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Abstract

We examine how highway accessibility influences local employment outcomes. We exploit the stagewise expansion of the "Baltic Sea highway", the largest contiguous highway construction project in Germany since 1945. Results from difference-in-differences estimations and an event study approach show that highway access influences local employment outcomes in peripheral municipalities within 10 km road distance. Improved accessibility decreases employment by 9%. These effects are driven by reduced commuter flows within the periphery, while we find opposing effects on core municipalities. Improved accessibility also gives rise to a shift of population and economic activity from the periphery to the core, weakening the periphery as a place of work.

JEL code: H54, H71, O18

Keywords: Highway, infrastructure, accessibility, commuting, employment, municipalities, local governments

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1 Introduction

New infrastructure projects are often viewed as catalysts for regional economic growth. However, there is an ambiguity of new transportation infrastructure known as the "two way roads problem" (Cheshire *et al.*, 2014). On the one hand, infrastructure acts as an agglomeration force because it improves a region's access *to* other regions. This taps additional market potential as (new) markets become accessible at reduced cost (Donaldson, 2018). On the other hand, investment in infrastructure triggers deagglomeration forces. Reachability of a region *from* other regions is broadened, increasing competitive pressure. Against this background, individuals or firms might react to changing local economic conditions and adapt their employment choices. We examine how highway access influences local employment and commuting outcomes in core and peripheral regions in Germany.

The theoretical prediction that market access plays a major role in explaining the spatial distribution of economic activity has been widely established by the new economic geography literature (see e.g., Davis and Weinstein, 2002; Hanson, 1996; Krugman, 1991). While empirical contributions have shown that extensions of the transportation network are generally beneficial for the average region, recent work - especially in the context of developing countries - identified differential effects within the "regional hierarchy" (Baum-Snow *et al.*, 2020). We contribute to this literature by investigating how infrastructure shapes the regional distribution of economic activity along the lines of a core-periphery model. More specifically, we focus on changes in employment locations and commuting patterns, two outcomes that have received relatively little attention in the study of transport-induced effects so far. To test the relationship between these variables and market access empirically, we exploit a particularly fast and extensive expansion of the East German highway network in the aftermath of reunification. As a proxy for municipalities' market access, we use road-distance measures to the next highway access point.

Many studies examine how infrastructure development affects economic outcomes. Large infrastructure investments in developing countries such as China or India offer a widely-used testing ground for these questions. Evidence on the overall positive effect of transportation infrastructure on regional[1] economic development (Ahlfeldt and Feddersen, 2018; Banerjee *et al.*, 2012; Donaldson and Hornbeck, 2016; Hornung, 2015), however, has been complemented by findings that confirm substantial heterogeneity at the local level (Berger and Enflo, 2017; Chandra and Thompson, 2000; Faber, 2014). In China, better regional highways increase production and population in "regional primates" at the expense of peripheral areas (Baum-Snow *et al.*, 2020). Highways have also distributional consequences. For Switzerland,

[1] At the firm level, studies show that new transportation infrastructure influences production optimization (Datta, 2012) as well as, ultimately, productivity (Gibbons *et al.*, 2019; Holl, 2016; Wan and Zhang, 2018).

Fretz *et al.* (2021) show that in non-urban municipalities, the advent of a highway access point within 10 km increases the share of top-income taxpayers.

Previous work shows that improved accessibility can have spatially ambiguous effects on employment (Fujita *et al.*, 2001; Krugman, 1991). Improved access *to* other regions taps new market potential and attracts new business activity and new residents (market potential or agglomeration effect). In the context of new economic geography models, high transportation costs are equivalent to tariffs and protect local producers from trade competition. As transportation costs decline, inter-regional competition increases. When consumers substitute locally produced goods with imported ones, the connected region loses economic activity (competition or deagglomeration effect). Whether the market potential or the competition effect prevails could depend on the position of a region in the urban hierarchy (Baum-Snow *et al.*, 2020). Following the core-periphery model by Krugman (1991), peripheral producers are protected by high transportation costs. As transport costs fall, the periphery is delivered from the core at a reduced rate, while core producers exploit agglomeration benefits. We expect that the competition or deagglomeration effect outweighs the market potential or agglomeration effect in peripheral regions. When examining possible channels that drive the employment effect, we test for variables that have been shown to react to new transportation infrastructure, e.g., population (Ángel Garcia-López *et al.*, 2015; Baum-Snow, 2007) and house prices (Mikelbank, 2004).

Our sample covers the period 1995-2015 in the German state of Mecklenburg-Western Pomerania (*Mecklenburg-Vorpommern*, MV). More specifically, we consider the opening of the highway number 20 (BAB 20 or "Baltic Sea highway") in MV, which constitutes an ideal setting for two reasons. First, the opening of the BAB 20 in MV took place in several stages, providing us with variation in the timing of infrastructure access. Second, as the largest contiguous highway construction project since 1945 in Germany, the BAB 20 had a considerable impact on municipalities' accessibility. During our sample period a municipality's average distance to the next highway access was more than halved. The location of new highways is likely endogenous to rural regional fundamentals because highways are built to connect economic units. To reduce concerns of endogeneity, we follow the inconsequential units approach and exclude large and economically strong cities that shape the route of the highway (Banerjee *et al.*, 2012; Chandra and Thompson, 2000; Faber, 2014; Möller and Zierer, 2018). Non-agglomeration regions often receive access to a new highway because they are located on a convenient route between two larger cities that are connected. The exact opening year for these municipalities is close to random. Using difference-in-differences and event study estimations, we find that inbound commuting is negatively affected by highway access. This effect is driven by peripheral or very peripheral municipalities that, due to the spatial structure of MV, make up the majority of our sample. We observe a shift of commuting flows very much in line with predictions from the core-periphery model: The volume of commuting between peripheral places of residence and work decreases, while central locations benefit from an increase in commuters and employment. When examining possible channels, we provide supportive evidence for these counteracting effects between central and peripheral municipalities. It seems that central localities benefit from highway accessibility in terms of population and employment effects, but do so at the expense of the periphery.

2 Institutional background

2.1 The Federal system of Germany

The federal system of Germany distinguishes between the federal and state level as two layers of government. Local governments – counties (*Landkreise*) and municipalities (*Gemeinden*) – are part of the state level. The German Constitution guarantees municipalities the right of self-government (Art. 28 Basic Law). Responsibilities regarding their expenditures involve transferred compulsory tasks that are assigned by the federal government (*übertragene Selbstverwaltungsaufgaben*), compulsory responsibilities (*pflichtige Selbstverwaltungsaufgaben)* and voluntary self-government responsibilities (*freiwillige Selbstverwaltungsaufgaben*). For voluntary tasks, municipalities possess full autonomy of decision. They decide on whether they will engage in these tasks and determine how much they want to invest or what quality they want to provide. The voluntary responsibilities of municipalities comprise economic, cultural, and social issues like public transport, industry settlements, libraries, theater, sport facilities, and elderly care. Compulsory tasks, like energy and water supply or land-use planning must be executed by the municipalities, but they decide on how to do so. This is different for transferred compulsory responsibilities (for instance public administration and building supervision), where municipalities have no discretionary power at all. Municipalities also have revenue autonomy by setting user charges and taxes. Within the scope of their self-government responsibilities, they determine tax factors for business tax (*Gewerbesteuer*), general property tax (*Grundsteuer B*) and agricultural property tax (*Grundsteuer A*) independently.

2.2 Highway expansion in Mecklenburg-Western Pomerania

After reunification, as part of the German Unity Transport Project (*Verkehrsprojekt Deutsche Einheit*), the highway number 20 (*Bundesautobahn 20* – BAB 20) was built through Lower Saxony, Schleswig-Holstein, Mecklenburg-Western Pomerania, and Brandenburg to better connect regions in MV to the Western German and European transportation network. The BAB 20 is the longest contiguous highway construction project in Germany since 1945.

Plans for long-distance roads passing through MV have existed since the 1930s. In construction plans from 1926, two roads connect Lübeck with Stettin[2], one in the interior of the country running through Neubrandenburg, and one following the coastline passing by Stralsund. In 1934, the west-east connections disappeared in the construction plans and were replaced by north-south routes, connecting Hamburg, Stettin, Rostock, and Stralsund directly with Berlin. This route was given up in 1935 in favor of a new route in eastern direction. After an extensive examination of traffic conditions and requirements in Mecklenburg and Western Pomerania, the precursor of the BAB 20 was incorporated into the network of the *Reichsautobahnen* in 1937. Even though construction started in 1938, it was stopped in 1939 because of WWII. The construction of the BAB 20 was still planned by the German Democratic Republic, but the regional road development in north-eastern Germany was – due to the division of Germany – aligned for decades in a north-south direction (BMVBW et al. 2007).

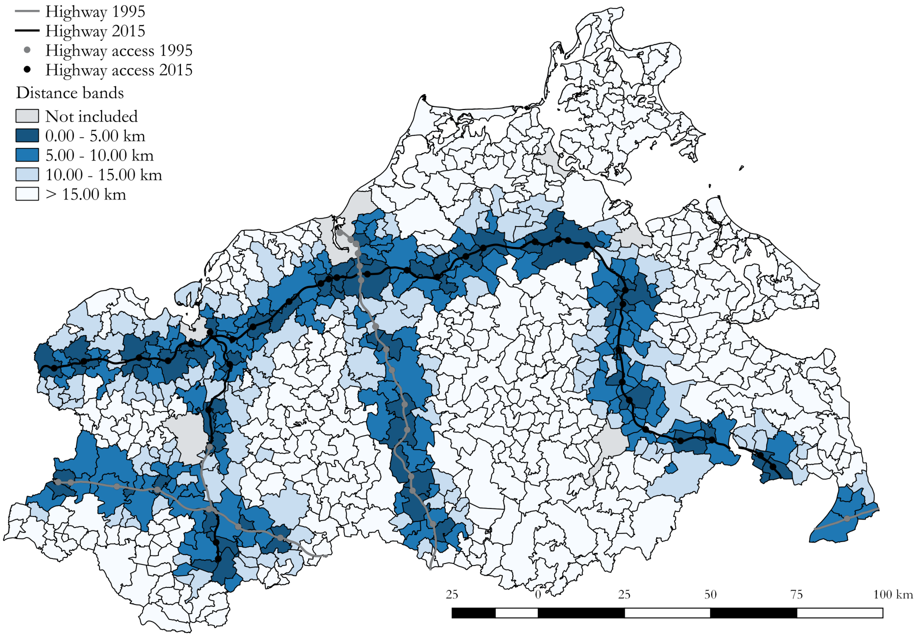
After reunification, the construction of the BAB 20 started in 1992; in 1997 its first 26 km were opened for the public in MV. Another 311 km, spread on 18 subsections (16 in MV), opened between 2000 and 2009. The total length of the BAB 20 amounts to 345 km[3]; 280 km are located in MV. Starting in Lübeck in Schleswig-Holstein, the BAB 20 runs in an eastern direction through the cities of Wismar, Rostock, and Greifswald. In Greifswald, the BAB 20 turns south to connect the city of Neubrandenburg, where it turns south-east to the highway intersection of Uckermark in the state of Brandenburg (see figure A1). There the BAB 20 merges with the BAB 11, which leads to Berlin. Parts of the BAB 14 were also open for the public and connect Wismar and Schwerin with Saxony-Anhalt and Saxony in the south of MV.[4] Other highways that run through MV and have already been open in 1992 are the BAB 24, connecting Hamburg and Berlin, the BAB 19, connecting Rostock and Berlin, and a small segment of the BAB 11, connecting the Polish border with Berlin. Figure 1a shows the highway network in MV in the year 1995 (gray) and 2015 (black).

Further, it shows the variation in distances that we are going to exploit in the empirical analysis. We group municipalities in three 5 km distance bands between 0 and 15 km. Darker shaded areas mark those municipalities within the closest distance bands. Distance is measured as the road distance (in km) of each municipality's centroid in MV to the nearest highway access in each year. In 1995, the average road distance between a municipality centroid in MV and the nearest highway access was 47 km. With the expansion of the highway network, the road distance was more than halved; in 2015 the nearest highway access was on average within a distance of 22 km. Especially the north-east of MV with the regional centers Stralsund, Greifswald, and Neubrandenburg gained access to the highway network via the BAB 20. Figure 1b shows the spatial structure of MV which is largely classified as peripheral.

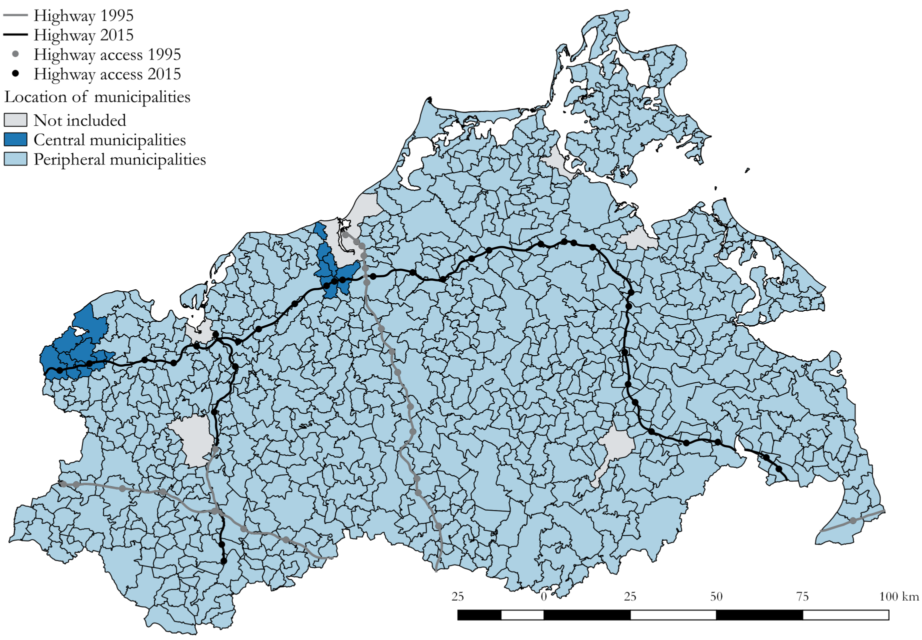
[2]Szczecin, Poland.
[3]196 km in Lower Saxony are still planned
[4]In 2006, BAB 241 was renamed and became part of the BAB 14.

Figure 1: Highway network in Mecklenburg-Western Pomerania

(a) Distance bands



(b) Peripheral and central municipalities



Notes: The maps show municipalities in the German state of Mecklenburg-Western Pomerania (black borders). The highway network (access points) of 1995 is depicted in dark gray lines (points); black lines (points) represent the highway network (access points) of 2015. Figure 1a groups municipalities in different distance bands to the next highway access points in 2015, figure 1b groups municipalities according to their location in central and peripheral. Gray municipalities are independent cities and not included.

3 Empirical analysis

3.1 Data and sample

We use a panel of yearly employment and geographical data at the municipal level in Mecklenburg-Western Pomerania. As dependent variables we use different labor market outcomes such as employment and commuter levels. We distinguish between whether a municipality is registered as an employee's place of work or residence to get a more precise impression of how highways affect the spatial distribution of economic activity. In addition, we investigate aggregate and disaggregate commuting flows (inbound and outbound commuters) between municipalities and the number of firms as supply-side element of local labor markets. To calculate the road distance to the closest highway access, we use geographic data from the Federal Office for Cartography and Geodesy and Geofabrik. Using GIS software, OpenStreetMap Data, and the Open Source Routing Machine (OSRM), we compute the distance measure as the road distance in km of a municipality's centroid to the nearest highway access in each year. For the main analysis, we transform the distance measure to a dummy variable indicating whether the next highway access lies within 10 km road distance (*access=1*) or not (*access=0*).

We focus on the time period between 1998 (1995 for some analyses) and 2015.[5] After 1995, the length of the road network of national primary, state, and county roads in MV stayed constant, and the only change in the road network was due to the construction of the highway (see table A1 in the appendix). The largest waves of connections to the highway occurred in 1998, 2001, and 2003, where 15, 22 and 32 municipalities gained access to the BAB 20 (see table A2 in the appendix).

There have been several local boundary reforms during our sample period. We adjust the data to the territorial status of 2015.[6] We exclude the cities Schwerin, Rostock, Wismar, Stralsund, Greifswald, and Neubrandenburg for two reasons. First, they have been consolidated city-counties until 2011; after 2011, only Schwerin and Rostock remained consolidated city-counties. Consolidated city-counties exercise functions of counties and municipalities at once and are therefore not comparable to municipalities. Second, the highways in MV are mainly built to better connect these cities and we exclude them to reduce endogeneity concerns. Our final panel dataset includes 745 municipalities over the period 1998-2015.

We control for lagged demographic and electoral variables. Demographic variables include population size (in log), population by age groups (age under 15, age between 15 and 25,

[5]The main dependent variables used in the analysis are only available from 1998 onward, whereas data on socio-demographic or political variables at the local level start in 1995.

[6]Our baseline results are unchanged when we exclude all merged municipalities from our sample; see table A4 in the appendix.

age between 25 and 40, and age between 40 and 65), and population density. We include four age variables to map the age structure of the population to proxy for different levels of human capital. As electoral controls, we use the share of left-wing votes[7] in the last municipal election, as well as those of elections for the county assembly (*Kreistag*), and state assembly (*Landtag*). We include the individual party vote shares to control for potentially different local economic policies of left-wing governments. Mecklenburg-Western Pomerania shares an eastern border with Poland. To control for the dynamic economic growth accompanying Poland's transition to a market-based economy during the 1990s, which might have had an impact on economic development in Mecklenburg-Western Pomerania, we include in a robustness test GDP in Poland multiplied with the inverse linear distance of each municipality to the Polish border. At the same time this variable proxies for the number of cross-border commuters.

Table 1 shows the descriptive statistics. We use data in levels which are later transformed to logarithms in the empirical analysis. Municipalities as local labor markets in MV are very small-scaled. Around 457 employees live and 551 employees work in an average municipality. However, these mean values are driven by few large regional centers, since the respective median values are 254 and 91. The number of inbound commuters was on average 296, ranging between 0 and 7,625. The average number of outbound commuters (412) was slightly higher and varied between 3 and 4,426. In the raw data, we observe some anonymized values for our dependent variables, see table A3 in the appendix.[8] Due to increased data protection regulations, the share of anonymized values – especially for employees at the place of work and inbound commuters – increased sharply from 2010 onward.[9] Although it is conceivable that part of these anonymized values truly reflect low numerical values, we code them all as missing for our baseline analysis. The estimated effects can thus be understood as a lower bound. 21% of all observations lie within a road distance of 10 km to the next highway access point.

Municipalities in Mecklenburg-Western Pomerania are relatively small in terms of their area with an average size of 30 km^2. Compared to studies that use counties as observational units, we pursue a more detailed geographical analysis. The geographical level plays an important role in case of relocation effects. An analysis at the aggregate (county) level is unable to uncover possibly large between-municipality movements of residents or firms.

[7]Left-wing votes combine votes for the social democratic *SPD*, the green party *Grüne*, and the left party *Die Linke/PDS*.

[8]For reasons of data protection and statistical confidentiality, numerical values of 1 or 2 and data from which such a numerical value can be mathematically inferred are anonymized. The same applies if a region or an industry has 1 or 2 establishments or if one of the establishments has such a high share of employees that the number of employees is practically a single figure for this establishment (dominance case).

[9]We check that our baseline results remain unchanged when we focus on the period before 2010 only (table A5 in the appendix).

Table 1: Descriptive statistics

	Observations	Mean	SD	Min	Max
Dependent variables					
Employees (place of residence)	12,273	457.11	1,128.08	0	14842
Employees (place of work)	13,410	551.45	915.41	23	11591
Inbound commuters	12,092	296.09	658.33	0	7625
Outbound commuters	12,786	412.27	495.30	3	4426
Firms	12,664	44.84	93.88	0	1124
Access dummy (yes = 1)					
Access (<10 km)	13,410	0.21	0.41	0	1
Control variables					
Population	13,410	1,562.70	2,697.51	102	33014
Age: < 15, share	13,410	12.93	2.80	3.33	31.3
Age: between 15 and < 25, share	13,410	11.25	3.60	0.98	40.2
Age: between 25 and < 40, share	13,410	18.14	3.63	5.15	41.9
Age: between 40 and < 65, share	13,410	39.63	5.47	12.4	62.1
Population density	13,410	52.05	63.98	4.91	630.6
Election county assembly, share left	13,410	45.45	6.90	32.5	61.8
Election state assembly, share left	13,410	57.93	4.93	50.4	62.7
Election mayor, share left	13,410	16.27	18.93	0	100
Further control variables					
GDP Poland × distance	13,410	7,605.82	27,089.70	1032.4	683812

Notes: The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use yearly data between 1998 and 2015. The dummy variable *Access* equals one when a municipality is within a 10 km road distance to the next highway access point, and zero otherwise. *GDP Poland × distance* is GDP in Poland multiplied by the inverse linear distance of each municipality to the Polish border.

3.2 Identification and regression specifications

To estimate how highway accessibility influences employment outcomes, we exploit variation across space and variation in time, since the highway was opened in different segments throughout our period of study (see figure A2 in the Appendix). We estimate the following difference-in-differences model:

$$y_{it} = \delta_i + \theta_t + \beta Access_{it} + X'_{it}\lambda + \epsilon_{it}, \tag{1}$$

with y_{it} as our dependent variables, employees, commuters or firms of municipality i in year t. The dummy $Access_{it}$ denotes a measure of transportation infrastructure external to municipality i. It takes the value of one when a municipality is within a road distance of 10 km to the next highway access point, and zero otherwise.[10] X'_{it} is a vector of location and time-specific covariates (see section 3.1). δ_i denotes location-specific time-invariant factors (like distance to large cities, airports, harbors), θ_t denotes common time effects for all locations and ϵ_{it} is the time-varying location-specific error. Our coefficient of interest is β, which measures the effect of access to the highway network on municipalities' labor market outcomes.

[10] Additionally, we estimate specifications for $Access_{it}$ with road distance of 5 km, 15 km, 0-5 km, 5-10 km and 10-15 km as well as a continuous distance measure, see table 5.

Identification relies on the main assumption that municipalities with a highway access would have evolved similar to municipalities without a highway access in the hypothetical case without a new highway. To estimate a causal effect, two conditions have to be met. First, treatment and control municipalities should follow a common trend before the opening of the highway. To show that this condition is fulfilled, we extend equation (1) and estimate an event study of the following form:

$$y_{it} = \delta_i + \theta_t + \sum_{j=c}^{C} \beta_j Access_{it}^{j} + X_{it}'\lambda + \epsilon_{it} \tag{2}$$

Compared to equation (1) we replace the dummy $Access_{it}$ by a vector of dummies measuring the years before and after a municipality gained access to the highway. $\sum_{j=c}^{C} \beta_j$ describes our coefficients of interest. $Access_{it}^{j}$ takes on the value of one when a municipality i is within a road distance of 10 km to the next highway access point in $(t + j)$ years and zero otherwise. We include five dummies measuring the years before a municipality gains access (-5 *and less* to -1) and five dummies measuring the years after a municipality gains access (1 to 5 *and more*). The year before the highway opened serves as our base category. Therefore, j ranges from $c = -5$ *and less* to $C = +5$ *and more*, excluding -1 (base category). Event studies not only enable us to test the common trend assumption equation (1) rests on, they also give a more detailed picture of the highway effects over time.

The second assumption for a causal interpretation of our results is an exogenous source of variation. The location of highways is likely endogenous to regional patterns because they are built to connect economic units. Location-specific factors, like productivity or amenity, which are generally unobserved, may influence the location of infrastructure and employment outcomes (Redding and Turner, 2015). To reduce concerns of endogeneity, we follow the inconsequential units approach and focus on non-agglomeration areas (Banerjee *et al.*, 2012; Chandra and Thompson, 2000; Faber, 2014; Möller and Zierer, 2018). Non-agglomeration regions often receive access to a new highway because they lie on a convenient route between two larger cities that are connected. Moreover, for these rather rural municipalities, the exact opening year can be regarded as close to random and exogenous to their development (Fretz *et al.*, 2021). While Chandra and Thompson (2000) and Möller and Zierer (2018) focus only on peripheral regions and assume exogeneity[11], Banerjee *et al.* (2012) draw straight lines to connect nearest neighbor pairs of historical cities and ports. Faber (2014) uses an IV approach and constructs a hypothetical least cost path spanning tree network. Figure 1 shows that the highways in MV connect the larger centers Rostock, Wismar, Schwerin, Greifswald, and Neubrandenburg with Berlin, Hamburg, Lübeck, and Magdeburg in nearly straight lines. We follow Chandra and Thompson (2000) and Möller and Zierer (2018) and concentrate only on non-agglomeration municipalities, while excluding the larger cities connected by the highway.

[11] Möller and Zierer (2018) use the inconsequential units approach as a robustness test. Their main specification relies on historical instrumental variables. With both strategies they find "remarkably similar results" for Germany (p.19).

The main planning and investments in high level transportation infrastructure in Germany are made at the federal level, not the local level. The planning of the course of the BAB 20 followed environmental, economic, spatial, and traffic concerns. First, a southern course was excluded, and a broader environmentally sustainable corridor in the north was defined to connect the coastline. Second, an environmental impact study was conducted, and it covered 6,300 km^2, or a quarter of the area in MV. Several variants were worked out and compared before the course of the highway was determined (BMVBW et al. 2007). With the special environmental territory in MV (MV has more national parks than any other German state), the course of the highway, and hence which municipality got connected, was not predominantly determined by economic reasons. To further strengthen the inconsequential units approach, we estimate equation (1) with two sub-samples where we first exclude municipalities whose location is classified as "central" and second exclude municipalities whose structure is classified as "predominantly urban". Moreover, to examine a potential difference between central and peripheral municipalities we conduct a heterogeneity analysis considering the location of each municipality in our baseline regression.

One may argue that municipalities that lie between two larger cities are not comparable to municipalities that are located in the hinterland. They could, even without the construction of a new transportation network, follow a different growth path, because municipalities located between two larger cities may be more accessible in the first place. Table 2 shows the mean of population (log), share of population between age 15 and 65, and population density for different clusters of municipalities, depending on their road distance to the next access in 2015 and their location before the first highway segment opened.[12] The upper part of table 2 shows that municipalities located less than 10 km and more than 10 km from the next highway access in 2015 have a similar demographic structure in 1995 and 1996. This indicates that municipalities are comparable, regardless of whether or not they are located close to the future highway and therefore between two larger cities. Furthermore, the lower part of table 2 shows that central and peripheral municipalities also did not differ in these demographic outcomes.

Table 2: Sorting into treatment – t-tests

Panel A: Distance to access	Mean road distance to next access in 2015 $<$ 10km	Mean road distance to next access in 2015 $>$ 10km	Diff	SE	Obs
Population (log)	6.79	6.70	0.10	0.08	745
Poulation age 15-65 (log)	6.40	6.31	0.09	0.08	745
Population density	53.43	47.88	5.55	5.33	745
Panel B: Location of municipalities	Mean peripheral municipalities	Mean central municipalities	Diff	SE	Obs
Population (log)	6.77	6.81	-0.05	0.24	745
Poulation age 15-65 (log)	6.38	6.46	-0.08	0.24	745
Population density	51.64	68.50	-16.86	15.52	745

Notes: The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use yearly data before the first highway segment was opened – 1995 and 1996.

[12] Economic proxies like unemployment, number of firms or number of employed workers and commuters are not available for 1995 and 1996.

Table 3 shows that demographic, economic, and political outcomes are not correlated with receiving highway access. We estimate survival models with getting a highway access within 10 km road distance as the failure event using Cox regressions. Demographic factors, employment variables, the number of firms, commuter patterns, fiscal variables and election outcomes do not turn out to significantly alter the hazard rate. We conclude that pre-reform characteristics do not predict sorting into treatment.[13]

Table 3: Sorting into treatment – Cox regression

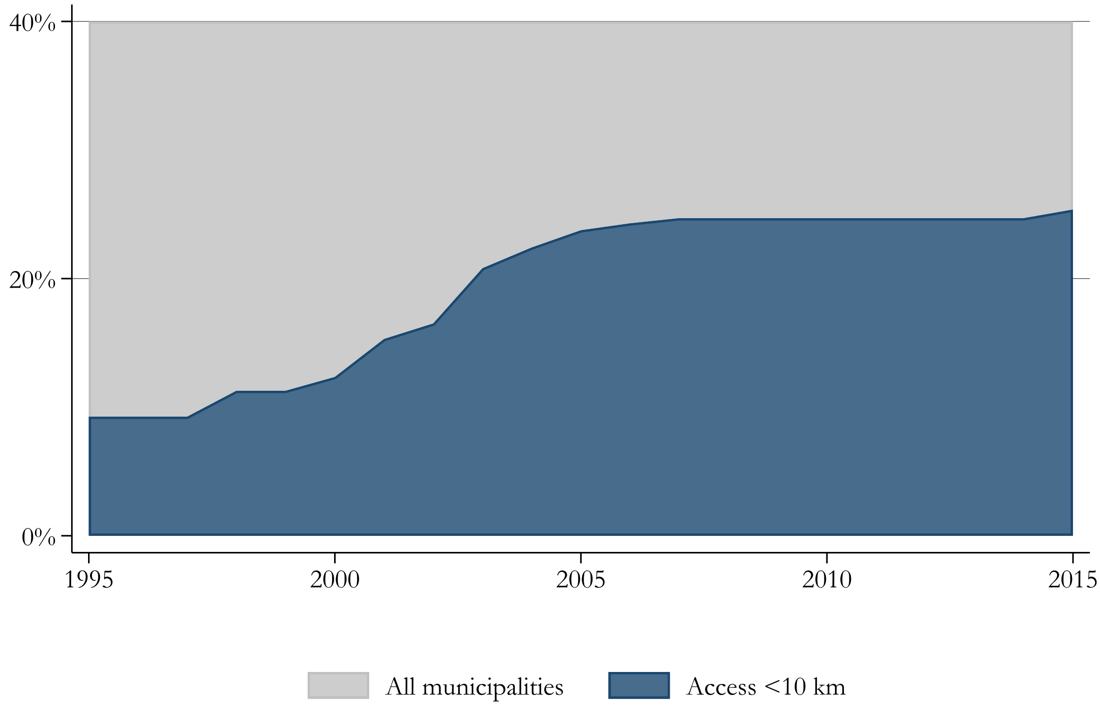
	(1)	(2)	(3)	(4)
Population (log)	-1.50	1.60	1.83	1.86
	(1.42)	(1.98)	(1.94)	(1.95)
Population age 15-65 (log)	1.43	-1.81	-2.37	-2.30
	(1.40)	(2.13)	(2.15)	(2.16)
Population density	-0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment rate		0.03	0.04	0.04
		(0.03)	(0.03)	(0.03)
Employed (place of work, log)		-0.15	-0.16	-0.07
		(0.45)	(0.45)	(0.43)
Employed (place of residence, log)		0.57	0.06	-0.19
		(0.76)	(0.83)	(0.82)
Firms (log)		-0.35	-0.41	-0.16
		(0.27)	(0.27)	(0.30)
Inbound commuter (log)		0.19	0.18	0.10
		(0.38)	(0.39)	(0.38)
Outbound commuter (log)		-0.12	-0.12	-0.13
		(0.13)	(0.14)	(0.14)
Income tax revenues (log)			0.85*	0.69
			(0.47)	(0.48)
Business tax revenues (log)			0.00	0.00
			(0.10)	(0.10)
Election mayor, share left				0.00
				(0.01)
Election county assembly, share left				0.02
				(0.02)
Tourism destination				-2.43**
				(1.17)
Pseudo R^2	0.00	0.00	0.01	0.02
Observations	12789	9505	8746	8746

Notes: The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. The Cox regressions estimate a survival model with receiving a highway access within 10 km road distance as the failure event. Tourism destinations are municipalities listed in 2015 as resorts, health resorts, spas, coastal resorts, and coastal health resorts by the Statistical Office of Mecklenburg-Western Pomerania.

Figure 2 shows that our panel is well balanced. Between 1998 and 2007 the share of municipalities within a road distance of 10 km to the next highway access increased steadily and somewhat proportionally over time. Temporal clustering, therefore, should not be a problem.

[13]The same holds true when we use a dummy variable indicating the existence of a highway access point on a municipalities' territory as dependent variable in the Cox regressions. Due to lower variation in the access variable, we have to run the regression with a subset of controls to reduce correlation between the explanatory variables.

Figure 2: Sample balancedness



Notes: The figure shows the cumulative share of municipalities within a road distance of 10 km to the next highway access point between 1995 and 2015.

4 Results

4.1 Difference-in-Differences

Panel A of table 4 shows our baseline regression results for the five labor market outcomes considered. All specifications include municipality-fixed effects to account for variation in average employment, commuter or firm levels between municipalities and year-fixed effects to address temporary shocks that are common to all municipalities. Differences in local labor market outcomes could be a result of different local preferences of employees or firms. Our estimation strategy accounts for these preference-related differences between municipalities, but changing preferences over time within municipalities could be a confounding factor. We control for population, population age categories, population density, and the share of left-wing votes at local and state elections. Since these variables could at the same time be influenced by highway accessibility, we include them as lags.

On average, as the results in panel A show, we do not find statistically significant differences in employment outcomes between accessible and less accessible municipalities. Although the estimated coefficients for employees at their place of work, inbound commuters and firms turn out negative and are also numerically larger than estimates for employees at their place of

Table 4: DD Regression – Baseline

	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Panel A: All municipalities					
Access (<10 km)	0.005	-0.053	-0.048	0.001	-0.028
	(0.01)	(0.04)	(0.05)	(0.01)	(0.02)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.474	0.130	0.0727	0.230	0.0820
Number of mun.	745	737	732	744	737
Observations	13410	12237	12038	12786	11933
Panel B: Peripheral municipalities - Baseline					
Access (<10 km)	0.000	-0.091**	-0.093*	-0.002	-0.035
	(0.01)	(0.04)	(0.05)	(0.01)	(0.03)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.467	0.136	0.0767	0.218	0.0835
Number of mun.	728	720	715	727	720
Observations	13104	11961	11784	12522	11653
Panel C: Rural municipalities					
Access (<10 km)	0.005	-0.052	-0.047	0.002	-0.028
	(0.01)	(0.04)	(0.05)	(0.01)	(0.02)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.462	0.130	0.0733	0.219	0.0810
Number of mun.	733	725	720	732	725
Observations	13194	12022	11823	12570	11730

Notes: Each panel shows the results of five difference-in-differences estimations. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units (Panel A). We use data in levels (logs) over the period 1998 to 2015. Our variable of interest (Access) equals one for municipalities within a road distance of 10 km to the next highway access point, and zero otherwise. Panel B shows our baseline regression results for the sub-sample where municipalities classified as being "central" (location) are excluded. In Panel C, we exclude municipalities that are "predominantly urban" (structure). Control variables are lagged demographic and political variables, see table 1. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

residence and outbound commuters in columns (1) and (4), they are too imprecisely estimated to reach conventional levels of statistical significance.

Strengthening the argument of the inconsequential units approach, we in turn exclude central (panel B of table 4) and predominantly urban (panel C of table 4) municipalities. Excluding central municipalities constitutes thereby our baseline specification, where we test our hypothesis that in peripheral regions the deagglomeration effect prevails. Central and peripheral municipalities are classified based on the accessibility of concentrations of population and employment, while the structural categories urban and rural are determined by population density and settlement area measures.[14] Due to the spatial structure of MV, only few municipalities, namely those surrounding the cities Rostock and Wismar, are defined as central.

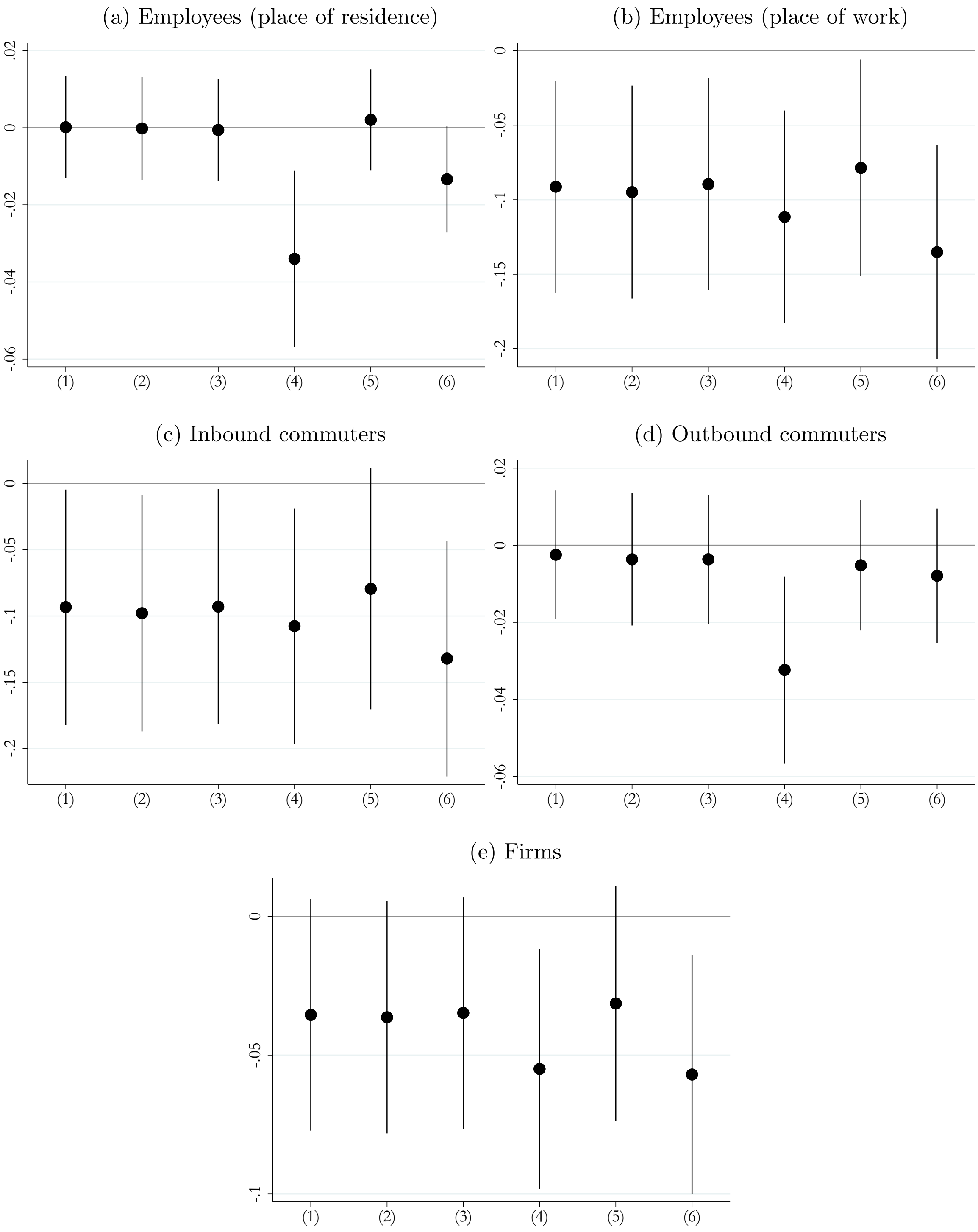
[14]The spatial categories are defined by the Federal Institute for Building, Urban Affairs, and Spatial Research (*BBSR*) at one point in time, so they remain constant over our sample period and are not affected by highway accessibility.

Against this background, the increase in the coefficient for the 10 km dummy in columns (2) and (3) (panel B) of table 4 when excluding these municipalities is sizable. Municipalities whose road distance to the next highway access falls below 10 km, experience a 9% decrease in their employment level (column 2), which seems to be entirely driven by a reduced inbound commuter flow (column 3). The remaining coefficients do not turn out statistically significant. When excluding predominantly urban municipalities in panel C, estimates closely resemble those in panel A. This first set of results already hints at some heterogeneity of the highway effect within our sample. Overall, we estimate zero effects of highway access on local labor market outcomes. For the periphery, i.e. localities without immediate access to populous and economically active urban centers, however, improved infrastructure seems to impact employment and inbound commuting detrimentally. Structural factors, i.e., whether the municipality itself is of (predominantly) urban or rural type, however, do not play a crucial role.

In an attempt to corroborate the baseline findings of table 4 for peripheral municipalities, we conduct several robustness checks, which are presented in figure 3. The first bullet in each graph represents the baseline estimate for comparability. First, we include municipality-specific linear time trends to rule out the possibility that accessible municipalities – defined as falling under the 10 km distance band – and less accessible localities were already on differential growth paths in their outcome variables. In this case, we would find an effect on local labor market outcomes even in the absence of the construction of the BAB 20. However, these concerns are not supported by the results as the coefficient estimates in figures 3b and 3c demonstrate. For employees (place of work) and inbound commuters, the negative differential between accessible and less accessible municipalities persists. Coefficient estimates are quite comparable to our baseline estimates, so the treatment effect does not seem to be absorbed by the time trends. Second, we extend the set of control variables and control for the market access to Poland. Results remain unchanged (figure 3, third bullet). Third, we exclude all control variables (figure 3, fourth bullet). The results fairly reproduce our baseline findings for employees at their place of work and inbound commuters. Estimates for employees at their place of residence and outbound commuters are sensitive to this exclusion, however, suggesting that part of the effect of accessibility on these variables is mediated by the population channels.

Fourth, with its many national parks and its location at the Baltic Sea, MV is a popular tourism destination. As touristic municipalities might benefit particularly from better accessibility, we exclude them in a further robustness test. Our baseline results remain unchanged. Fifth, we follow Bertrand *et al.* (2004) and estimate a pooled OLS. Ignoring the time dimension accounts for a possible inconsistency of the standard errors. Again, our baseline results hold (figure 3, sixth bullet) and coefficient estimates even increase in magnitude.

Figure 3: DD Regression - Robustness



Notes: We compare five different robustness checks to our baseline specification for peripheral municipalities (Table 4, Panel B). Each bullet represents the coefficient for the access dummy; bars represent the 90% confidence interval. Baseline estimates are also included for comparability (first bullet). The dependent variables are labor market outcomes (in logs) at the level of 728 peripheral municipalities in Mecklenburg-Western Pomerania. In the first robustness check (second bullet), we include municipality-specific linear time trends. Second, we control for market access to Poland. Third, we exclude all control variables. Fourth, we exclude all municipalities classified as tourism destinations. Tourism destinations are municipalities listed as resorts, health resorts, spas, coastal resorts, and coastal health resorts by the Statistical Office of Mecklenburg-Western Pomerania in 2015. Fifth, we estimate a pooled OLS.

Moreover, table 5 repeats our baseline analysis for peripheral municipalities when using alternative specifications of the distance variable to ease concerns about arbitrary cutoff-values. In panels A and B, we specify the treatment dummy to equal one for municipalities within a road distance of 5 km and 15 km, respectively. In panel C, we differentiate the effect for those distance bands by simultaneously including all 5 km sub-categories (as dummies). The results yield some interesting insights. Namely, our baseline finding of a negative employment and commuter differential is driven by peripheral municipalities within a distance band of 5 to 10 km from the next highway access (columns 2 and 3, panel C). In this distance band, also the number of firms decreases. Peripheral municipalities located in even closer proximity to the highway – less than 5 km – also have negative, albeit statistically insignificant, coefficient estimates for employees at their place of work and inbound commuters (columns 2 and 3, panel C). Coefficients for the maximum distance band (10-15 km) turn out statistically significant and negative, but their magnitude decreases by around 40% compared to municipalities within the medium distance band. Therefore, the detrimental effect of accessibility on employees working in and commuting to peripheral municipalities decays with distance to the highway access.

Is it really improved accessibility that matters for employment in peripheral locations? To answer this question, we conduct a final robustness check that differentiates between treatment intensity effects (see table 6). We re-estimate our baseline specification for peripheral municipalities including an interaction term between the access dummy and a dummy variable indicating high or low initial distance from the next highway access in 1995. The cutoff between high and low initial distances is defined at the median. Results confirm that the degree of infrastructure improvement matters. We observe statistically significant negative effects for employees, inbound commuters and firms in peripheral municipalities that benefited the most from increased accessibility. In comparison, employment effects in peripheral municipalities that have always been moderately close to the next highway access do not turn out statistically significant.

4.2 Event Studies

Our baseline effects in table 4 measure averages over all municipality-year observations characterized by improved access to the highway following equation (1). One could, however, argue that the effect on local labor market outcomes is just a result of increased local labor demand during the construction phase of the BAB 20 that recedes back to normal levels when the highway segment and access points are completed and opened for the public. To discern whether these temporary patterns exist, we normalize the year of improved accessibility for all peripheral municipalities and build a categorical variable taking on different values for a time window of 5 years around the opening of the highway segment (equation 2). Figure 4 displays

Table 5: DD Regression – Different distance bands

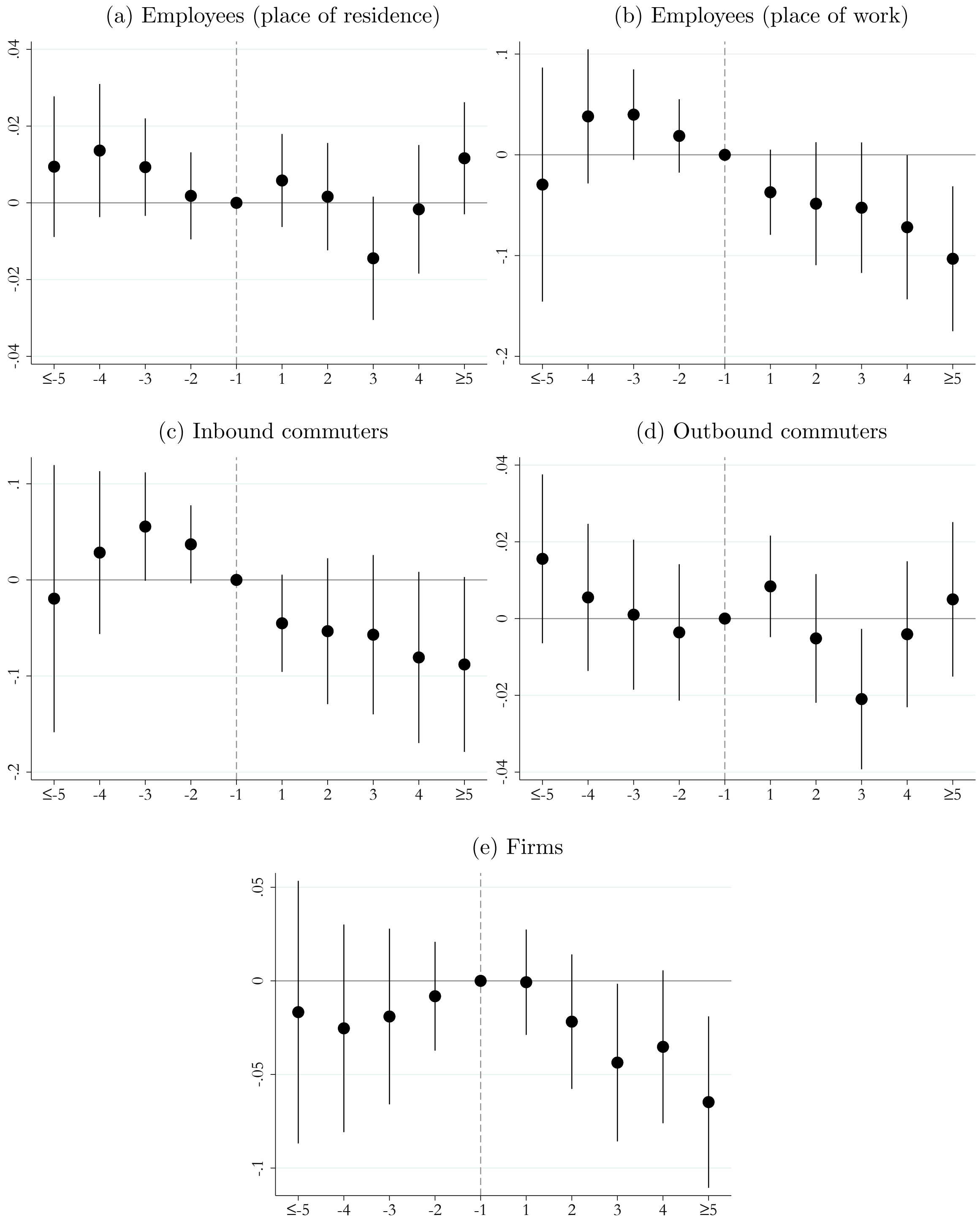
	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Panel A: Access <5 km					
Access (<5 km)	-0.009	-0.007	0.006	-0.008	0.027
	(0.01)	(0.08)	(0.09)	(0.02)	(0.06)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.467	0.134	0.0752	0.218	0.0829
Number of mun.	728	720	715	727	720
Observations	13104	11961	11784	12522	11653
Panel B: Access <15 km					
Access (<15 km)	-0.003	-0.097***	-0.103***	0.007	-0.008
	(0.01)	(0.03)	(0.04)	(0.01)	(0.02)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.467	0.137	0.0780	0.218	0.0828
Number of mun.	728	720	715	727	720
Observations	13104	11961	11784	12522	11653
Panel C: Distance bands together					
Access (<5 km)	-0.009	-0.036	-0.026	-0.005	0.027
	(0.01)	(0.08)	(0.09)	(0.02)	(0.06)
Access (5-10 km)	0.003	-0.141***	-0.152**	0.003	-0.055**
	(0.01)	(0.05)	(0.07)	(0.01)	(0.03)
Access (10-15 km)	-0.005	-0.083**	-0.091**	0.013	0.018
	(0.01)	(0.04)	(0.04)	(0.01)	(0.02)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.467	0.138	0.0787	0.218	0.0845
Number of mun.	728	720	715	727	720
Observations	13104	11961	11784	12522	11653

Notes: Each panel shows the results of five difference-in-differences estimations. The 728 peripheral municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data in levels (logs) during the period 1998 to 2015. Our variable of interest (Access) equals one for municipalities within a certain road distance to the next highway access point, and zero otherwise. Control variables are lagged demographic and political variables, see table 1. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

the coefficient estimates and their 90% confidence intervals graphically. All effects are relative to the year before the opening of the highway segment (indicated by the dashed line).

The observed patterns for the employees at their place of work and inbound commuters are relatively similar, although confidence bands for the estimates are large, which explains why we do not find any effects in our baseline regressions. Nevertheless, for both variables, effect sizes increase with each year of highway access from roughly -0.03 to -0.08 (see figures 4b and 4c). Four years after the opening of the highway segment – and thus after falling under the 10 km distance band – the estimate for the negative employee differential turns statistically significant, suggesting negative long-term effects for employment in peripheral municipalities with highway access. Reassuringly, the development in both labor market outcomes does not differ significantly between treatment and control group before the highway was opened (90% confidence intervals always include the zero) and therefore the common trend assumption seems to be met. For employees at their place of residence and outbound commuters the

Figure 4: Event study results



Notes: The figure shows the results of five event-study estimations. Vertical dashed lines represent the year when a municipality falls within a road distance of 10 km to the next highway access point. The 728 peripheral municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use yearly data in levels (log) during the period 1998 to 2015. Bullets are point estimates, and black lines represent the 90% confidence interval. We include year and municipality-fixed effects and control variables (see notes to table 4). $Year = -1$ is the base category. We use standard errors robust to heteroskedasticity.

Table 6: Treatment intensity

	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Access (<10 km) × high $dist_{1995}$	-0.002	-0.110***	-0.121**	-0.008	-0.056**
	(0.01)	(0.04)	(0.06)	(0.01)	(0.03)
Access (<10 km) × low $dist_{1995}$	0.005	-0.053	-0.038	0.010	0.009
	(0.01)	(0.10)	(0.11)	(0.01)	(0.05)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.467	0.136	0.0770	0.218	0.0841
Number of mun.	728	720	715	727	720
Observations	13104	11961	11784	12522	11653

Notes: The table shows the results of five difference-in-differences estimations. The 728 peripheral municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data in levels (logs) during the period 1998 to 2015. We interact our Access dummy with a dummy indicating high and low baseline distance from the highway in 1995. High/low initial distances are defined as values above/below the 1995 median value of 39 km. Control variables are lagged demographic and political variables, see table 1. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

post-treatment patterns are less clear. If at all, there is some suggestive evidence for a negative effect on firms in peripheral municipalities within and outside of the 10 km distance band to the highway access.

To also submit our event study results to a robustness check, we use a more balanced window around highway access. We exclude municipalities with less than three pre- or post-treatment years. Results for the remaining municipalities, as shown in figure A3, confirm the observed patterns in figure 4. From the year of improved highway access onward, peripheral municipalities experience a continuous decline in the number of inbound commuters which is reflected in a corresponding decrease in local employment levels.

4.3 Heterogeneity

The average estimated effects of the baseline specifications might mask substantial heterogeneities in municipal labor market outcomes. Conditional on the spatial characteristics of a municipality, for example, firms might have more or less scope to adjust their employment levels in the first place, and, more importantly, might be affected differently by increased accessibility. For this reason, we re-estimate our baseline specification by adding multiplicative interactions between the treatment indicator and dummy variables for central and peripheral municipalities. Although the small number of central municipalities in our sample warrants caution in interpreting the corresponding interaction coefficient, results in table 7 provide suggestive evidence for heterogeneity of the highway effect along the spatial dimension. For all labor market outcomes coefficient estimates for peripheral and central municipalities display opposing signs. Highway access makes central municipalities a more attractive place to live (+6% of employees) and peripheral municipalities a less attractive place to work (-9% of employees), while commuting flows adapt accordingly. Without knowing the origin or destination of inbound and outbound commuters, it remains unclear, however, how commuting volumes shift between the periphery and the core. This question will be examined in section 4.4.

Table 7: Baseline with location heterogeneity

	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Access (<10 km) × periphery	-0.000	-0.091**	-0.093*	-0.003	-0.035
	(0.01)	(0.04)	(0.05)	(0.01)	(0.03)
Access (<10 km) × central	0.058***	0.316**	0.386**	0.043**	0.060
	(0.02)	(0.15)	(0.19)	(0.02)	(0.05)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.475	0.133	0.0766	0.230	0.0824
Number of mun.	745	737	732	744	737
Observations	13410	12237	12038	12786	11933

Notes: The table shows the results of five difference-in-differences estimations. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data in levels (logs) during the period 1998 to 2015. We interact our Access dummy with a dummy for central (peripheral) municipalities. Control variables are lagged demographic and political variables, see table 1. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

We investigate possible mechanisms to explain the negative employment differential for accessible municipalities. Effects could run through population or area-based channels, which we investigate in turn in table 8 with our baseline specification. Panel A shows how these variables are affected by accessibility. Most of the coefficients are very imprecisely estimated, but overall population seems to matter. Receiving a highway access within 10 km is associated with a population decline of 3% in the municipality. Similar to table 7, panel B repeats the analysis when including an interaction term between the treatment indicator and the central/periphery-dummy. While effect sizes in peripheral locations – relative to central municipalities – are moderate, they nevertheless reveal a striking pattern: For all variables, we observe negative effects when peripheral municipalities fall within 10 km road distance to the next highway access. The respective municipalities lose around 4% of their overall and working-age population, rendering them less densely populated. In line with these downward trends in population, the supply of buildings with residential areas decreases. For central municipalities, we observe exactly the opposite pattern. Effect sizes are large and positive throughout, i.e. central municipalities seem to benefit in terms of population and residential buildings with increased highway accessibility. The small number of municipalities classified as central, however, raises questions about sample size and how reliable the estimate for central municipalities actually is.

Table 8: Channels

	Population			Buildings
	(1) all	(2) age 15-65	(3) density	(4) with residential areas
Panel A: Baseline				
Access (<10 km)	-0.025**	-0.015	-1.276	-0.008
	(0.01)	(0.01)	(1.13)	(0.01)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Within R^2	0.484	0.585	0.174	0.510
Number of mun.	745	745	745	745
Observations	13410	13410	13410	2980
Panel B: Heterogeneity				
Access (<10 km) × periphery	-0.043***	-0.034**	-2.904**	-0.025***
	(0.01)	(0.01)	(1.33)	(0.01)
Access (<10 km) × central	0.185***	0.204***	12.564***	0.118***
	(0.04)	(0.03)	(3.63)	(0.04)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Within R^2	0.393	0.480	0.119	0.523
Number of mun.	745	745	745	745
Observations	14900	14900	14900	2980

Notes: Each panel shows the results of four difference-in-differences estimations. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data in levels (logs), except for population density, which is measured in inhabitants per ha, during the period 1998 to 2015. Data on buildings with residential areas are aggregated for the periods 1996-2000, 2001-2004, 2005-2008, 2009-2011. We interact our Access dummy with a dummy for central (peripheral) municipalities. Control variables are lagged demographic and political variables, see table 1. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

The effect of highway accessibility on local labor market outcomes can also run via property values. If accessible municipalities become more or less attractive places to work or live, this should be reflected in the development of real estate prices. We test this channel with real estate advertisement data from 2005 to 2015 containing a large battery of object characteristics and the offer price.[15] Table A6 in the appendix presents summary statistics for the variables used in our analysis covering sales of detached houses, apartment buildings, condominiums and commercial properties between 2005 to 2015 in MV. Unfortunately, the data coverage does not overlap with the main construction window of the BAB 20 such that variation in the access variable is low.[16] Therefore, the results presented in table 9 should be viewed as suggestive. We run pooled OLS estimations at the object level, controlling for municipality and year fixed effects, our baseline political and population variables and object characteristics. The dependent variable is the object price per m^2. The results show a clear pattern of reduced offer prices across all property types. Detached houses within 10 km road distance to the next highway access are offered at around €165 less per m^2 than detached houses further away. Results in panel B show that the negative price effects are largest in the second distance band (5-10 km). Once we move further

[15] The data was collected by F+B, a commercial real estate consultancy firm, and covers roughly 18 million properties that were offered for sale in Germany during the period from January 2005 until December 2018.

[16] Because of the low variation in the shorter time window we cannot conduct a heterogeneity analysis between peripheral and central municipalities.

away from the highway access, prices for apartment buildings, condominiums and commercial property are insensitive to highway accessibility.

Table 9: Channels - Real estate offers

	Detached house	Apartment building	Condominium	Commercial property
	(1)	(2)	(3)	(4)
Panel A: Baseline				
Access (<10 km)	-165.446***	-205.924***	-345.724***	-248.473***
	(23.54)	(50.57)	(50.94)	(81.38)
Panel B: Different distance bands				
Access (<5 km)	-174.647***	-152.975***	-185.911*	-165.473*
	(40.31)	(55.63)	(99.44)	(85.95)
Access (5-10 km)	-192.641***	-236.359***	-427.667***	-291.636***
	(29.03)	(70.39)	(57.98)	(110.63)
Access (10-15 km)	-75.182***	102.178	-73.574	-321.938
	(18.92)	(74.18)	(47.95)	(298.85)
Municipality FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Housing controls	Yes	Yes	Yes	Yes
Municipality controls	Yes	Yes	Yes	Yes
Within R^2	0.438	0.452	0.524	0.316
Observations	150,187	9,708	73,723	16,472

Notes: Each panel shows the results of four pooled OLS estimations. The observation units are the real estate properties offered for sale in the municipalities of the German state of Mecklenburg-Western Pomerania. We use data in levels during the period 2005 to 2015. All specifications include municipality and year fixed effects, housing controls and municipality controls. Municipality controls are demographic and political variables, see table 1. Housing controls are the number of rooms, total area, year of construction, object type and postal code, see table A6. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

4.4 Analysis of commuting flows

To give a more detailed picture on commuting flows in the wake of highway access, we use disaggregated commuter numbers by municipality of origin (for inbound commuters) and by municipality of destination (for outbound commuters). We have data on between municipality commuting flows for the years 2002, 2008 and 2013. At these three points in time, we can link the place of residence and the place of work for all employees in Mecklenburg-Western Pomerania. We use the share of inbound and outbound commuters by spatial categories of origin and destination as dependent variables. Due to the cross-sectional nature of the data, regression specifications are more parsimonious. We run difference-in-differences estimations including our access dummy, a post-dummy, indicating whether a municipality gained highway access until 2008 or 2013, and their interaction. Furthermore, we control for district and year fixed effects as well as spatial, socio-demographic and political characteristics of the municipality (see table A7 in the appendix).

Table 10 shows results for the estimations with the share of inbound commuters from very peripheral, peripheral, central municipalities and cities as dependent variables. If an employee's place of work receives access to the new highway network, inbound commuting flows from peripheral municipalities and cities decrease by 6 and 5 percentage points, respectively (panel A). In line with previous results, it is the (very) peripheral places of work that drive these average effects (panel B). When remote localities get connected to the highway, they lose inbound commuters from both the periphery and the closest city, whereas the former effect is numerically larger than the latter.

Table 10: Inbound commuters

	Inbound commuters by place of residence			
	(1) very peripheral	(2) peripheral	(3) central	(4) city
Panel A: All places of work				
Access (<10 km)	-0.008	0.009	0.019	-0.009
	(0.04)	(0.03)	(0.02)	(0.02)
Access (<10 km) × post	0.005	-0.062***	-0.027	-0.048***
	(0.03)	(0.02)	(0.03)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.533	0.414	0.859	0.654
Observations	1019	772	258	1290
Panel B: Very peripheral place of work				
Access (<10 km)	0.002	-0.031	0.026	-0.039*
	(0.05)	(0.02)	(0.02)	(0.02)
Access (<10 km) × post	0.003	-0.078**	-0.024	-0.039**
	(0.03)	(0.03)	(0.03)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.413	0.487	0.670	0.477
Observations	872	467	119	969
Panel C: Peripheral place of work				
Access (<10 km)	-0.048	0.056	0.065*	0.044
	(0.05)	(0.06)	(0.04)	(0.03)
Access (<10 km) × post	0.063	-0.068	0.004	-0.015
	(0.08)	(0.05)	(0.05)	(0.04)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.718	0.406	0.823	0.810
Observations	130	276	106	288
Panel D: Central place of work				
Access (<10 km)	0.000	-0.161	-0.044	0.257***
	(.)	(0.13)	(0.06)	(0.06)
Access (<10 km) × post	-0.181	-0.115	0.005	0.305***
	(0.33)	(0.13)	(0.07)	(0.08)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.957	0.946	0.987	0.989
Observations	17	29	33	33

Notes: Each panel shows the results of four difference-in-differences estimations. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data on inbound commuters by place of residence in the years 2002, 2008 and 2013. Panel A shows results for all commuting destinations, while Panels B, C and D differentiate between very peripheral, peripheral and central places of work. All specifications include district and year fixed effects. Control variables are spatial, demographic and political variables, see table A7. Significance levels (standard errors clustered at the municipality of residence): *** 0.01, ** 0.05, * 0.10.

Results for outbound commuters (see table 11) mirror those for inbound commuters. Across the different panels of table 11, we keep employees' places of residence constant and estimate differential effects by the location of the commuting destination. On average, if employees' municipality of residence falls under the 10 km distance band to the next highway access, they tend to commute less to very peripheral places of work. Results in panels B and C show that commuting flows within the periphery decrease substantially. At least for very peripheral places of work, we observe a shift of commuting flows to the nearest city.

Table 11: Outbound commuters

	Outbound commuters by place of work			
	(1) very peripheral	(2) peripheral	(3) central	(4) city
Panel A: All places of residence				
Access (<10 km)	-0.065***	0.015	-0.015	0.012
	(0.02)	(0.02)	(0.01)	(0.02)
Access (<10 km) × post	-0.082***	0.026	-0.031***	0.024
	(0.02)	(0.02)	(0.01)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.513	0.432	0.858	0.736
Observations	1709	1782	678	2187
Panel B: Very peripheral place of residence				
Access (<10 km)	-0.052**	0.028	-0.000	0.020
	(0.02)	(0.02)	(0.02)	(0.02)
Access (<10 km) × post	-0.069***	0.028	-0.007	0.040**
	(0.02)	(0.02)	(0.01)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.438	0.476	0.694	0.646
Observations	1538	1302	419	1686
Panel C: Peripheral place of residence				
Access (<10 km)	-0.020	-0.083**	0.021	-0.008
	(0.02)	(0.04)	(0.02)	(0.02)
Access (<10 km) × post	-0.010	-0.112***	-0.021	-0.013
	(0.02)	(0.03)	(0.03)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.657	0.696	0.887	0.863
Observations	165	441	211	452
Panel D: Central place of residence				
Access (<10 km)		-0.111**	-0.007	0.000
		(0.04)	(0.02)	(0.02)
Access (<10 km) × post		-0.134***	-0.009	0.032
		(0.04)	(0.02)	(0.02)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	1	0.882	0.995	0.998
Observations	6	39	48	49

Notes: Each panel shows the results of four difference-in-differences estimations. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data on outbound commuters by place of work in the years 2002, 2008 and 2013. Panel A shows results for all commuting origins, while Panels B, C and D differentiate between very peripheral, peripheral and central places of residence. All specifications include district and year fixed effects. Control variables are spatial, demographic and political variables, see table A7. Significance levels (standard errors clustered at the municipality of work): *** 0.01, ** 0.05, * 0.10.

5 Conclusion

We focus on an episode of extensive highway construction in East Germany following reunification and examine how access to the highway network influences municipal labor market outcomes. Getting access to a highway reduces transportation costs and increases attractiveness of municipalities as residential and firm locations. This may be an asset in the local competition for capital and labor. However, a more accessible location might also face increased competitive pressure. We consider the opening of highway number 20 that runs through the German state of Mecklenburg Western-Pomerania. The construction of the BAB 20 is the largest contiguous highway construction project in Germany since 1945. With its opening, the average distance of municipalities in MV to the next highway access was more than halved. In the baseline estimation, we use the difference-in-differences approach. The stagewise opening of the highway also allows us to exploit variation in the timing of access in event study estimations. Our sample includes 745 municipalities over the 1998 to 2015 period. We follow the inconsequential units approach and exclude large cities that shape the route of the BAB 20. Highways are likely built to connect economic units, but peripheral municipalities often receive access to the highway network because they "accidentally" lie on a convenient route between two larger cities. Therefore, the connection to the highway network as well as the exact timing of access is close to random in peripheral municipalities.

Our results suggest that peripheral municipalities in MV that gained immediate access to the newly constructed highway BAB 20 experienced a decrease in local employment. This effect proves to be persistent and very robust across specifications, conditioning factors, and estimation methods. Employment levels in peripheral municipalities within 5 to 10 km road distance to a new highway access decrease by 14%. Despite improved accessibility, inbound commuter flows to these locations were reduced. Using event studies, we show that there is no adjustment in local employment and inbound commuter flows in the four years prior to the highway opening, but both labor market outcomes start to fall immediately afterwards. In line with the baseline findings, more accessible municipalities experience a persistent decrease in employees who used to commute to work in the periphery. With the advent of the new highway system, less city or peripheral residents choose to commute to (very) peripheral places to work.

Finally, we reconcile our findings with the literature by examining the role of economic outcomes as possible drivers of the labor market effect. We examine population, area-related and property price channels. Improved accessibility, i.e. a decline in trade costs, leads to a shift of population and employment to central municipalities at the expense of the periphery. Against the background of relatively equal populations between central and peripheral municipalities preceding the construction of the BAB 20, this finding is especially striking. While the benefits of central municipalities in terms of population and employment seem implausibly large to be solely attributable to the highway construction, the negative pattern for peripheral municipalities that gain close access is noticeable. This suggests that for the periphery, deagglomeration forces outweigh agglomeration forces (vice versa for core municipalities).

Our findings can be rationalized by new economic geography models that state a home market effect amplified by population mobility. Upon construction of the BAB 20, falling transport costs reduce the degree of trade protection in the periphery, and there might be substitution away from local production. Population and the number of firms is reduced in peripheral municipalities. In the long term, reducing transportation costs gives rise to concentration, i.e. to an agglomeration-periphery structure rather than to a uniform distribution between regions. Based on our analysis, we conclude that the BAB 20 cemented the core-periphery structure in MV by weakening the periphery as a place to work. Thus, highways are not always a panacea for economic growth. Policymakers should carefully gauge the initial economic conditions in connected regions when planning large-scale infrastructure investments. For the periphery, investments in infrastructure could be flanked by other place-based policies to ease the competitive pressure through increased accessibility.

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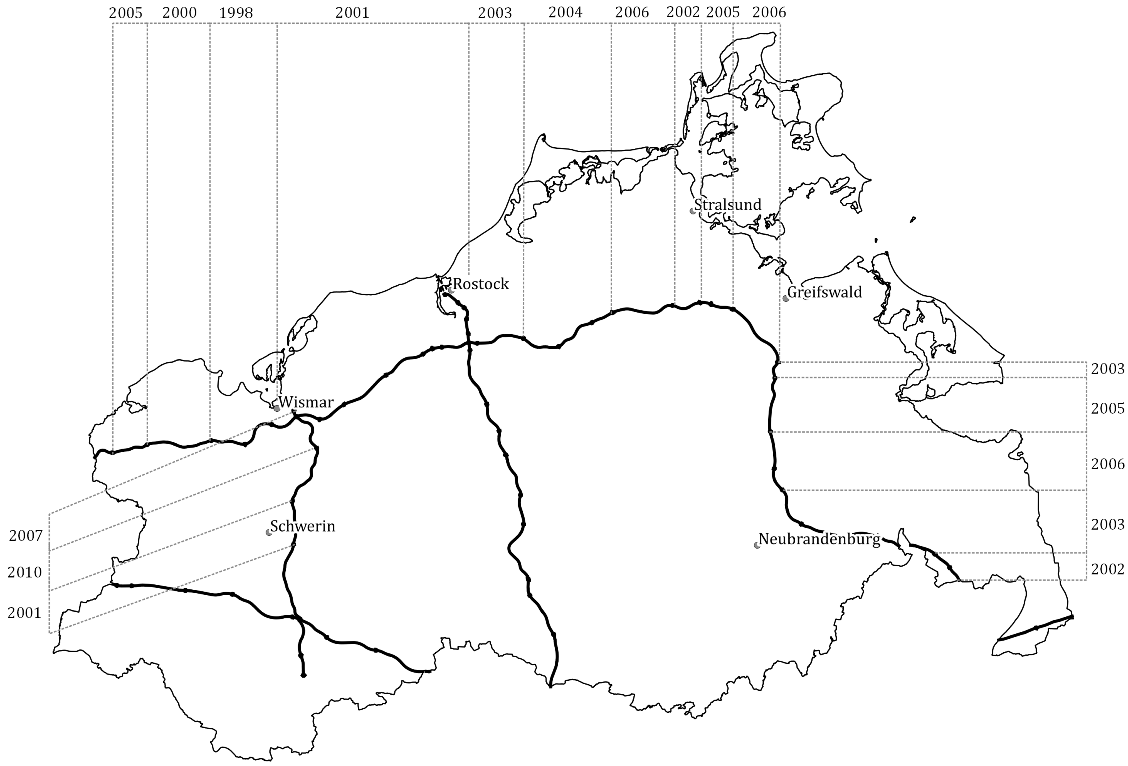
Appendix (for online publication only)

Figure A1: Highway network in Mecklenburg-Western Pomerania and neighboring states

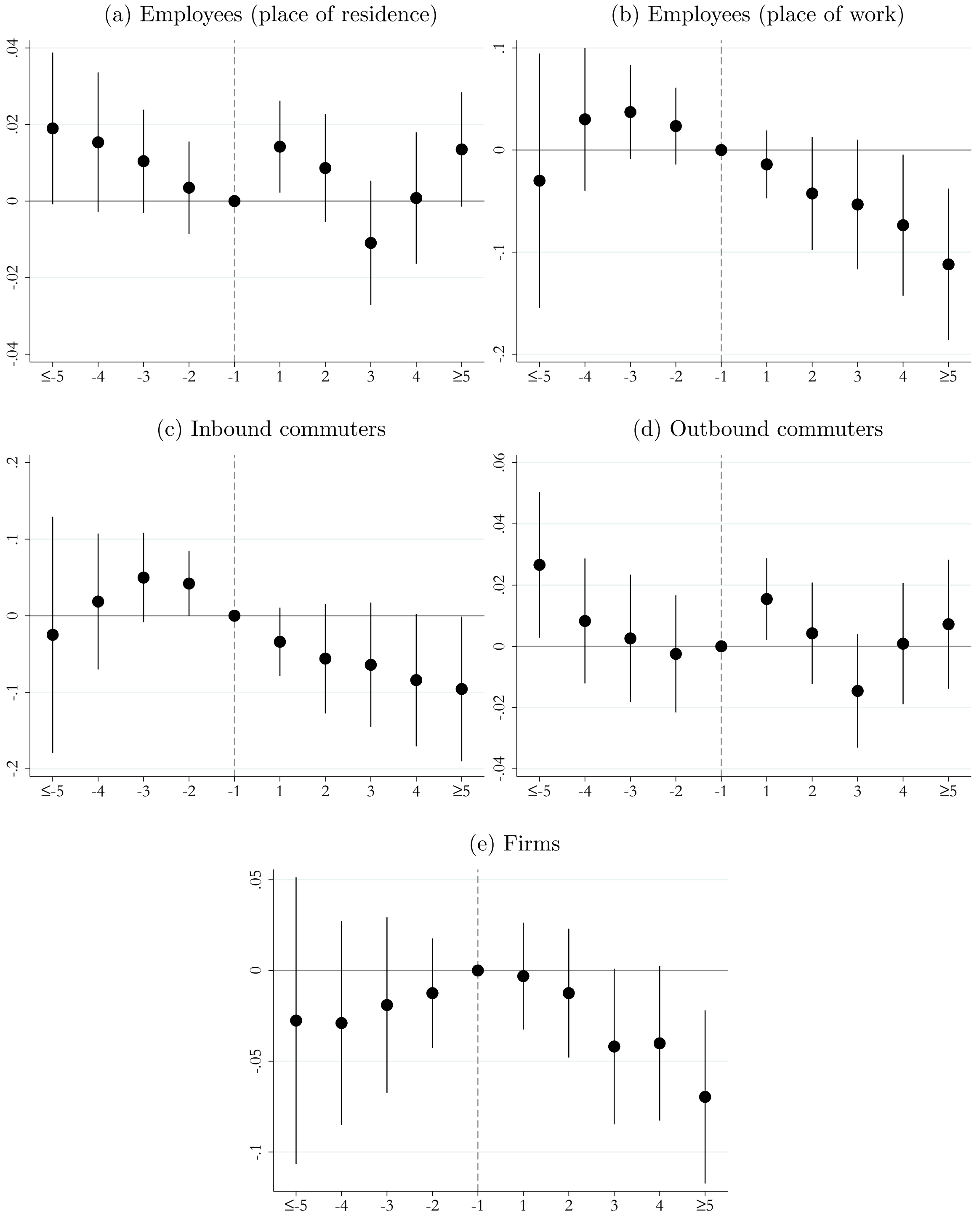
Notes: The map shows the highway network as of 2021 in the German state of Mecklenburg-Western Pomerania (dark gray) and its neighboring states Schleswig-Holstein, Lower Saxony, Sachsen-Anhalt and Brandenburg (all shaded in light gray). The highway network is depicted as dark black lines; gray lines represent state borders. Municipality borders are omitted for reasons of visibility.

Figure A2: Opening of highway segments in Mecklenburg-Western Pomerania, 1995-2015



Notes: The map shows the highway network in the German state of Mecklenburg-Western Pomerania. Parts of the highway that were open 2002, 2003, and 2005 were not immediately connected to larger cities until 2006. These parts without continuous routing to a larger city amounted to 7.4 km in 2002, 14.2 km in 2003 and 2004, and 33.4 km in 2005.

Figure A3: Event study results - balanced event window



Notes: The figure shows the results of five event study estimations. Vertical dashed lines represent the year when a municipality falls within a road distance of 10 km to the next highway access point. We exclude municipalities with less than three pre- or post-treatment years, i.e. we end up with 717 peripheral municipalities of the German state of Mecklenburg-Western Pomerania as our observation units. We use yearly data in levels (logs) during the period 1998 to 2015. Bullets are point estimates, and black lines represent the 90% confidence interval. We include year and municipality-fixed effects and control variables (see notes to table 4). $Year = -1$ is the base category. We use standard errors robust to heteroskedasticity.

Table A1: Road network in MV

year	National highway (in km)	National primary, state and county roads (in km)
1995	237	9,475
2015	554	9,434
Δ	317	-41

Notes: The table shows the length of the road network in Mecklenburg-Western Pomerania in 1995 and 2015. The decrease in of the length in national primary, state and county roads is due to re-classification into municipal roads.

Table A2: Timing of highway access

	Freq.	Pct.
1998	15	12.50
2000	8	6.67
2001	22	18.33
2002	9	7.50
2003	32	26.67
2004	12	10.00
2005	10	8.33
2006	4	3.33
2007	3	2.50
2015	5	4.17
Total	120	100.00

Notes: The table displays the absolute and relative frequency of municipalities falling under 10 km road distance to the next highway access by year. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use yearly data between 1998 and 2015.

Table A3: Anonymized values

	place of residence	place of work	inbound	outbound	firms
1998	0.00	0.03	0.04	0.03	0.00
1999	0.00	0.05	0.05	0.05	0.00
2000	0.00	0.06	0.06	0.06	0.00
2001	0.00	0.03	0.06	0.06	0.00
2002	0.00	0.07	0.07	0.06	0.00
2003	0.00	0.07	0.07	0.05	0.00
2004	0.00	0.07	0.07	0.06	0.00
2005	0.00	0.05	0.07	0.04	0.00
2006	0.00	0.05	0.09	0.05	0.00
2007	0.00	0.04	0.07	0.05	0.00
2008	0.00	0.05	0.08	0.05	0.00
2009	0.00	0.04	0.08	0.05	0.00
2010	0.00	0.15	0.17	0.05	0.00
2011	0.00	0.15	0.16	0.04	0.00
2012	0.00	0.14	0.15	0.03	0.00
2013	0.00	0.15	0.16	0.04	0.00
2014	0.00	0.15	0.16	0.04	0.00
2015	0.00	0.16	0.17	0.04	0.00
Total	0.00	0.08	0.10	0.05	0.00

Notes: The table displays the yearly share (mean) of anonymized values for our main dependent variables. The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use yearly data between 1998 and 2015.

Table A4: Baseline without merged municipalities

	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Access (<10 km)	-0.007	-0.117**	-0.129*	-0.000	-0.042
	(0.01)	(0.06)	(0.07)	(0.01)	(0.03)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.479	0.145	0.0802	0.414	0.0840
Number of mun.	548	540	535	547	540
Observations	9864	8772	8599	9289	8621

Notes: This table reproduces panel B of table 4 without merged municipalities. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

Table A5: Baseline - Sample until 2009

	Employees		Commuters		Firms
	(1) place of residence	(2) place of work	(3) inbound	(4) outbound	(5) firms
Access (<10 km)	0.001	-0.077*	-0.107**	-0.002	-0.027
	(0.01)	(0.04)	(0.05)	(0.01)	(0.02)
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Within R^2	0.515	0.183	0.109	0.182	0.0983
Number of mun.	728	720	714	727	719
Observations	8736	8262	8124	8325	7691

Notes: This table reproduces panel B of table 4 excluding the years 2010 to 2015. Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

Table A6: Summary statistics - Real estate offers

	Observations	Mean	SD
Detached house			
Price per m^2	150,187	1,112.68	695.35
Number of rooms	150,187	4.52	2.05
Area in m^2	150,187	140.03	65.95
Apartment building			
Price per m^2	9,708	714.31	578.39
Number of rooms	9,708	8.46	8.38
Area in m^2	9,708	357.28	369.10
Condominium			
Price per m^2	73,723	1,882.80	1,220.50
Number of rooms	73,723	2.93	1.75
Area in m^2	73,723	87.03	60.28
Commercial property			
Price per m^2	16,472	1,096.77	945.71
Number of rooms	16,472	4.00	6.35
Area in m^2	16,472	554.50	1,716.45

Notes: The observation units are the real estate properties offered for sale in the municipalities of the German state of Mecklenburg-Western Pomerania. We use data in levels during the period 2005 to 2015. For data protection reasons, we cannot show the minimum and maximum values of the variables.

Table A7: Descriptive statistics - Commuter data

	Observations	Mean	SD	Min	Max
Dependent variables					
Share inbound by place of residence:					
very peripheral	1,037	0.37	0.21	0	0.88
peripheral	790	0.24	0.16	0	0.73
central	276	0.17	0.18	0	0.69
city	1,755	0.08	0.14	0	0.65
Share outbound by place of work:					
very peripheral	1,710	0.33	0.19	0.0046	0.79
peripheral	1,783	0.30	0.20	0.020	0.77
central	679	0.16	0.19	0.0049	0.77
city	2,230	0.18	0.20	0	0.75
Control variables					
Distance to highway access (1995), in km	2,241	46.96	33.54	0.24	143.8
Location (categorical)	2,241	1.26	0.49	1	3
Distance to closest city, in km	2,241	29.93	15.18	1.04	77.4
Distance to Poland, in km	2,241	115.32	60.90	0.63	242.6
Population	2,241	2,232.31	9,367.86	110	203431
Dependency ratio	2,241	0.30	0.09	0.064	0.72
Population density	2,241	59.13	104.89	5.02	1122.3
Election mayor, share left	2,223	0.16	0.18	0	1
Election county assembly, share left	2,238	0.44	0.12	0.12	0.80
Election state assembly, share left	2,241	0.54	0.10	0.16	0.79
Share inbound (place of residence: access <10 km)	1,308	0.13	0.17	0	0.85
Share outbound (place of work: access <10 km)	2,188	0.18	0.21	0	0.78

Notes: The 745 municipalities of the German state of Mecklenburg-Western Pomerania are our observation units. We use data for the years 2002, 2008 and 2013. The location variable represents a categorical variable which takes on the value one for very peripheral municipalities, two for peripheral municipalities and 3 for central municipalities. Distance to the closest highway access is measured as road distance in km, while the other distance variables measure linear distance (to the closest city/to the Polish border).