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Regional Economic Development Along the Polish-German Border: 1992-2012

In this brief, we summarize the results of a recent analysis focused on the regional economic development in Poland and Germany along the Oder-Neisse border (Freier, Myck and Najsztub 2021a). Economic activity is approximated by satellite night-time light intensity, a comparable proxy available for regions on both sides of the frontier consistently between 1992 and 2012. This period covers the time of economic transformation and the first eight years of Poland's membership in the European Union. We find that convergence in overall activity across the border has been complete: Polish municipalities that used to be economically much weaker have caught up with those on the German side of the Oder and the Neisse rivers.

The question of the harmonious development of economic activity is at the heart of the European integration project (Art. 2, Treaty of Rome, 1957), and the Maastricht Treaty (1992) made economic convergence between member states an explicit objective. In a forthcoming paper (Freier et al. 2021), we take a new approach to the question of regional European integration.

This brief derives from a recent publication in Applied Economics (Freier et al. 2021a), in which we examine the degree of regional economic convergence along the German-Polish border by taking advantage of satellite night-time illumination data covering the period between 1992 and 2012. The data allows us to study detailed regional patterns of economic development along the river-delimited part of the frontier and further inland.

The seminal work by Henderson et al. (2012) was the first to use night-time light intensity data which covers the entire globe to measure economic activity. Unlike traditional regional economic indicators, light intensity data is independent of administrative border reforms and has been collected in a consistent format over the studied two decades.

Our analysis suggests that, over the analysed period from 1992-2012, there has been essentially full convergence in economic activity between municipalities on both sides of the Polish-German border. While the average value of night-time illumination in our selected group of municipalities in 1992 was 3.7 (on a scale between 0 and 63) in Poland and 7.7 in Germany, the respective values were 9.0 and 9.7 by 2012, and the latter difference is not statistically significant. This convergence suggests a much stronger rate of growth in economic activity on the Polish side of the border. Additionally, we show that within Germany, the distance to the border has much less relevance for economic activity compared to Poland, where it reflects interesting trends. In 1992, Polish towns farther from the border showed significantly higher economic performance. Within Poland, this gap has been greatly reduced

over the 20 years we analyse, with regions closer to the border growing much faster compared to those farther away.

Night Lights Along the Polish-German Border

In our dataset, we include municipalities that are located within 100 km from the river delimited part of the PL-DE border. To avoid the sensitivity of the analysis to top censoring of the night-time light intensity data, we removed regional capital cities: Berlin (with surrounding municipalities), Dresden, Gorzów Wielkopolski, and Zielona Góra. This leaves us with 488 municipalities on the German side of the border and 193 municipalities on the Polish side.

The night lights data series, provided by the National Oceanic and Atmospheric Association (NOAA), starts as early as 1992 and continues in a consistent, comparable format to 2012. The data is independent of the administrative structures of local governments, which over time have changed on both sides of the border. This allows us to aggregate the night-time lights information for municipalities using the most recent available administrative borders. This data is essentially the only source of information on economic activity that is consistently available and comparable on both sides of the border over such a long period of time.

The night-time lights data has been applied widely as a proxy of economic development on the country and regional level (Henderson et al., 2012; Bickenbach et al., 2016). Clearly, the intensity of night-time lights does not capture the entire spectrum of economic activity. It has been pointed out that the relationship between night-time light intensity and conventional measures of economic development, such as GDP, is likely to differ depending on a region's stage of economic development (Hu and Yao, 2019). However, we focus on mostly rural and sparsely populated areas (where there is little risk of top censoring of the data), and compare dynamics between regions

that are similar in terms of their stage of economic development, geography, and weather. All these factors support the use of night lights as a proxy for regional development in our application (a number of technical steps are necessary to validate and calibrate the data for use in our analysis, see: Freier et al. 2021).

Economic Convergence Along the PL-DE Border

To understand the overall development of economic activity over the period of interest, we map the changes in the night-time light intensity in Figure 1.

Figure 1. Night lights: changes in light intensity between 1992 – 2012 along the Polish-German border
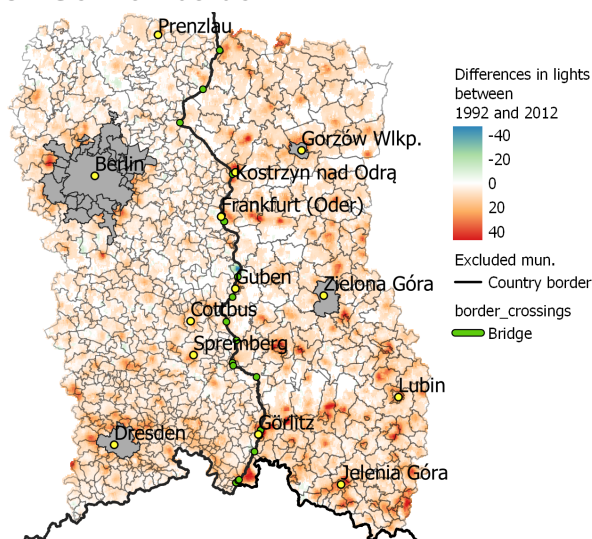
Notes: municipalities along the PL-DE river border up to 100 km to the border; municipalities marked in grey treated as outliers and excluded from analysis due to high proportion of top-coded lights pixels in 1992; municipality borders as of 2013 (DE) and 2012 (PL).
Source: GeoBasis-DE / BKG 2013, PRG 2012, DMSP OLS v4, OpenStreetMap, own calculations. For details see Freier et al. (2021).

The colour scale on the map represents differences in light emissions between 1992 and 2012, with the range going from -40 to 40. A negative value indicates a reduction, and a positive value highlights an increase in light intensity. The negative values have been coloured in a blue-green scale (-40 to 0), while positive values in a red scale (0 to +40).

As notable in Figure 1, the red areas are predominant. This exemplifies that between 1992 and 2012, nearly all municipalities in this area witnessed positive economic development as manifested in the intensity of night-time lights. We have a few areas that reflect negative dynamics on the German side of the border. This is mainly due to the regional implications of shutting down activity in agriculture and traditional industries as they were unable to compete with West-German technology and productivity. In Poland, green-blue areas are essentially non-existent, illustrating a universally positive economic development over the studied period. This difference in the pace of changes in light intensity between the German and the Polish side reflects a process of rapid convergence of economic development between municipalities on both sides of the border. These developments are represented in Figure 2 which shows the difference between the night-time light intensity in Germany and Poland by year and provides a test for its statistical significance. The estimation is done on mean log pixel values per municipality and clearly highlights the steep path of convergence. In the early nineties, the difference in mean light intensity was around 100 percent - i.e., the mean difference was as high as the mean level of lights on the Polish side of the border. Already ten years later it reduced to around 50 percent and disappeared by the end of the analysed period. It is notable that, after an initial steep convergence, the difference in light intensity had a period of stagnation between 2002 and 2008. Interestingly, the full convergence which followed coincides with Poland's entry into the Schengen agreement in December 2007. As seen in Figure 2, the difference in the average night-time light intensity between Poland and Germany was statistically insignificant and essentially zero since 2009.

Figure 2. *Difference in mean night-time lights between Germany and Poland over time*
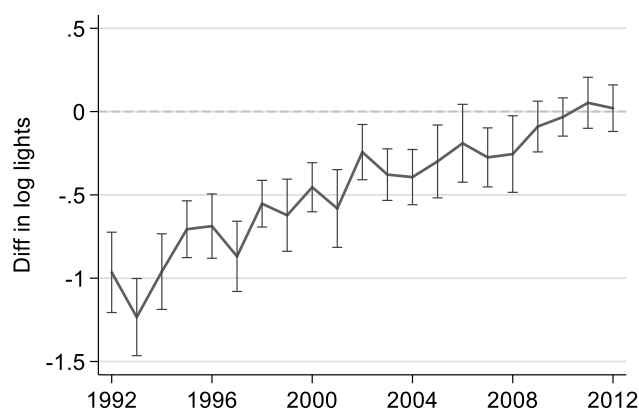
Notes: Difference in log of average pixel values per municipality; year fixed effects included, weighted by municipality area; 95% CI.
Source: see Figure 1.

Regional Development and Distance from the Border

Thanks to its high degree of geographical precision, the night-time lights data allows us to study the detailed spatial patterns within each country and, in particular, the relationship between distance to the border and economic activity. This is done by looking across the years 1992 to 2012 and examining three-year windows at each end of the analysed period. Our results, which are reported in Table 1, confirm a strong positive relationship between economic activity and distance to the border on the Polish side of the Oder-Neisse rivers. Overall, Polish regions farther from the border show a greater degree of economic activity, but this relationship has substantially diminished over time. While in Germany, economic activity was higher in regions farther from the border and increasing at the average rate of about 0.3% per km, this rate was about three times higher in Poland, falling from about 1.2% per km in 1992-94 to 0.6% in 2010-2012.

Table 1. *Total night-time lights along the Polish-German border, 1992-2012*

	(Log) total lights:		
	1992-2012	1992-1994	2010-2012
DE * distance to border	0.00296*	0.00223	0.00190
	(2.17)	(1.42)	(1.56)
PL * distance to border	0.00863**	0.0121**	0.00617**
	(3.04)	(3.17)	(3.21)
Constant	1.640***	1.674***	2.471***
	(20.75)	(19.56)	(42.22)
N	13499	1917	1944
R-squared	0.120	0.123	0.105

Notes: Notes: municipalities along the PL-DE river border up to 100 km to the border; municipality borders as of 2013 (DE) and 2012 (PL); mean municipal total lights calculated using average pixel values per municipality and weighted by municipality area. Standard errors in parentheses, statistical significance: $^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$.
Source: see Figure 1.

Table 2 reports changes in light intensity between the beginning and the end of a specific period. Here, we find some interesting and perhaps disconcerting results on the relationship between the distance to the border and changes in light intensity. While the distance-to-border coefficient in the Polish case for the full period is negative, suggesting that regions closer to the border were catching up to the more developed regions farther away, the corresponding coefficient for the final three years is positive. This means that, in the years 2010-2012, economic development was faster in municipalities farther away from the border. Although the relationship is not very strong (the change in light intensity grows by about 0.1% per kilometre of distance to the border), it still suggests a reversal in the fortunes of municipalities close to the border on the Polish side. This result points towards the fact that homogeneity of development cannot be taken for granted and that physical distance might continue to play a role in determining the regional rate of growth in the future.

Table 2. *Changes in night-time lights along the Polish-German border: 1992-2012*

	Change in (log) total lights:		
	1992-2012	1992-1994	2010-2012
DE * distance to border	0.00157[+] (1.68)	0.00161[*] (2.37)	0.00085[+] (1.73)
PL * distance to border	-0.00672[**] (-2.60)	-0.00183 (-1.53)	0.00099[+] (1.73)
Constant	0.348[***] (7.29)	-0.0676[+] (-1.78)	-0.436[***] (-15.24)
N	639	637	650
R-squared	0.228	0.0170	0.0142

Notes: Notes: municipalities along the PL-DE river border up to 100 km to the border; municipality borders as of 2013 (DE) and 2012 (PL); mean municipal total lights calculated using average pixel values per municipality and weighted by municipality area. Standard errors in parentheses, statistical significance: [+] $p < 0.10$, [*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$.
Source: see Figure 1.

Conclusion

In this brief, we report results from a forthcoming paper (Freier et al. 2021) in which we evaluate regional development in municipalities on the German and Polish side of the Oder-Neisse border between 1992 and 2012, using night lights data as a proxy for economic activity. We find that driven by rapid growth in Polish municipalities and somewhat sluggish growth in German ones, the light intensity levels across the Oder-Neisse border show no significant differences by the end of our observation period. This is despite significant initial differences just 20 years earlier and the fact that municipalities on the German side also experienced increases in economic activity. In as far as economic development can be proxied by the intensity of night-time illumination, it seems that economic convergence between regions on both sides of the border was complete by 2012.

We also show interesting patterns regarding the relationship between economic activity and distance from the border. For Germany, this relationship is weakly positive and remains stable throughout the analysed period. In Poland, distance is strongly and positively correlated with light emissions at the beginning of the period, hence indicating that municipalities farther from the border show higher average economic activity. By 2012, however, the border regions have closed most of the gap and the distance to the border is a substantially weaker predictor of economic activity, suggesting a much more homogenous pattern of activity.

Acknowledgements

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