its disappearance from regional consciousness. Although this cannot be measured by the presented results based on a deep quantitative analysis, our findings are a crucial first step in broader research focusing on how people actually perceive the detected phantom border. The quantitative results provide us with new hypotheses that can be tested in follow-up qualitative research. At the same time, any such study should bear in mind that an ill-considered emphasis on the existence of the border could inadvertently contribute to its entrenchment in the regional consciousness and thus produce some possible opposite effects to those originally intended. However, the precise identification and quantification of the phantom border issue through the proposed innovative methodological approach is essential for the right regional policy setting.

Software

Data preparation and statistical analyses were done using SPSS 28. Spatial analyses and cartographic visualisations including design of final map layout were performed in ArcGIS Pro 3.2.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data are openly accessible at https://doi.org/10.17605/OSF.IO/WDMUE.

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