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Timo Mitze and Philipp Breidenbach[1]

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Abstract

We use four subsequent EU enlargement waves over three decades (1980s, 1990s, 2000s) to assess the regional effects of macro-institutional changes. Our focus is set on EU internal border regions which are specifically exposed to international integration, but it remains unclear how they benefit from this exposure. Treatment effects for different outcomes (per capita GDP, labor productivity, employment, population, night light emissions) are estimated by comparing the performance of EU internal border regions to overall regional development trends in the EU. We find significant border effects that build up over time and decay with spatial distance to the enlargement border. While per capita GDP, labor productivity levels and night light emissions develop positively on average, negative effects are found for the employment rate in border regions. However, effects can be specific to enlargement waves and country groups considered: Border regions in established member countries mainly gain from EU enlargement in terms of increasing their GDP per capita and labor productivity levels but face lower employment rates and population decline. However, border regions in new member countries, particularly in 2004 and 2007, most significantly gain through population and employment increases. This complex pattern of effects makes a straight "winner-loser" categorization difficult and poses challenges to policy support for EU border regions.

JEL-Code: C23, F15, O47, R11

Keywords: Economic integration; EU enlargement; internal border regions; regional development; treatment effect estimation

March 2023

1 Timo Mitze, University of Southern Denmark and RWI; Philipp Breidenbach, RWI. – Conflict of Interest: The authors declare that they have no conflict of interest. – All correspondence to: Timo Mitze, Department of Economics, University of Southern Denmark, Campusvej 55, DK-5230 Odense, Denmark; Email: tmitze@sam.sdu.dk

1. Introduction

It appears straightforward to reason that regions located along the borders of economically integrating countries gain from this macro-institutional change. As borders are a natural barrier to economic interaction (Capello et al., 2018a), the dismantling of border impediments increases their market access and heaves border regions from the country's periphery to the heart of the newly formed economic block (e.g., Percoco, 2015). However, if borders have previously pertained for a long time, border regions may have suffered from a gradual marginalization process that potentially deprives them of the absorptive capacities and scale effects needed to benefit from economic integration more than their better endowed, more agglomerated non-border counterparts (Petrakos and Topaloglou, 2008; Floerkemeier et al., 2021). This may lead to a development trap in border regions (Diemer et al., 2022).

Border effect would also be absent if trade costs were sufficiently low so that closer geographical proximity to new markets itself is not a decisive factor for reaping the benefits of open borders and economic integration as it is, for instance, predicted in Krugman (1991)-type core-periphery models. And finally, socio-economic development levels in countries on both sides of the integration border may differ in such a way that the gains from economic integration are unevenly distributed across border regions. Thus, what seemed straightforward on a first glance, namely, to identify the treatment effects of economic integration for border regions along the integration border may, in fact, actually be quite complex. In this paper, we take this 'complexity' perspective as starting point for an in-depth study of the integration effects associated with four consecutive enlargement waves of the European Union between 1986 and 2007.

We argue that a focus on EU internal border regions is well deserved. First, as stated by the EU Commission (2017), these regions account for approximately 30% of EU population and a similar aggregate production share in the EU. At the same time, border regions generally perform less well economically than other regions within EU member states (EU Commission, 2017), labor market integration and public service provision are typically lower in border vis-à-vis non-border regions, which is why EU Regional Policy supports the development in border regions through different funding programmes (most notably through Interreg project funding or the b-solutions initiative, see EU Commission, 2021).

Second, beyond their status as being a specifically (disadvantaged) regional group within the wider internal economic geography of the EU, the EU Commission sees border regions also as important “living labs of European integration” (EU Commission, 2021). The idea of such living labs is that they allow to study integration effects in border regions under the magnifying glass and that findings obtained here provide important general insights on the overall progress of EU integration and cooperation at large. Extending this logic, we argue that EU internal border regions are particularly well-suited to measure the economic returns to EU economic integration at the regional level as they have been particularly exposed to the associated territorial shift in the EU’s internal geography, while the enlargement process itself can be seen as an exogenous source of variation to their development potential. The latter results from the fact that political decisions for the enlargement were made at the national and/or supra-national level with goals not specifically tailored to the needs and economic conditions of border regions. The same logic applies to the allocation of EU regional funding volumes, which focus more on the regions’ development status than their geographical location within a country (Breidenbach et al., 2019). We accordingly argue in this paper that the focus on border regions enables us to study effects of EU integration in a quasi-experimental manner.

Prior empirical evidence on growth and development premia associated with EU accession and the associated economic freedoms in the European single market has remained largely inconclusive. While, e.g., Campos et al. (2019) report significant positive income growth effects of EU membership at the country level (with few exceptions), Andersen et al. (2019) generally do not find evidence for an EU membership growth premium. There is also a knowledge gap on how the potential gains from economic integration are distributed across the different regions within integrating countries (Niebuhr and Stiller 2004, Braakmann and Vogel, 2004, and Heider, 2019). With regard to the inter-regional distribution of welfare gains induced by the process of economic integration, it is generally supposed that effects chiefly depend on a region's relative competitiveness driven by industry composition and settlement structure, its institutional setup, trade intensity as well size and geographical proximity to the enlargement border (e.g., McCallum, 1995; Brakman et al., 2012; Brülhart et al., 2012; Brülhart et al., 2018).

While earlier studies have mainly focused on GDP growth as sole outcome variable, a key novelty of our analysis is that we conduct a comprehensive empirical analysis of the complex border regional effects associated with the EU enlargement process during the 1980s, 1990s and 2000s. Specifically, we employ a broad set of outcome variables covering region-specific time patterns of per capita GDP, (sectoral) labor productivity and employment, population development and night light emissions. Night light emissions can thereby be regarded as a general measure for agglomeration trends as they also cover changes in housing stocks and infrastructure associated with private and public physical investments. Night light data has therefore previously been used to map population and firm density across regions (Mellander et al., 2015). Also, prior empirical analyses have used night light data to measure processes of economic integration, growth and convergence, especially when other economic data are missing (see, e.g., Henderson et al., 2012; Galimberti, 2020; Tang et al., 2021).

Four EU enlargement periods are covered in our analysis: First, the EU accession of Spain and Portugal in 1986 (third enlargement wave): second, the EU membership of Austria, Sweden, and Finland in 1995 (fourth enlargement wave); third, the so-far largest EU enlargement of mostly central and eastern European countries (hereafter called "NMS10") in 2004 (fifth enlargement wave); and fourth, the accession of Romania and Bulgaria to the EU in 2007 (sixth enlargement wave). To identify treatment effects of EU integration in border regions vis-à-vis non-border regions during these enlargement periods, we use a sample of 1,289 EU27 NUTS3 regions over the time period 1980-2014 and apply static and dynamic difference-in-difference (DiD) estimation.[2] The DiD approach has shown a high degree of flexibility and robustness when previously been applied to spatio-temporal analyses of border regional growth effects such as for the division and reunification of Germany (Redding and Sturm 2008) and economic transformations after the fall of the iron curtain (Brülhart et al., 2012, Brülhart et al., 2018) among other applications.

One key advantage of the flexible DiD approach is that it enables us to control for the fact that EU enlargement waves cannot be treated as precisely timed exogenous events. For example, in 2004, EU accession followed a gradual phasing-in process covering early agreements between old and new EU member states (Dangerfield, 2006), which have been initiated in the aftermath of the collapse of the Soviet system (Adam et al., 2003). This process may result in 'early anticipation' effects that weaken the power of static DiD estimations, which rely on a precise classification of a single pre- and post-treatment period. To account for these methodical challenges, the flexible DiD approach is specified in such a way that it estimates time-heterogeneous coefficients for the different stages of the integration process and thus allows us to meaningfully interpret any observed treatment effect. The same logic applies to gradual 'phasing-in' effects associated with delays in full access to the EU single market for new members states under the 2+3+2 rule.[3]

The remainder of this paper is organized as follows: Section 2 outlines the underlying theory related to border regional growth effects of economic integration, summarizes prior empirical

[2] The dynamic DiD model is also referred to as panel event study. See Section 3 for further details.

[3] The 2+3+2 rule is an institutional framework which enables EU member states to regulate (limit) the free movement of workers from new member states for up to seven years after their accession to the EU.

findings for the economic effects of EU enlargement and identifies gaps in the literature. Section 3 describes our empirical study design, which is followed by a description of the data and variables used in Section 4. Section 5 reports our empirical results for homogeneous and heterogeneous treatment effects of EU economic integration together with a series of robustness tests. Finally, Section 6 discusses policy implications and concludes the paper.

2. Border regional effects of economic integration: theory, evidence and gaps

2.1. A complexity perspective of economic integration

Models of regional growth, international trade, and economic geography stress the role of trade related to market size, market access and transport cost for regional development (e.g., Krugman and Venables, 1990; Percoco, 2015). It can be conjectured that border regions gain from EU enlargement due to their unique geographic location. These effects may, however, be partly or fully offset by sustaining border impediments, lacking absorptive capacities and this insufficient scale economies in border regions, which may reflect the regions' historical peripherality prior to integration (Petrakos and Topaloglou, 2008, Capello et al., 2018a-c).

Our conceptual approach, which takes these conflicting considerations into account starts with a fairly general specification of a regional production function defined as $\mathrm{Y} = A(K^{\alpha}L^{\beta}\mathbf{N}^{\varphi})$, where *Y* is a measure of regional output (typically GDP or GVA), *A* is technology, *K* is capital, *L* denotes labor input and **N** is a vector of further inputs; α, β and φ are the respective output elasticities. If we write this regional production function as growth specification in intensive form, we get

$$\Delta y_{it} = \Delta A_{it} + \alpha\, \Delta k_{it} + \sum_{r=1}^{R} \varphi_r \Delta n_{l,it} \qquad (1)$$

where Δy_{it} is as measure for per worker (or per capita) output growth for region *i* at time *t*, $y = Y/L$, $k = K/L$ and similar for the remaining inputs ($n_r = N_r/L$). In an earlier analysis with national data for the EU-15, Badinger (2005) has focused on two potential channels how economic integration affects Δy_{it} as: i) a technology channel ($\Delta A_{it} = \gamma_{A0} + \gamma_{A1}\Delta INT_{it}$) and ii) a physical investment channel ($\Delta k_{it} = \gamma_{k0} + \gamma_{k1}\Delta INT_{it}$) with ΔINT being an indicator for changes in the level of integration at time *t*; γ_{A0} and γ_{k0} are exogenous components of technological progress and capital formation, respectively. This logic can be straightforwardly extended to the integration effects of other inputs such as for input *r* as $\left(\Delta n_{r,it} = \gamma_{r,n0} + \gamma_{r,n1} \Delta INT_{it}\right)$ and we can measure the relative performance of border regions for these different inputs separately.

Alternatively, these input channels can be aggregated to an overall effect of economic integration on per capita income growth as

$$\Delta y_{it} = \delta_0 + \delta_1 \Delta INT_{it} \tag{2}$$

with $\delta_0 = \left(\gamma_{A0} + \alpha\gamma_{k0} + \sum_{r=1}^{r} \varphi\gamma_{r,n0}\right)$ and $\delta_1 = \left(\gamma_{A1} + \alpha\gamma_{k1} + \sum_{r=1}^{R} \varphi\gamma_{r,n1}\right)$.

Given our focus on border regions, eq.(2) can be extended by incorporating a spatial component into the analysis of growth effects from economic integration as

$$\Delta y_{it} = \delta_0 + \left(\rho_1 + \rho_2 \left(\frac{1}{DIST_i^{\theta}}\right)\right) \Delta INT_{it}, \tag{3}$$

where $\left(\frac{1}{DIST_i^{\theta}}\right)$ measures proximity for each region *i* to the newly integrated unit (with $DIST_i$ being some distance measure to the integration border or a specific point of interest across the border). Eq.(3) thus splits the growth effects of integration δ_1 into a general non-spatial component ρ_1 and a growth premium for regions with closer proximity to the border (ρ_2) with $\delta_1 = \rho_1 + \rho_2$. While distance/proximity can be measured in different dimensions (Boschma, 2005), we refine to geographical distance as a catch-all term for other forms such as cultural, social, and historical proximity. This extension reflects that benefits from economic integration do not affect each region equally, but those regions close to the integrated market have higher benefits as typically found in gravity-type models of inter-regional trade such as in McCallum (1995).[4] The parameter θ shown in eq.(3) expresses the

[4] Referring to the argument of intensified inter-regional trade in the course of EU enlargement, Figure A1 in the Supplementary Online Materials provides an overview of trade flows between German NUTS1 regions

power of distance decay. For instance, for sufficiently high values of θ, we expect to only observe a spatial growth premium for regions directly adjacent to the enlargement border. Different ways to empirically proxy the spatial proximity to the enlargement border will be presented below.

The role of distance decay as a factor determining trade cost and eventually output effects from economic integration is also stressed in models of the New Economic Geography (NEG). Krugman and Venables (1990), for instance, show for an NEG model application to the EU single market in 1992 that with reduced transport costs more firms may find it attractive to relocate in the periphery, i.e., Southern European accession countries, as a way take advantage of factor price differentials between countries. Other NEG models similarly predict that regions with a lower distance and thus transport cost to international markets reap the largest benefits from economic integration (Crozet and Koenig, 2004, Brülhart et al., 2004).

Behrens et al. (2007) and Monfort and Nicolini (2000) show in NEG model settings that a country's internal economic geography constitutes a significant conditioning factor for the regional economic effects of international economic integration. For instance, Rauch (1991) presents a model in which costal border regions are the main trade hub of a country. In this case border regions can particularly benefit from trade integration. Overman and Winters (2006), study the impact of UK accession to the larger European market and find evidence for this setup indicating that coastal (border)

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and their two neighboring Eastern countries (Poland and Czechia). What can be seen is that those German NUTS1 regions located in geographical vicinity to the enlargement border experienced a much stronger export growth to Poland and Czech Republic after 2004 than other German regions. In line with this stylized finding and with regard to the expected economic effects of EU integration for border regions, it can be hypothesized that improved cross-border exchange increases the regions' potential for economic development (see also EU Commission, 2001; Brülhart et al., 2004; Hanson, 2005; Brülhart, 2011).

regions hosting a port with better market access for exports and intermediate inputs experience higher employment compared to other similar regions.

If border regions suffer from locational disadvantages, model predictions may differ, though. Without scale effects emanating from locational advantages, consumers typically have to pay higher prices and firms can only supply goods to the market at higher costs when being located in a border region (Niebuhr and Stiller, 2004). Increased proximity to foreign markets of integrating countries then only allows border regions to grow faster than non-border regions if they possess specific territorial assets (Capello et al., 2018a). If such assets are missing, there is the risk of a 'tunnel effect', i.e., a bypassing of border regions after integration, which could further marginalize the development of border regions if trade patterns after EU enlargement are dominated by central core regions (Petrakos and Topaloglou, 2008). In this case, ρ_2 can be expected to be zero or even negative.

2.2. Prior empirical evidence and remaining gaps

Several empirical contributions have been concerned with the identification of growth effects of economic integration – though predominately at the national level (e.g., Henrekson et al., 1997; Badinger, 2005; Andersen et al., 2019; Campos et al., 2019). Bridging the gap between the available national and missing regional-level evidence, Monastiriotis et al. (2017) analyze the spatial effects of EU integration for Central and Eastern European (CEE) regions. Using an event-study approach, the authors find that the process of EU accession has particularly strengthened agglomeration forces in CEE countries favoring regions with a high market potential, industry concentrations and regional specializations in increasing returns sectors.[5]

[5] Niebuhr (2008) adds to this finding by studying the income effects of EU enlargement in 2004 using a three-region economic geography model calibrated with pre-accession data for 1995-2000. The simulation results

Brülhart et al. (2012) and Brülhart et al. (2018) analyze the wage and employment effects of trade liberalization caused by the fall of the iron curtain for Austrian border towns. Their empirical results indicate that the improved access to Eastern markets has a positive impact on employment and nominal wages in these regions vis-à-vis the rest of the country. The results in Brülhart et al. (2018) additionally suggest that larger cities benefit more strongly from the border shock in terms of wages, whereas smaller cities experience larger employment effects with a peak for towns with a population of around 150,000. Taken together, their evidence suggests that residents of medium-sized towns gain the most from a given opening of cross-border trade.

Brakman et al. (2012) focus on the population effects of EU integration in EU border regions. Analyzing data for 1,457 regions and 2,410 cities since 1973, the authors find evidence for positive population growth effects in border regions vis-à-vis non-border regions. This effect is found to be significant at the regional and urban level within a 70km radius from national borders. It holds for both sides of the integration border and amounts to roughly 0.15%. Relatedly, Heider (2019) focusses on the population growth effects of German and Polish border town in the course of the EU enlargement in 2004. The author finds evidence for positive population growth effects for German but not for Polish border towns.

While the majority of studies thus reports positive population and economic effects of trade liberalization and economic integration in border regions of the EU (particularly in the EU15), there is also empirical evidence for insignificant or negative effects as, for instance, reported in Braakmann and Vogel (2011) or Marin (2011). Using data for firms located in East Germany close to Germany's eastern border, Braakmann and Vogel (2011) find basically no short-run employment effects of the

indicate that border regions realize higher integration benefits than non-border regions with the strongest effects found for CEE regions along the former external EU15 border.

EU enlargement in 2004 except for firms active in wholesale and retail trade, hotels and restaurants. Negative wage effects are found for skilled workers in consulting, research and related activities. This points to sector-specific effects in border regions subject to EU enlargement. Studying employment growth from the perspective of firms in Central and Eastern European Countries (CEECs), Serwicka et al. (2022) find a significant increase in foreign investment and employment growth after the 2004 EU enlargement.

While the prior literature has started to shed light on regional effects of EU integration for selected outcomes, mainly income levels and individual enlargement waves, a comprehensive analysis of the complex spatial effects of EU integration over the last decades is still missing. We aim at closing this gap in the following.

3. Estimation setup

Our empirical identification strategy to uncover the growth effects of EU enlargement in border vis-à-vis non-border regions faces several challenges; these include i) the proper measurement of the timing of expected effects from EU enlargement together with ii) a suitable selection of border regions. With regard to the latter, we start from a benchmark specification which estimates treatment effects of integration for regions directly adjected to territorial border lines for the four different enlargement waves considered (1986, 1995, 2004 and 2007). We then extend this benchmark specification by including indirect border regions, i.e., higher-order neighbors of regions adjacent to the enlargement borders, in the treatment group to investigate spatial spillover effects of EU integration.

Regarding the timing of expected effects from EU enlargement, we allow our model to measure integration effects over time in a flexible manner. In extension to a baseline static DiD model, which identifies treatment effects on the basis of a strict definition of a pre- and a post-treatment period around the formal accession of new EU member countries, we adopt a flexible dynamic DiD approach. This allows us to account for leads and lags in the transmission process from EU enlargement to regional economic effects together with a staggered treatment start (in our case, the four different enlargement waves covered). The dynamic DiD approach is also referred to as panel event study (see, e.g., Schmidheiny and Siegloch, 2019; Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021). As outlined in Borusyak and Javarel (2020) dynamic DiD estimates may particularly be helpful to overcome a potential estimation bias in the static baseline approach that arises if treatment effects have a significant temporal pattern.

Another challenge relates to the potential problem of endogeneity as the event of EU accession cannot be seen as a source of exogenous variation to the national economic performance, especially for new member states. The two-way link between national development and EU accession mainly stems from the fact that a good economic performance partly reflects a successful transition policy and the adoption of certain institutions linked to democratic governance and a functioning market economy, which in turn are a prerequisite for signing accession agreements. Here, we follow the argumentation in Brakman et al. (2012) referring to the fact that EU enlargement did not primarily target the economic development in border regions and, hence, that this macroeconomic enlargement 'shock' can still be seen as an exogenous source of variation for border regions.

In addition, we lean on the empirical identification approach used in Monastiriotis et al. (2017) and specify regional growth models that control for observable and unobservable regional time-fixed and time-varying characteristics that are assumed to influence regional economic growth besides the pure enlargement effect. Thus, by embedding our empirical identification approach in the well-established related literature on the regional effects of EU enlargement and economic integration, we can ensure to properly measure the relative growth effects of EU enlargement waves for border regions.

Based on the conceptual framework presented in Section 2, we focus on DiD estimations controlling for regional characteristics in the analyses. As multiple economic effects of the European integration are conceivable, we run the model with different outcome measures such as the growth rate of GDP per capita, labor productivity, employment and population growth, as well as night light emissions. In order to allow a straightforward identification, we adapt a standard approach of regional growth models extended by the integration effect shown in eq.(3). Formally, our baseline static DiD approach takes the following form

$$outcome_{it} = \beta'\mathbf{x}_{it} + \delta \underbrace{\left(d_i^{Border} \times d_t^{EU}\right)}_{\left[\left(\frac{1}{DIST_i^{\theta}}\right) \times \Delta INT_{it}\right]} + \mu_i + \left(\xi_{c(i)} \times \lambda_t\right) + \varepsilon_{it}, \qquad (4)$$

where $outcome_{it}$ denotes the (log-transformed) outcome level in region *i* at time *t*, which is specified as a function of (log-transformed) regional covariates ($\mathbf{x}_{it}$), region fixed effects (μ_i) and country-year fixed effects $\left(\xi_{c(i)} \times \lambda_t\right)$, where $\xi_{c(i)}$ denote country fixed effects, with regions grouped to countries, and λ_t are time fixed effects. While region fixed effects are included to capture latent, time-invariant regional differences that are not covered in $\mathbf{x}_{it}$, the inclusion of country-year fixed effects shall additionally control for structural time-varying differences in the macroeconomic environment of regions, e.g., national effects of EU integration, national business cycle movements or national policy interventions (Ahrend et al., 2017). This likely increases the homogeneity of border and non-border regions in the light of structural differences across countries and thus works in favor of the common trend assumption of DiD models (Lechner 2011).[6]

[6] Further assumptions needed to ensure the consistency of the DiD estimator are i) exogeneity of the included control variables with regard the treatment and outcome, ii) common support implying that no other systematic factors are varying across geography and over time and iii) the absence of relevant interactions between the members of the population, which is also referred to as the stable unit treatment value assumption

Our main regression parameter of interest is δ. It measures the relative border regional outcome effect of EU enlargement for the included DiD term $\left(d_i^{border} \times d_t^{EU}\right)$, which is constructed as interaction term of a treatment group dummy for border regions (d_i^{border}) and a time dummy that measures the associated timing of EU enlargement (d_t^{EU}), which may differ for each enlargement wave. Specifically, the interaction term takes a value of one from 1986 onwards for internal border regions affected by the second EU enlargement wave (and similarly for 1995, 2004 and 2007, respectively) and is zero before that year. As shown in eq.(4), the focus on border regions along the integration border as default treatment group (measured as those NUTS-3 regions with territorial overlap to the integration border) implicitly chooses a very high distance decay parameter θ as baseline specification. During the course of the analysis, we also design a more flexible distance indicator, which is defined by a set of dummies indicating different distances to the integration border. These dummies relax any assumption on the functional form of the distance decay of border effects.

Moreover, eq.(4) measures EU integration effects in a static setup by comparing the average relative outcome comparison between treated and non-treated regions after EU enlargement took place. If δ is found to be statistically significant and positive, this indicates that border regions along the internal territorial border between old and new member states have grown faster than other EU regions in the post-enlargement period. We also test for differences in effect size across enlargement waves and country groups.

The baseline regression setup is extended in two dimensions. A first extension relates to the dynamic nature of EU integration effects. We can do so by estimating time-specific treatment effects in line with the literature on dynamic DiD or panel event studies (see above). The specification of a

(SUTVA, see Rubin 1977). We use alternatively composed treatment groups to account for spatial spillovers that may affect the SUTVA.

flexible dynamic DiD estimator has the advantage that it accounts for potential lead and lag structures in the distribution of the economic integration effect on regional growth processes over time. The underlying assumption is that economic integration effects captured by the coefficient of the DiD term (δ) in eq.(4) are not uniformly distributed over time. We capture temporal lead- and lag-effects as

$$outcome_{it} = \beta'\mathbf{x}_{it} + \sum_{s=-N}^{M} \delta_s\left(d_i^{border} \times d_{t0+s}^{EU}\right) + \mu_i + \left(\xi_{c(i)} \times \lambda_t\right) + \varepsilon_{it}, \qquad (5)$$

where the index $s = -N, \ldots, M$ denotes the maximum number of leads (-*N*) and lags (*M*) relative to the respective EU enlargement date (*t0*) considered for estimation in order to account for the presence of dynamic integrations effects for different time periods (Schmidheiny and Siegloch, 2019). Our data setup 1980-2014 ensures that we at least five lead years and seven lag period for all four enlargement waves (except for night light emissions, which is only available from 1992 onwards).[7] Importantly, the dynamic DiD specification measure effects relative to treatment start for each enlargement wave. The advantage of this flexible DiD estimation procedure is that it ensures an equal weighting of all integration waves, facilitates the estimation of incremental effects of economic integration and allows to test for the presence of Ashenfelter's dip (Ashenfelter, 1978), i.e., early anticipation effects. Borusyak and Javarel (2020) provide a discussion of consistency problems associated with static approaches when time dynamics is present.

[7] For this reason, we also exclude the 1981 EU accession of Greece as additional treatment. Besides, by the time of EU accession, Greece did not share any territorial border with an established EU country so that no treatment group can be identified here.

A second extension accounts for the fact that economic integration may not only have an impact on direct border regions but also the broader geographical neighborhood. Clarke (2017) has recently pointed out that the stable unit treatment value assumption (SUTVA) underlying DiD estimation may be too strong when dealing with regional data to estimate treatment effects. The reason is that territorial borders are porous and may give rise to spatial spillovers. In order to estimate unbiased treatment effects in the presence of spillovers. Clarke (2017) proposes the use of a weaker condition than SUTVA, which relies on the assumption that there exists at least some subset of units which are not affected by the treatment status of others. As it can be assumed that those economic actors living in regions close to treated (border) regions are able to either partially or fully access treatment, the subset of regions unaffected by the treatment can be determined by their (geographic, economic etc.) distance to treated units.

We can capture this mechanism by including a set of treatment group dummies $\left(d_i^k\right)$, where the index k=g,…,G indicates the total number of treatment group dummies included in the empirical specification. Each of the K treatment groups thereby represents a slice of space, for instance, defined by a specific maximum geographical distance g relative to the enlargement border. This process can be seen as testing for incremental changes in economic integration effects over space, where the hypothesis from standard inter-country and inter-regional trade models is that a potential growth effect of economic integration decreases with further distance to the border. We combine this spatialized treatment indicator with the time dynamic representation from above to identify incremental growth effects of EU integration over space and time as

$$outcome_{it} = \beta' \mathbf{x}_{it} + \sum_{s=-N}^{M} \sum_{k=g}^{G} \delta_{s,k} \left(d_i^k \times d_{t0+s} \right) + \mu_i + \left(\xi_{c(i)} \times \lambda_t \right) + \varepsilon_{it}. \qquad (6)$$

Eq.(6) shows the most general (space-time) flexible DiD estimator and allows us to conduct a grid search for significant coefficients over slices of time and space to provide a comprehensive assessment of the border regional growth effects of EU enlargement.

4. Data and variables

We use 1,289 NUTS3 regions as spatial units of observation and set the estimation period to 1980-2014. These data settings allow us to work on a finely granulated spatial level with a sufficiently long observation period to include leads and lags for all covered EU enlargement waves (except for night light emissions, which are only available from 1992 onwards). The data set is unbalanced since observations for East Germany and Central and Eastern European regions are only recorded from 1991 onwards. However, this does not affect the maximum number of lead and lag terms used for the identification of treatment effects in the flexible DiD case since those regions are only subject to later, i.e., the 2004 and 2007, EU enlargement waves.

We apply a comprehensive testing approach for different outcome variables to capture the potentially complex effects of EU integration on internal border regions. The set of outcome variables includes:

$outcome_{it}$ = {GDP per capita, (sectoral) labor productivity, (sectoral) employment rates, regional population levels, night light emissions}.[8]

In all cases, we test for differences in (log-transformed) levels in these variables between the respective treatment and comparison groups. To give an example, in the case of per capita GDP we

[8] While the latter variable is collected as raw DMSP (Defense Meteorological Program) data from the Radiance Light Trends Application (lightrends.lightpollutionmap.info) for 1992 onwards, all other variables are taken from the European Regional Database (ERD) provided by Cambridge Econometrics.

test for static and dynamic treatment effects by comparing GDP levels across groups before and after EU enlargement. If we find significant differences in GDP levels, these can be interpreted as temporary short- to mid-run growth effects in the light of our fixed effects specifications and the theoretical arguments outlined in Section 2. Variable definitions and summary statistics are given in Table 1.

Geographical information on the EU's internal territorial borders is extracted from a shapefile on administrative units in the EU obtained from Eurostat. Direct border regions for the enlargement waves 1986, 1995, 2004 and 2007 are defined as those regions whose administrative boundaries intersect with a corresponding NUTS3 region from a new member state (and vice versa).[9] By this definition, the enlargement in 2004 marks the biggest enlargement wave with 4.6% of all observed regions defined as direct border regions (Table 1). The 1995 enlargement wave covers 2.6% of the regions and 1986 (2007) only 0.8% (0.7%). As sketched above, our sample design allows us to measure treatment effects of economic integration in border regions for at least five years prior to and seven years after the institutional changes for all four EU accession waves.

[9] See Capello et al. (2018b) for a discussion of alternative methods to define border regions.

Table 1: Definitions and summary statistics for variables used in the empirical analysis for 1,289 NUTS3 periods during 1980-2014

Variable	Description	Mean	S.D.	Min.	Max.
GDPpc	Per capita GDP (in 1,000 Euro, in 2005 prices)	20.114	11.070	1.083	188.679
Yprod	Labor productivity defined as Gross Value Added (GVA) per employee (in 1,000 Euro)	40.974	17.292	1.238	310.492
Yprod (Agriculture)	> Agriculture (NACE Rev. 2, Sector code A)	22.777	35.174	0.002	2048.154
Yprod (Construction)	> Construction Sector (F)	37.553	18.350	0.209	420.587
Yprod (Industry excl. Construction)	> Industry excl. Construction (B-E)	50.004	37.242	0.538	1157.735
Yprod (WR services, I&C)	> Wholesale, retail, transport, accommodation & food services, information and communication (G-J)	35.210	15.872	1.044	299.409
Yprod (Financial & Business services)	> Financial & business services (K-N)	94.973	62.386	1.094	2028.800
Yprod (Non-market services)	> Non-market Services (O-U)	33.515	14.325	0.485	287.712
Emprate	Employment per population in region (1=100%)	0.433	0.108	0.121	1.224
Emprate (Agriculture)	> Agriculture (NACE Rev. 2, Sector code A)	0.037	0.054	0	0.816
Emprate (Construction)	> Construction Sector (F)	0.033	0.013	0	0.188
Emprate (Industry w/o. Construction)	> Industry excl. Construction (B-E)	0.092	0.052	0.001	0.539
Emprate (WR services, I&C)	> Wholesale, retail, transport, accommodation & food services, information and communication (G-J)	0.108	0.042	0.007	0.362
Emprate (Financial & Business services)	> Financial & business services (K-N)	0.046	0.033	0.000	0.397
Emprate (Non-market services)	> Non-market Services (O-U)	0.118	0.048	0.006	0.417

Table 1 (continued): Definitions and summary statistics for variables used in the empirical analysis for 1,289 NUTS3 periods during 1980-2014

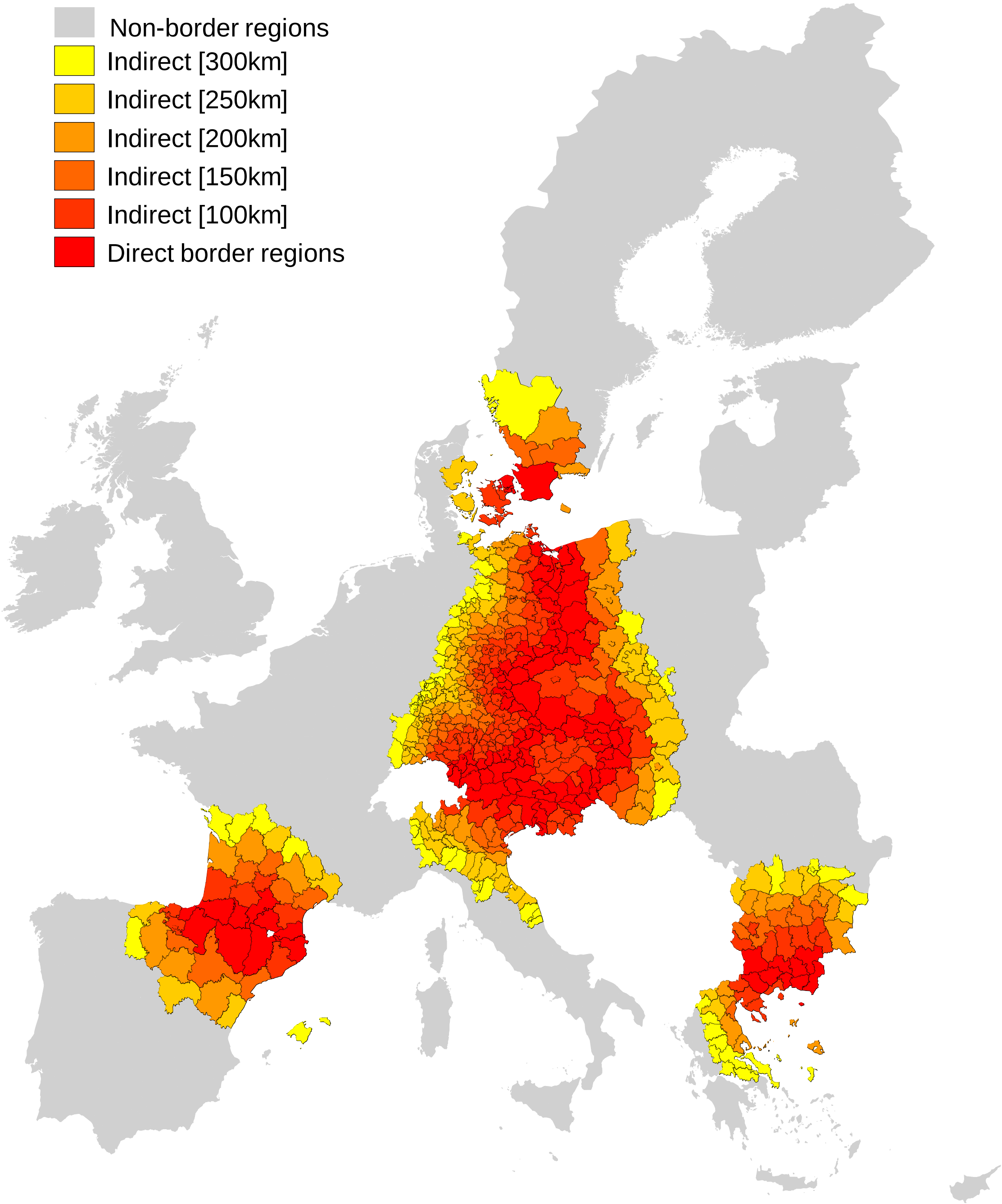
Variable	Description	Mean	S.D.	Min.	Max.
Empshare (Agriculture)	Sectoral employment share for agriculture in total regional employment (1=100%)	0.090	0.116	0	0.920
Empshare (Construction)	Sectoral employment share for construction in total regional employment (1=100%)	0.077	0.032	0	0.442
Empshare (Industry w/o. Construction)	Sectoral employment share for industry excl. construction (manufacturing sectors) in total regional employment (1=100%)	0.212	0.100	0.002	0.799
Empshare (WR services, I&C)	Sectoral employment share for wholesale and retail services, Information & Communication in total regional employment (1=100%)	0.249	0.063	0.017	0.610
Empshare (Financial & Business services)	Sectoral employment share for financial and business services in total regional employment (1=100%)	0.101	0.054	0.000	0.726
Empshare (Non-market services)	Sectoral employment share for non-market services in total regional employment (1=100%)	0.272	0.081	0.022	0.644
Pop	Population level of NUTS3 region (in 1,000 persons)	370.476	428.355	6.748	6418.41
Nlight	Night light emission level per NUTS3 region	17.251	15.536	0	63
Border regions (Enlargement 1986)	Binary dummy for direct border regions of EU enlargement in 1986 (see Figure 1)	0.008	0.088	0	1
Border regions (Enlargement 1995)	Binary dummy for direct border regions of EU enlargement in 1995 (see Figure 1)	0.026	0.160	0	1
Border regions (Enlargement 2004)	Binary dummy for direct border regions of EU enlargement in 2004 (see Figure 1)	0.046	0.209	0	1
Border regions (Enlargement 2007)	Binary dummy for direct border regions of EU enlargement in 2007 (see Figure 1)	0.007	0.083	0	1

Note: Data at the level of NUTS3 regions; all data (except for night light emissions) have been gathered from the European Regional Database (ERD) of Cambridge Econometrics (version 2017). Night light emission data have been extracted from: https://lighttrends.lightpollutionmap.info/#zoom=0&lon=0.00000&lat=33.78523

To measure the degree of spatial neighborhood effects, we define indirect border regions based on their geographical distance from the border. To do so, we calculate for all regions not classified as direct border regions the geographical distance from the region's centroid to the closest location at the border. Using 50km threshold distances g with k = {100km, 150km, …, 300km}, we then build additional treatment group dummies for regions within these 50km distance belts from the border and test for spatially distributed integration effects (with k = 0km being direct border regions along the integration border).[10] A graphical overview of direct and indirect border regions for our sample of 1,289 NUTS3 regions is given in Figure 1.

[10] All distances are calculated based on the regions' centroids. We merge the first two slices of 50km and 100km distances as there are few indirect border regions with a maximum distance of 50km to the enlargement border.

Figure 1: Direct and indirect border regions for EU enlargement 1986, 1995, 2004 and 2007



Notes: Information on the territorial borders of EU NUTS3 regions has been obtained from the GISCO statistical unit dataset available at: https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts

5. Empirical results

Baseline. Table 2 reports the estimation output for our baseline static DiD specification according to eq.(4). Accounting for the full set of fixed effects including country-specific time trends as most general specification to account for latent time-varying confounding factors, three significant findings emerge: First, border regions relatively increase their labor productivity to non-border regions (Panel A) and have higher levels of night light emissions (Panel E) as a general measure for agglomeration effects including population and establishment density (Mellander et al., 2015). Effect size points to a roughly 4-5% relative increase in labor productivity and night light emission levels. However, the development of the employment rate falls behind the overall EU-trend during the sample period by around 3% (for an average employment rate of approx. 43% in our data sample).

Table 2: Baseline treatment effects of EU enlargement for direct border regions

Specification	(i)	(ii)	(iii)
PANEL A: GDP per capita			
EU enlargement	0.0475***	0.0313**	0.0258**
	(0.01215)	(0.01274)	(0.01280)
R^2	0.65	0.78	0.79
Obs.	42,012	42,012	41,974
PANEL B: Labor productivity			
EU enlargement	0.0719***	0.0530***	0.0492***
	(0.01330)	(0.01350)	(0.01256)
R^2	0.52	0.72	0.74
Obs.	42,012	42,012	41,974
PANEL C: Employment rate			
EU enlargement	-0.0252**	-0.0268***	-0.0277***
	(0.00998)	(0.00979)	(0.00948)
R^2	0.15	0.38	0.46
Obs.	42,012	42,012	41,974
PANEL D: Population			
EU enlargement	-0.0086	-0.0012	-0.0064
	(0.00822)	(0.00845)	(0.00784)
R^2	0.18	0.41	0.43
Obs.	42,012	42,012	41,974
PANEL E: Night light emissions			
EU enlargement	0.0804***	0.0474***	0.0427***
	(0.01620)	(0.01247)	(0.01203)
R^2	0.51	0.80	0.81
Obs.	27,065	27,065	27,041
Region FE	YES	YES	YES
Time FE	YES	YES	YES
Time × Ctry FE	NO	YES	YES
Regional controls	NO	NO	YES

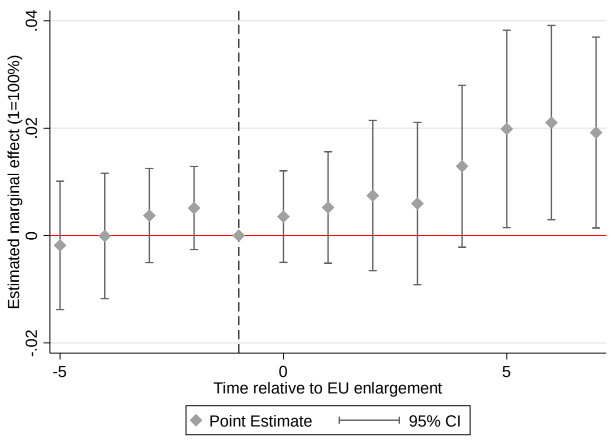
Notes: ***,**,*= denote significance at the 1%, 5% and 10% critical level; robust standard errors clustered at the regional level are given in brackets. Sample period 1980-2014; 1289 NUTS3 regions.

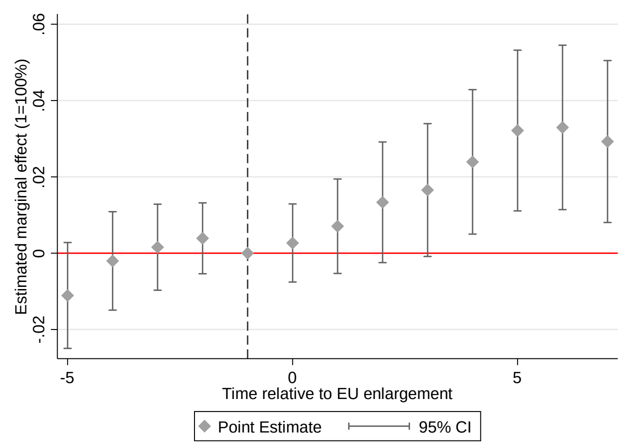
Dynamic effects. Static treatment regressions may be biased if estimated effects show significant patterns of early anticipation or gradual phasing-in. Figure 2 therefore plots the results of a flexible DiD approach, which estimates yearly treatment effects relative to the timing of EU enlargement. The pre-enlargement year (t–1) is used a reference year against which pre- and post-enlargement effects are evaluated. The results mainly confirm the static treatment effect estimates by showing positive and significant effects for labor productivity and night light emissions. Estimated annual effects are of similar magnitude as predicted in the baseline static DiD estimates. In addition, Panel A of Figure 2 also reports a positive and significant relative GDP per capita development in EU internal border vis-à-vis non-border regions. Maximum effect size for the 7-year lag period considered is an GDP per capita increase of about 2% (compared to 2.6% in the baseline static estimation approach). Annual treatment effects for labor productivity levels are found to range between 2% and 4% during the first seven years after EU enlargement. The temporal distribution of GDP and productivity effects point at a levelling out of additional growth effects after approximately 5-7 years, which supports the view of a medium-term growth bonus associated with EU integration (Baldwin and Wyplosz, 2015; in't Veld, 2019).

Except for population development we do not find any sign of early anticipation effects prior to treatment start, which would point to potential confounding factors in the analysis. Instead, effects turn significant with a time lag of 4-5 years after the enlargement took place. This indicates that positive economic effects from economic integration need to unfold until they are fully visible in the regional economy. Likely reasons for this gradual phasing-in process are that associated private and public investment effects typically only show up over time (Breidenbach et al., 2019; Eberle et al., 2019). Similarly, labor market opening followed a gradual pattern determined by the 2+3+2 rule regulating employment access in incumbent EU member states by citizens of new EU member after an up to seven years transition period. Also, the Schengen entry of new member countries (particularly for the 2004) followed EU accession with a temporal lag of about three years. Compared to the static baseline case, the flexible DiD estimates show negative, albeit marginally statistically insignificant effects of EU enlargement on the employment rate in internal border regions (Panel C, evaluated at 95% confidence intervals). The dynamic estimates also confirm positive and statistically significant increases in night light activity as general proxy for agglomeration effects in border regions.

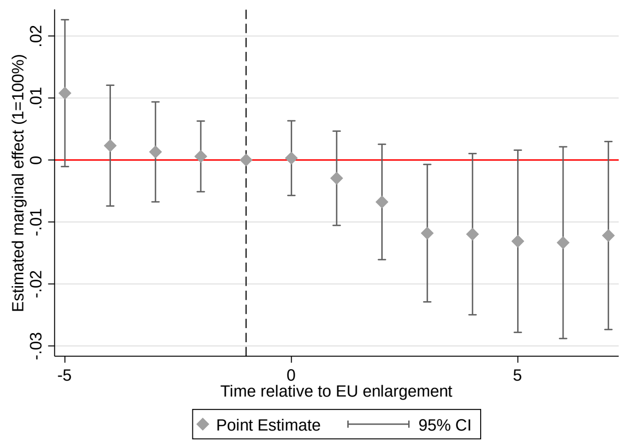
Figure 2: Dynamic treatment effects of EU enlargement on border regions

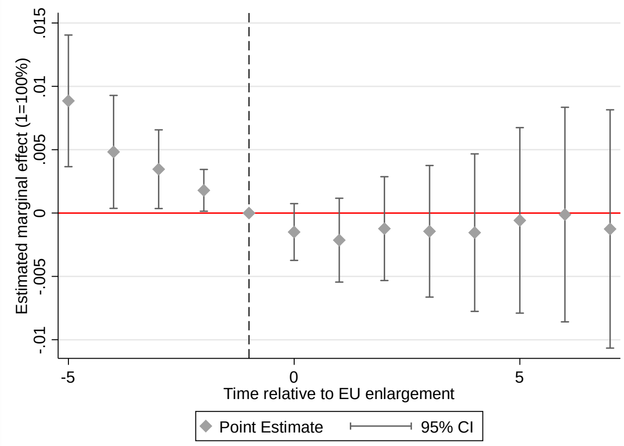
Panel A: GDP per capita Panel B: Labor productivity



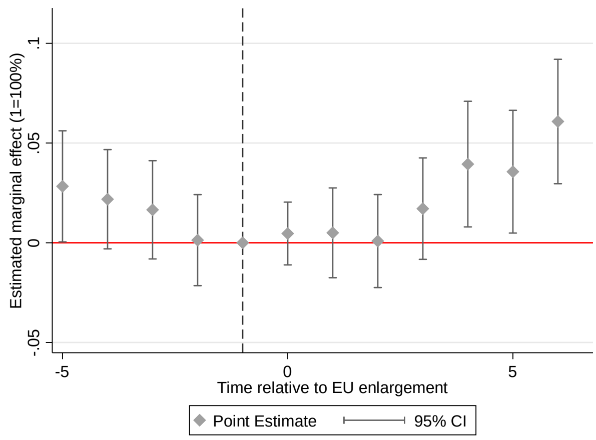


Panel C: Employment rate Panel D: Population level





Panel E: Night light emissions



Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

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Spatial spillovers. Next, we look at the extent of spatial spillovers in the estimated treatment effects from EU integration. Table 3 reports the results from baseline DiD regressions, which add indirect border regions based on their geographical distance (in 50km slices) to the enlargement border to the default treatment group as visualized in Figure 1. Given that very few indirect border regions have a distance of 50km to the enlargement border (while to not belong to the group of direct border regions), those regions have been merged with the 100km slice of indirect border regions.

Table 3: Treatment effects of EU enlargement by distance to enlargement border

Specification	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Outcome	**GDP per capita**	**Labor productivity**	**Employ-ment rate**	**Population**	**Night light emissions**
Direct border	0.0543***	0.0870***	-0.0318***	-0.0043	0.0746***
	(0.01449)	(0.01413)	(0.01076)	(0.00868)	(0.01450)
Indirect (100km)	0.0581***	0.0735***	-0.0092	0.0058	0.0460***
	(0.01329)	(0.01217)	(0.00798)	(0.00753)	(0.01142)
Indirect (150km)	0.0512***	0.0693***	-0.0102	0.0013	0.0670***
	(0.01653)	(0.01596)	(0.00937)	(0.00877)	(0.01193)
Indirect (200km)	0.0471***	0.0631***	-0.0057	-0.0082	0.0314***
	(0.01220)	(0.01195)	(0.00886)	(0.00781)	(0.01199)
Indirect (250km)	0.0266**	0.0401***	-0.0038	0.0031	0.0385***
	(0.01039)	(0.01041)	(0.00730)	(0.00680)	(0.01197)
Indirect (300km)	0.0007	0.0024	0.004	0.0053	0.0027
	(0.01279)	(0.01173)	(0.00952)	(0.00649)	(0.01013)
R^2	0.79	0.74	0.46	0.43	0.81
Obs.	41,974	41,974	41,974	41,974	27,041
Region FE	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES
Time × Ctry FE	YES	YES	YES	YES	YES
Regional con-trols	YES	YES	YES	YES	YES

Notes: ***,**,*= denote significance at the 1%, 5% and 10% critical level; robust standard errors clustered at the regional level are given in brackets. Sample period 1980-2014; 1289 NUTS3 regions.

As the results show in Table 3 show, the inclusion of additional treatment dummies for indirect border regions does not alter the effect size found direct border regions (as reported in Table 2 and Figure 1). In addition, we observe that indirect border regions experience treatment effects of the same direction but with diminishing size as the distance to the border increases. These spillover effects are especially observed for GDP per capita, labor productivity and night light emissions. From 300km onwards effects are absent. This observed decay in effects is in line with previous findings such as Brakman et al. (2012) and Brülhart et al. (2018). The results thus point to the theoretical argument that increased market access in the process of EU integration is a major development factor for EU internal border regions. The negative effect on the employment rate is limited to direct border regions.

Table 4 summarizes the main effects from individual flexible DiD estimates for the different groups of indirect border regions. Effects enter as being "positive" or "negative" in the table if at least one yearly post-treatment effect is estimated to be statistically significant (evaluated at 95% confidence intervals). Brackets in Table 4 indicate that significant post-treatment effects are found but also that pre-treatment trends were present. The latter limit the validity of estimated treatment effects. Detailed visualizations of the annual treatment effects by treatment group and outcome variable are given in the appendix.

Table 4: Summary of dynamic treatment effects by distance to internal enlargement border

Dynamic treatment effects (Geo distance to border)	**Positive**	**Negative**
GDP per capita	Direct border regions (Indirect border [100km]) Indirect border [200km] Indirect border [250km]	
Labor productivity	Direct border regions (Indirect border [100km]) Indirect border [200km] Indirect border [250km]	(Indirect border [300km])
Employment rate	Indirect border [250km]	Direct border regions
Population		Indirect border [200km] (Indirect border [250km])
Night light emissions	Direct border regions Indirect border [200km] Indirect border [250km]	(Indirect border [100km])

Notes: Reported are treatment groups with a significant positive/negative treatment effect for at least one post-treatment period. Brackets indicate significant pre-treatment effects. Detailed regression results are plotted in the appendix. Underlying dynamic DiD estimates include region FE, year FE, country-year FE and regional controls. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

The flexible dynamic DiD results summarized in Table 4 underline the presence of spatial spillover effects up to a maximum distance of 250km to the integration border. While almost all static and dynamic effects point to patterns of positive spatial correlation of effects, the flexible DiD results for the relative development of night light emissions point to negative spatial correlation between direct border regions and their immediate hinterlands [100km]. The latter pattern may point to some relocation effects taking place with economic activity moving out of the hinterlands closer to the enlargement border. Further, different from the development in direct border regions, the flexible DiD estimates report some evidence for positive employment rate effects in the hinterlands of border regions.

Structural heterogeneity. Differences in treatment effect patterns may be driven by structural (macro-)regional heterogeneity along the integration border and underlying compositional effects associated with region-sector combinations, which may not be fully captured by our set of regional controls (sectoral employment shares). To gain a deeper understanding of the underlying mechanisms at play, we disaggregate effects by enlargement waves (Panel A of Table 5) and country groups, i.e., we distinguish between effects for border regions in old (established) and new member states for each EU enlargement wave (Panel B of Table 5). Especially the enlargement waves in 2004 and 2007 saw larger structural differences between established EU member countries and CEECs in their transition from planned to market economies after the fall of the iron curtain. This meant that per capita income levels, labor productivity and labor market parameters were significantly different in established (old) EU member countries and newly joining CEECs in 2004 and 2007.

Table 5: Disaggregated treatment effects for different EU enlargement waves and country groups

Specification	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Outcome	**GDP per capita**	**Labor productivity**	**Employ-ment rate**	**Population**	**Night light emissions**
PANEL A: Symmetric effects across border regions in old and new EU member states					
Border region× Enlargement 1986	0.0298 (0.01856)	0.0326 (0.02164)	0.0030 (0.01378)	0.0091 (0.03198)	n.a.
Border region× Enlargement 1995	0.0324 (0.02370)	0.0532** (0.02201)	-0.0309** (0.01235)	0.0371*** (0.00950)	0.0867*** (0.02896)
Border region × Enlargement 2004	0.0207 (0.01593)	0.0469*** (0.01300)	-0.0274*** (0.01046)	-0.0409*** (0.00956)	0.0326** (0.01344)
Border region × Enlargement 2007	-0.0319 (0.03533)	-0.0049 (0.01310)	-0.0331 (0.07558)	-0.0084 (0.02406)	0.0250 (0.03904)
R^2	0.79	0.74	0.46	0.44	0.81
Obs.	41,974	41,974	41,974	41,974	27,041
PANEL B: Asymmetric effects across border regions in old and new EU member states					
Border region (old) × Enlargement 1986	0.0379 (0.03066)	0.0031 (0.02905)	0.0134 (0.01176)	0.0344 (0.04181)	n.a.
Border region (old) × Enlargement 1995	0.0764** (0.03176)	0.0978*** (0.02774)	-0.0268* (0.01538)	0.0308** (0.01248)	0.0969*** (0.03437)
Border region (old) × Enlargement 2004	0.0370* (0.01944)	0.0543*** (0.01612)	-0.0175 (0.01142)	-0.0582*** (0.01218)	0.0216 (0.01592)
Border region (old) × Enlargement 2007	-0.0451 (0.05206)	0.1085 (0.10202)	-0.1778** (0.08244)	-0.0049 (0.02981)	-0.0216 (0.04854)
Border region (new) × Enlargement 1986	0.0214 (0.01993)	0.0633** (0.02683)	-0.0078 (0.02473)	-0.0171 (0.04609)	n.a.
Border region (new) × Enlargement 1995	-0.0526*** (0.02037)	-0.0345 (0.02488)	-0.0371* (0.01998)	0.0487*** (0.01268)	0.0666 (0.05150)
Border region (new) × Enlargement 2004	-0.0341 (0.02425)	0.0141 (0.02179)	-0.0533** (0.02082)	0.0038 (0.00735)	0.0558** (0.02381)
Border region (new) × Enlargement 2007	-0.013 (0.04175)	-0.1738*** (0.06490)	0.1816*** (0.05834)	-0.014 (0.03987)	0.0865 (0.05343)
R^2	0.79	0.74	0.46	0.44	0.81
Obs.	41,974	41,974	41,974	41,974	27,041
Region FE	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES
Time FE × Ctry FE	YES	YES	YES	YES	YES
Regional controls	YES	YES	YES	YES	YES

Notes: ***,**,*= denote significance at the 1%, 5% and 10% critical level; robust standard errors clustered at the regional level are given in brackets. Sample period 1980-2014; 1289 NUTS3 regions.

As Panel A shows, the estimated positive treatment effects for labor productivity and night light emissions are mainly driven by the 1995 and 2004 enlargement waves. Similarly, negative effects on the employment rate and population development are also established for these waves. Panel B of Table 5 further indicates that estimated treatment effects not only differ across enlargement waves but are also determined by the regions' development level and, hence, the region's absorptive capacity at the timing of integration. Positive productivity effects of the 1995 and 2004 enlargement wave are captured by border regions in established (old) EU countries. For these regions the 1995 enlargement also induced general agglomeration effects measured in terms of a positive population development and increases in night light emissions relative to non-border regions.

This effect is less significant for border regions in established EU member countries during the fifth enlargement wave in 2004. Relative population levels are observed to decline in the process of EU integration. On the other hand, border regions in new EU member states grow in terms of general agglomeration effects (night light emissions) in 2004 and a strong increase in the employment rate by approximately 17% in 2007. The latter strong effect is likely driven by persistent wage differences between established EU countries (Greece) and Bulgaria and Romania as the two last CEECs joining in 2007. Only in the aftermath of the 1986 EU enlargement, border regions in new member countries benefit in terms of a productivity increase.

The overall treatment effects for the static DiD estimates across enlargement waves and country groups as shown in Table 5 are largely supported by dynamic treatment effect estimates as summarized in Table 6. Underlying individual regressions can be found in the appendix. What is visible from Table 6 is that the most general positive effect of EU integration for border regions is observed with regard to overall agglomeration effects (especially night light emissions). This finding is in line with a border population effect of EU integration identified in Brakman et al. (2012).

As Table 6 summarizes, the economic returns of EU integration differ by outcome variables. Border regions in established (old) EU member countries benefit mostly in terms of GDP per capita and labor productivity increases. At the same time, these regions suffer from a relative decline in employment rates. As sketched above, most border regions gain (both across enlargement waves and country groups) in terms of population and agglomeration effects (night light emissions). This supports the view that EU integration can reshape a country's internal geography and move border regions out of the (dark) periphery. However, interpreting changes in night light emissions should be done carefully as the data may be imprecise (Henderson et al., 2012, Rybnikova and Portnov, 2014) and further analyses would thus be needed to confirm the observed spatial patterns.

Table 6: Summary of dynamic treatment effects by country group and enlargement wave

Dynamic treatment effects	**Positive**		**Negative**	
(Country group by wave)	*Old*	*New*	*Old*	*New*
GDP per capita	1995, 2004			1995
Labor productivity	1995, 2004	1986		2007
Employment rate		2007	1995, 2007	(1995), 2004
Population	1995	1995, 2004	2004	
Night light emissions	1995	2004		

Notes: Reported are treatment groups by enlargement wave with a significant positive/negative treatment effect for at least one post-treatment period. Brackets indicate significant pre-treatment effects. Detailed regression results are plotted in the appendix. Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Finally, we check for sector-specific patterns associated with positive (or negative) integration effects in border regions. These effects are summarized in Table 7 for labor productivity (Panel A) and employment rates (Panel B); underlying estimation results can be found in the appendix. Our data allow to analyze effects separately for Agriculture (NACE Code: A), construction (C), industry (excl. construction (B-E), wholesale, retail, transport, accommodation & food services, information and communication (G-J), financial & business services (K-N) and non-market services (O-U).

Regarding labor productivity, we can see a clear differences in effects when we distinguish between border regions in old (established) and new EU members. For the enlargement waves 1995 and 2004, for which we already observed an overall increase in labor productivity, we see that the aggregate effect is mainly driven by productivity growth in 1) industrial production (sector B-E; effect up to +12%) and 2) financial and business services (sector K-N; effect between +6 to +9%). Given the large share of these two sectors in the gross value added of most European countries, these two particular sector-specific effects largely determine the effect of the overall economy. At the same time, for these sectors we observe overall negative treatment effects on productivity in border regions of new member state (particularly for the 2007 enlargement wave).

While negative productivity in regions of new member states may point to business relocations among the most productive firms, a closer look at the development of sector-specific employment rate shows that the effect is also driven by employment increases in border regions of new member states after the enlargement. Again, this effect is particularly significant for the 2007 enlargement wave and for the industrial sector together with wholesale & retail activity, transport, accommodation & food services, information and communication (sector G-J; effect up to +20%). Border regions in new EU member states associated with EU enlargement 1995 see a shift in employment towards industrial production and construction and away from service sector employment. Similarly, service sector employment declines in the aftermath of the 2004 EU enlargement in new member states. This pattern may indicate that sectors sensitive to spatial wage differences and changes in transport costs such as industrial production and the construction sector increase employment in border regions of new EU member states. Competition on local labor market may thereby reduce service sector employment. Apart from these significant effects, the results in Table 7 show a less clear sectoral picture for the development of the employment rate in border regions after EU enlargement, For instance,

Table 7: Disaggregated treatment effects for labor productivity and employment rate by sectors

Treatment effects	**Positive**		**Negative**	
(Country group by wave	*Old*	*New*	*Old*	*New*
Labor productivity				
Sector A			1995	2007
Sector C	1995, 2004		2007	
Sector B-E	1995, 2004, 2007			2007
Sector G-J	1995			
Sector K-N	1995, 2004, 2007	1986	1986	2007
Sector O-U	1986, 1995, 2004			2007
Employment rate				
Sector A		2007	1986	1995
Sector C		1995	2004, 2007	
Sector B-E		1995, 2007		
Sector G-J		2007		2004

Sector K-N				1995, 2004
Sector O-U				1995, 2004, 2007

Notes: Reported are treatment groups with a significant positive/negative treatment effect at the 90% critical level. Detailed regression results are plotted in the appendix (Table A1). Underlying static DiD estimates by sectors include region FE, year FE, country-year FE and regional controls. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions. Sector codes (NACE, Rev. 2) are: A = Agriculture; C = Construction; B-E = Industry excl. Construction; G-J = Wholesale, retail, transport, accommodation & food services, information and communication; K-N = Financial & business services; O-U = Non-market Services.

6. Discussion and Conclusion

This paper has studied the local economic effects of four EU enlargement waves in 1986, 1995, 2004 and 2007 using a comprehensive evaluation design. Our particular emphasis on direct and spatially indirect border regions as treated units goes along with the distinct focus of EU policy makers to closely monitor the performance of EU internal border regions (European Commission 2017, 2021). This monitoring reflects worries about the specific challenges of border regions, which typically experience lower development levels than non-border regions in the light of their remoteness related to limited market access, public service provision etc. Accordingly, it is of key interest for policy makers to gain insights on factors that improve their economic development potential and, hence, studying the regional effects of economic integration may add to the latter.

Theoretical approaches from international trade, standard location theory and the new economic geography indicate that border regions are particularly exposed to EU enlargement and can be expected to respond positively to this economic integration process. However, from a theoretical perspective also negative integration effects may be in order. We take up this ‘complexity’ challenge in our empirical identification approach, which uses multiple outcome variables and applies flexible difference-in-difference estimation for EU NUTS3 regions over the period 1980-2014.

Several distinct effects emerge: Overall, we find evidence for positive productivity and agglomeration effects in border regions subject to EU enlargement. However, effects vary by enlargement wave and country groups considered. While increases in overall socio-economic activity measured in terms of light night emissions are estimated as an overarching positive development trend for EU internal border regions, productivity gains are mostly experienced by border regions in established (old) member states. This is contrasted by increases in employment rates in border regions of new member states particularly after the 2004 and 2007 enlargements.

In new member states, positive employment effects cover different sectors, most notably agriculture and industrial production. EU enlargement found to exhibit positive spatial spillovers to the hinterlands for direct border regions and is estimated to gradually phase in over time. The latter temporal distribution of treatment effects is likely due to the gradual change of institutions after EU accession (particularly in 2004 and 2007), which temporarily protected labor markets in established EU member countries from wage competition through the labor force of EU accession countries. Similarly, border impediments such as passport-free border crossing associated with the Schengen area were fully implemented some years after EU accession of CEECs.

The complexity of estimated regional effects poses some challenges to the working of EU regional policy support schemes to boost growth and cohesion in EU border regions as a means to reduce the prevailing structural differences in border regions compared to non-border regions. Beside the specific support of firms in border regions to access larger markets and transnational networks (Schäffler et al. 2017) or the adoption of proper institutions (Pinkovskiy 2017), our results suggest that ongoing integration and a consequent facilitation of cross-border trade and mobility should be supported to accelerate economic development in border regions. Existing literature (see, e.g., Bosker et al. 2010, Kashiha et al. 2017, Capello et al. 2018a-c) shows that national borders still have strong impacts on trade and economic prosperity within the European Union and that border regions may be particularly affected by development traps (Diemer et al., 2022) and exogenous shocks such as the recent COVID-19 pandemic limiting international economic exchange (Capello et al., 2022). This leaving ample space for future integration efforts aiming to support the economic cooperation and development of border regions.

Future studies should also more carefully disentangle the effects of institutional changes and financial policy support given to EU border regions. This calls for in-depth studies zooming-in individual enlargement waves that further investigate differences in effects for border regions of different type (e.g., urban versus rural regions) and located in different countries. For instance, in the case of the 2004 accession treatment effects in established EU countries may differ between East German, Austria and Italy given their post-enlargement market access. As such, East German regions are located in close proximity to the large Polish market with roughly 10% of EU population. East German regions have also seen a significant modernization of their infrastructure endowments after German re-unification, which is identified as an important prerequisite for a balanced spatial development path in the progress of economic integration (Behrens, 2011). Finally, historical ties between East Germany and the NMS10 under the Soviet system may have given East German regions a relative advantage in cross-border interactions over other EU15 border regions. Despite the limitation of our aggregate approach, which cannot cover all underlying heterogeneities in border regions, we -though- hope the novel findings reported here can be of value for the academic and political discourse about the benefits and costs of economic integration for the internal economic geography of the newly formed integrated country block.

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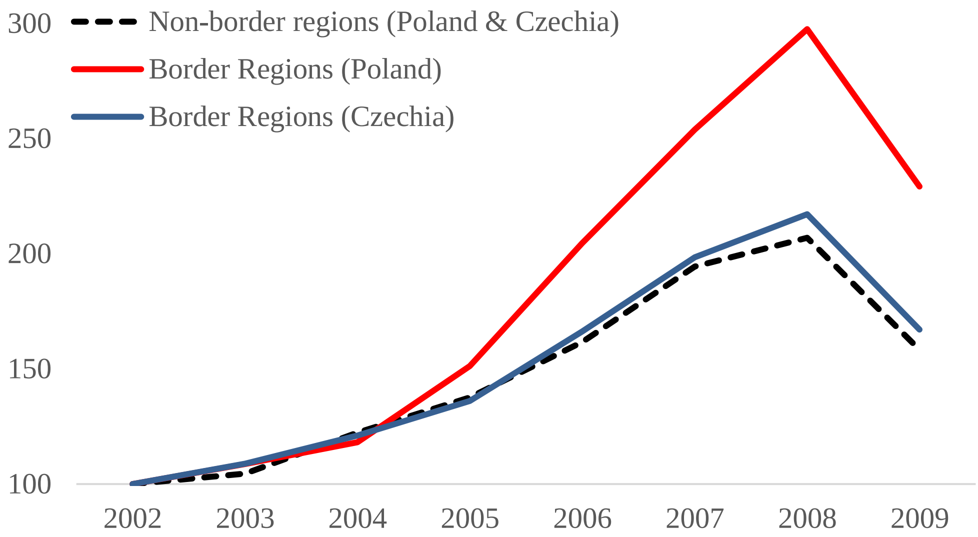
Appendix

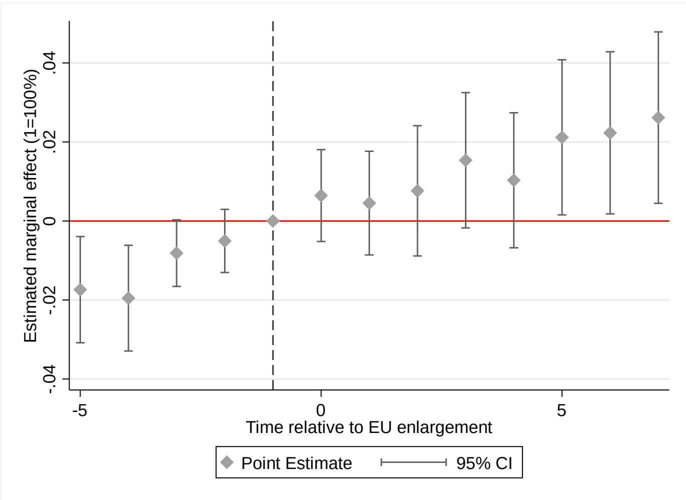
Figure A1: Exports index of German border regions (NUTS1) with Poland and Czechia (2002 = 100)

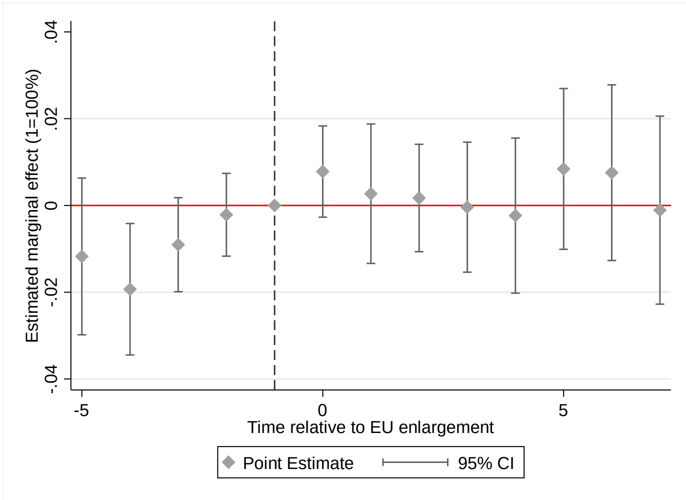


Source: Own figure based on data from German Federal Statistical Office (Destatis, 2020), Table 51000-0032: Foreign Trade: Federal States, Years, Country

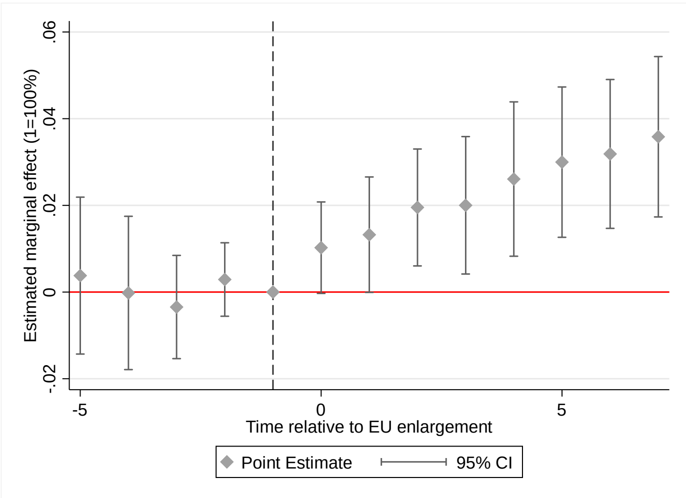
Figure A2: Dynamic treatment effects for indirect border regions (GDP per capita)

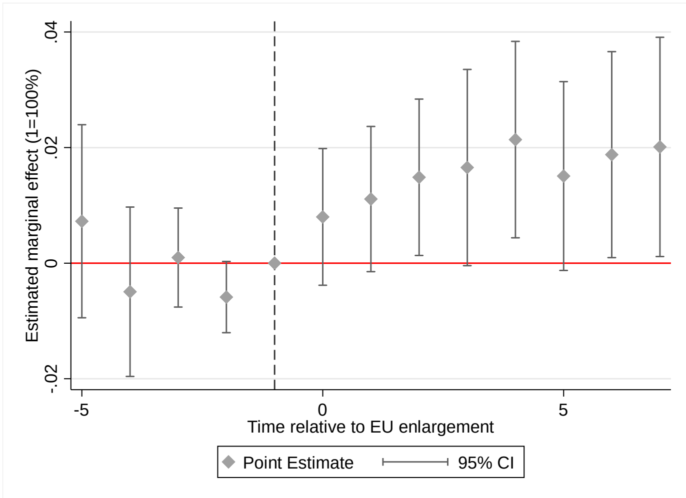
Panel A: 100km   Panel B: 150km



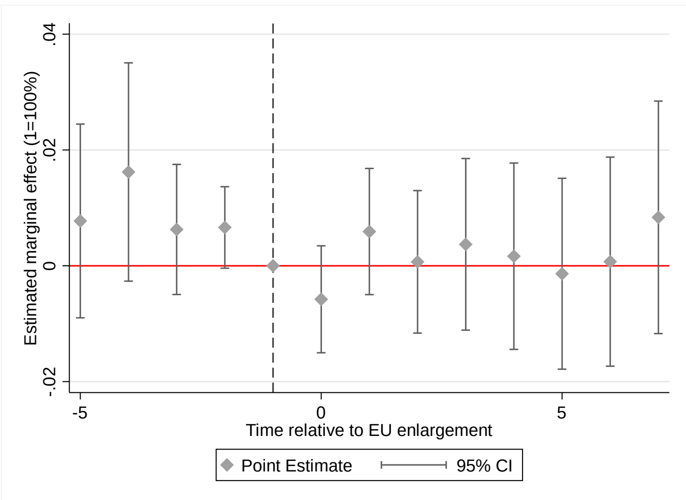


Panel C: 200km   Panel D: 250km





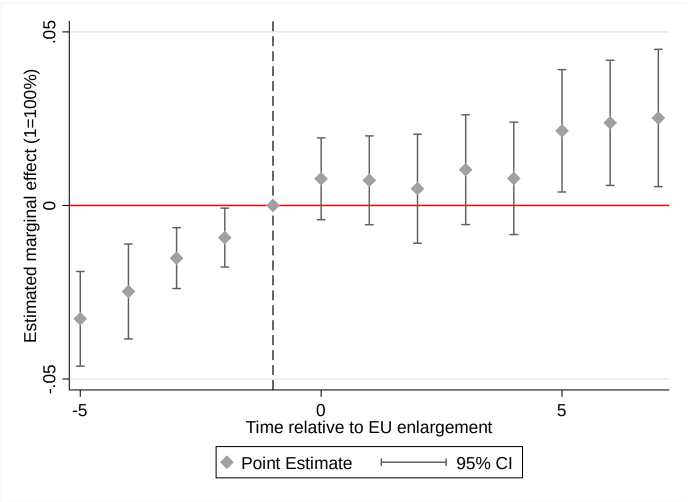
Panel E: 300km

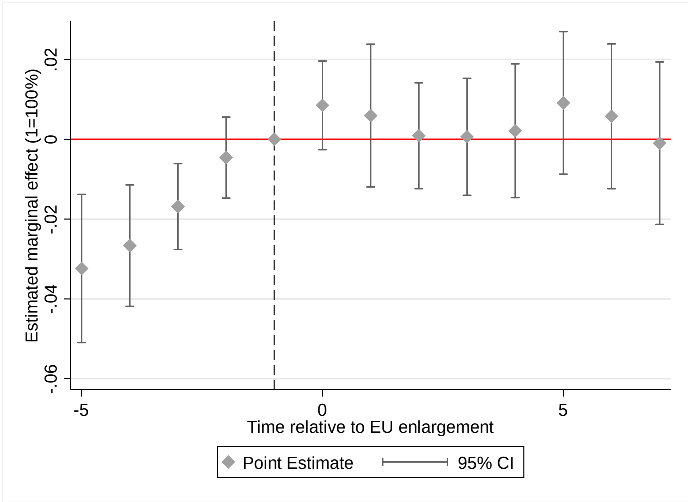


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

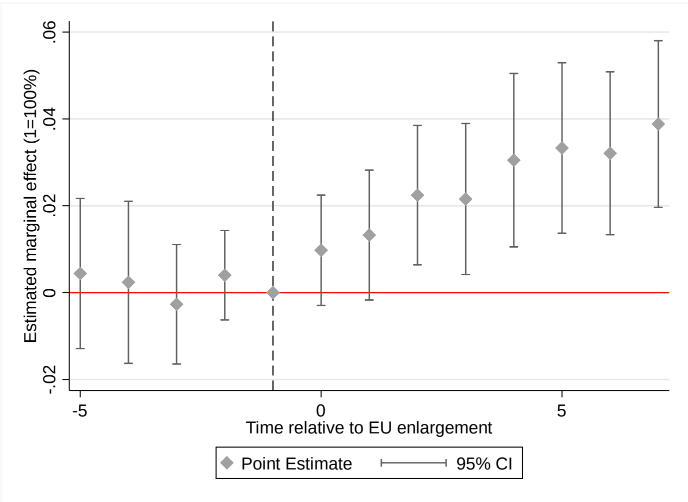
Figure A3: Dynamic treatment effects for indirect border regions (Labor productivity)

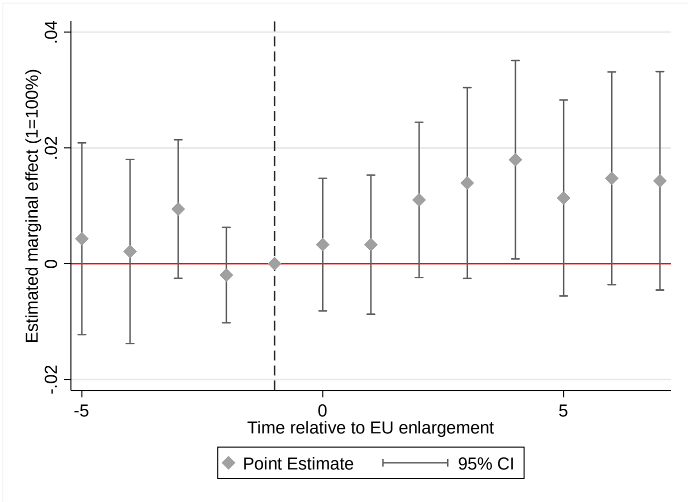
Panel A: 100km Panel B: 150km



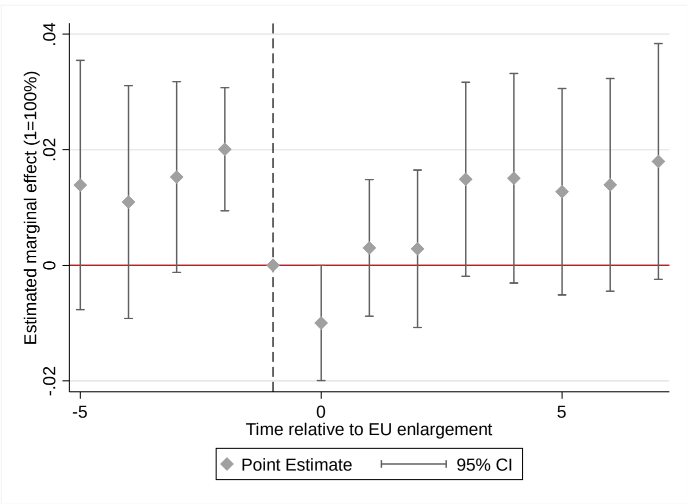


Panel C: 200km Panel D: 250km





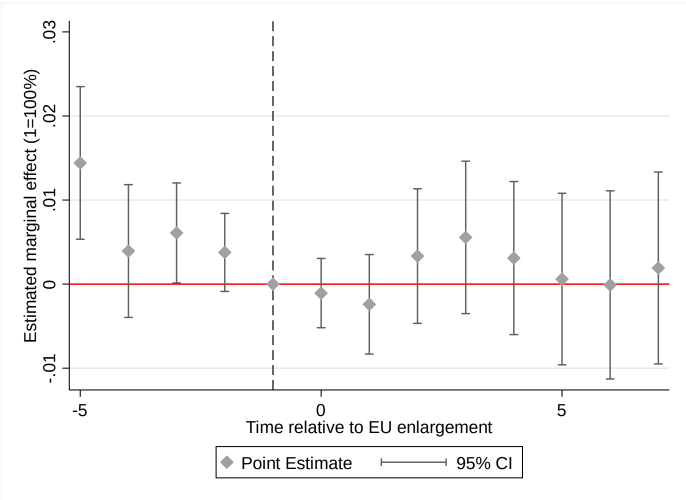
Panel E: 300km

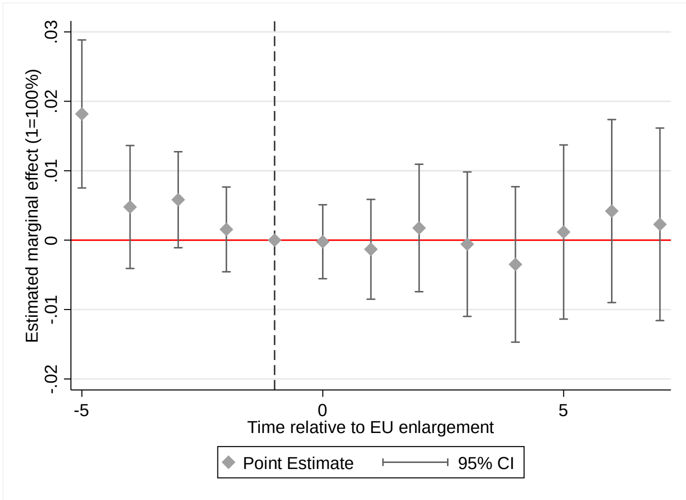


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

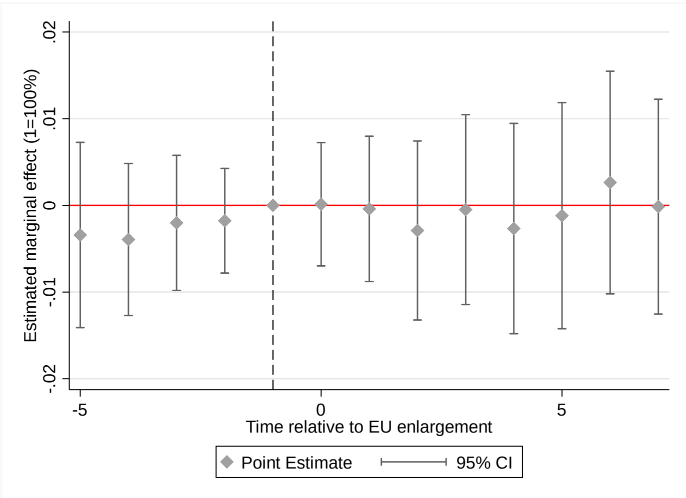
Figure A4: Dynamic treatment effects for indirect border regions (Employment rate)

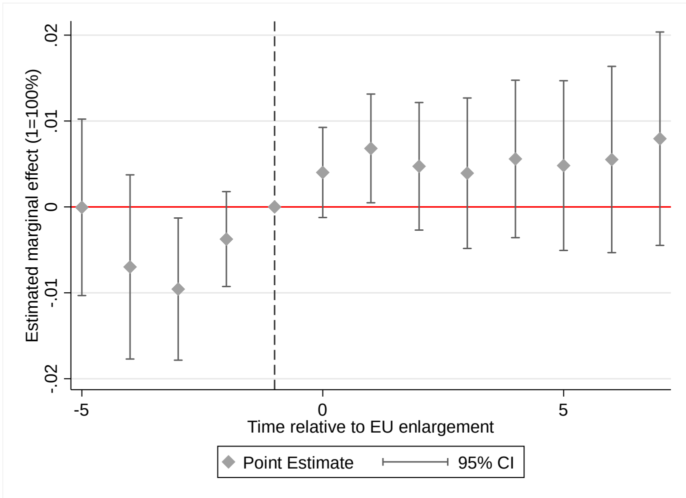
Panel A: 100km Panel B: 150km



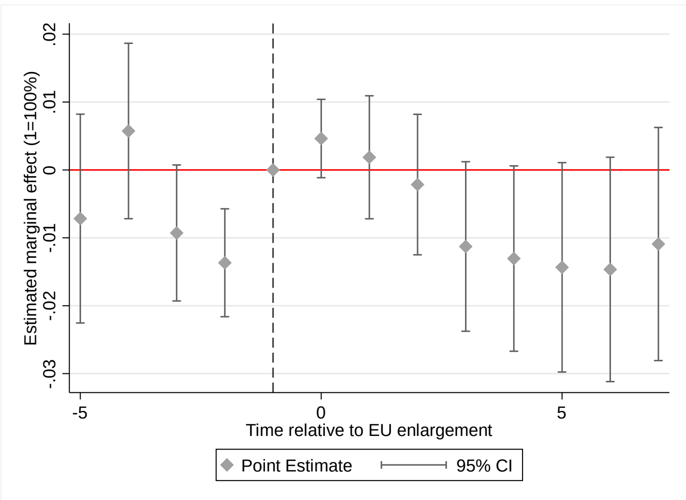


Panel C: 200km Panel D: 250km





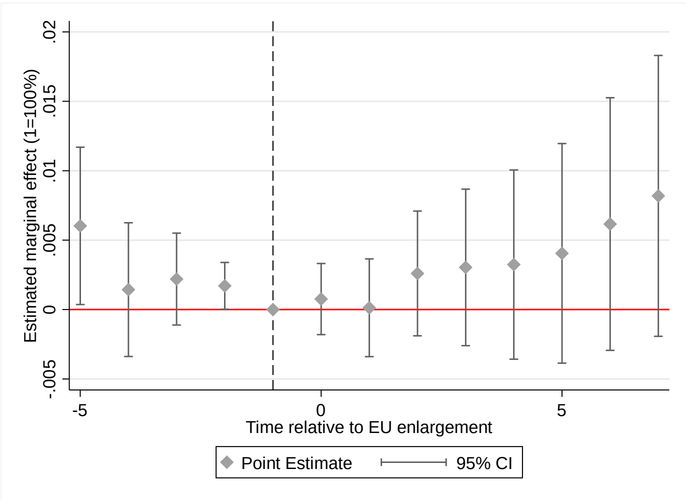
Panel E: 300km

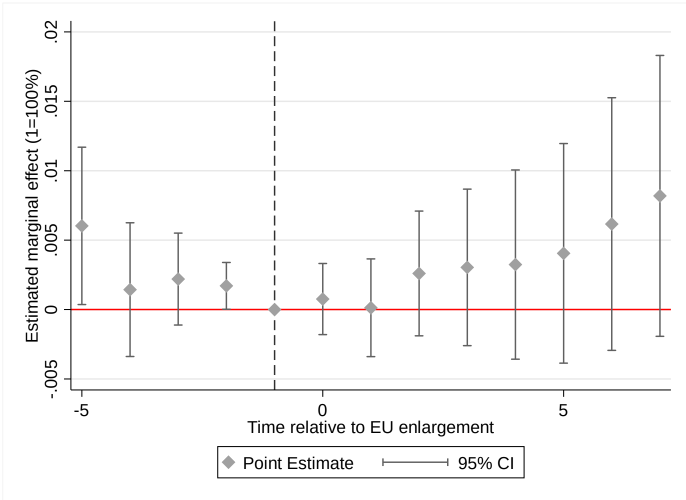


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

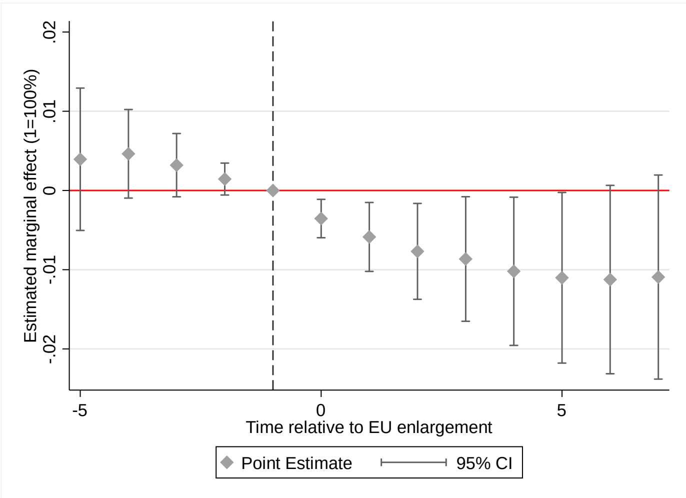
Figure A5: Dynamic treatment effects for indirect border regions (Population levels)

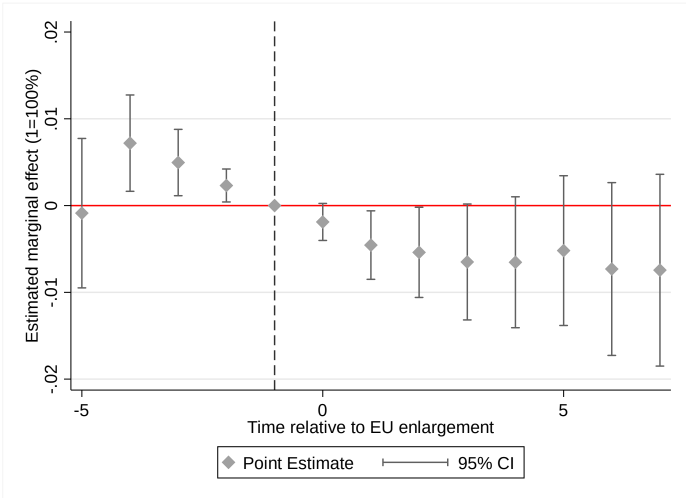
Panel A: 100km   Panel B: 150km



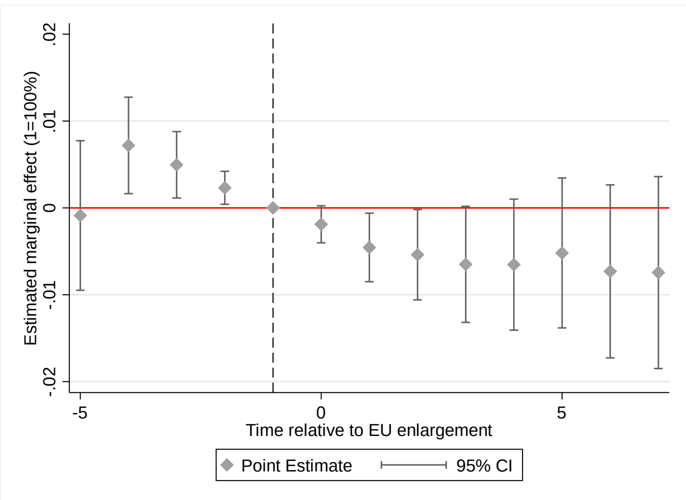


Panel C: 200km   Panel D: 250km





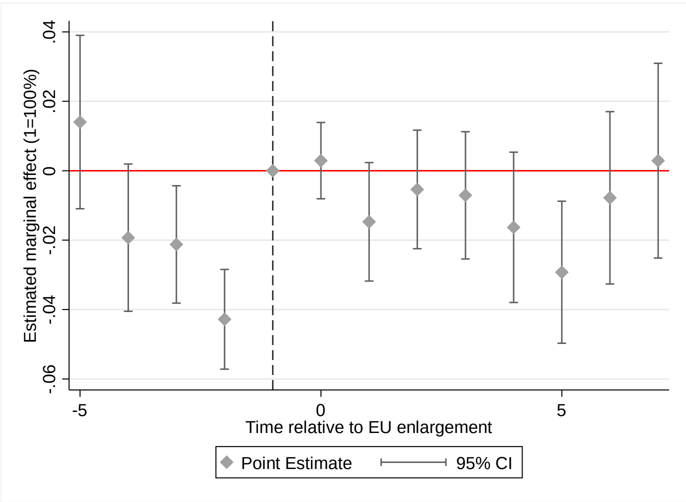
Panel E: 300km

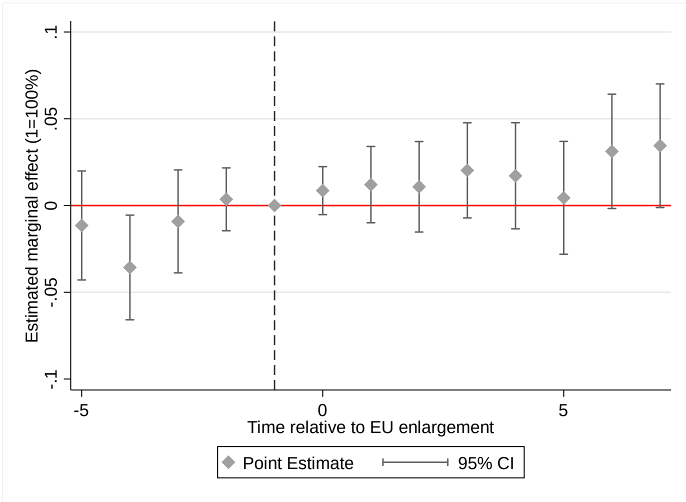


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

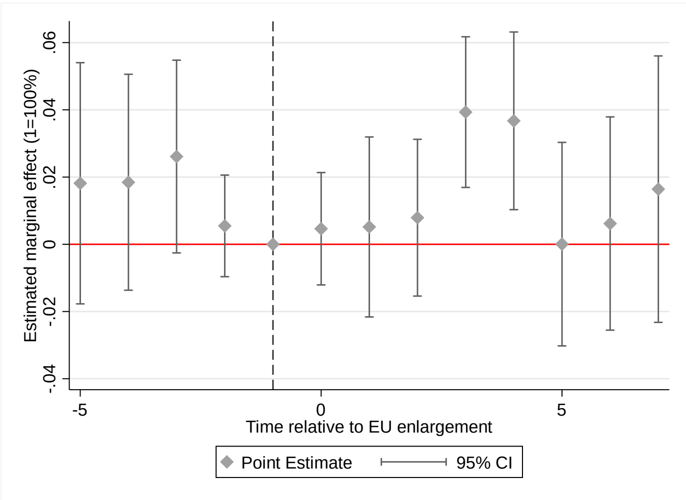
Figure A6: Dynamic treatment effects for indirect border regions (Night light emissions)

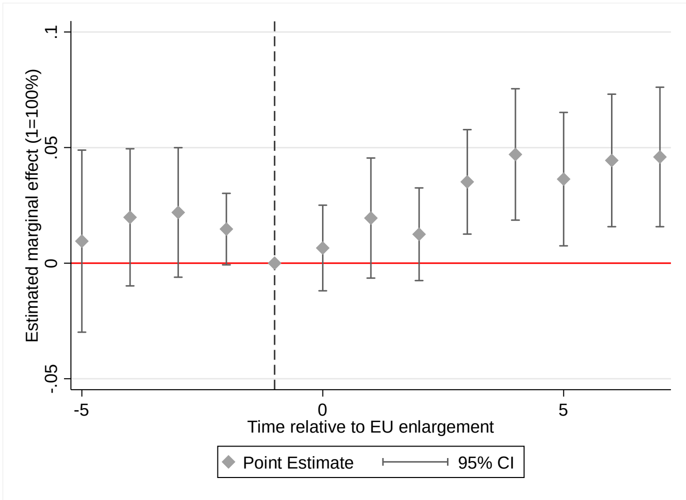
Panel A: 100km Panel B: 150km



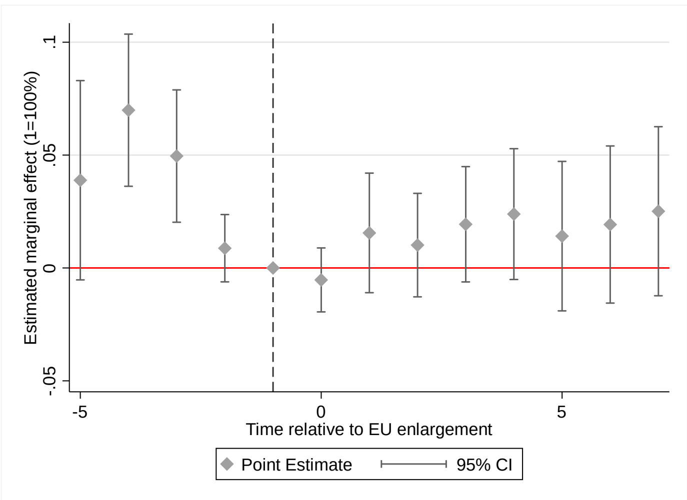


Panel C: 200km Panel D: 250km





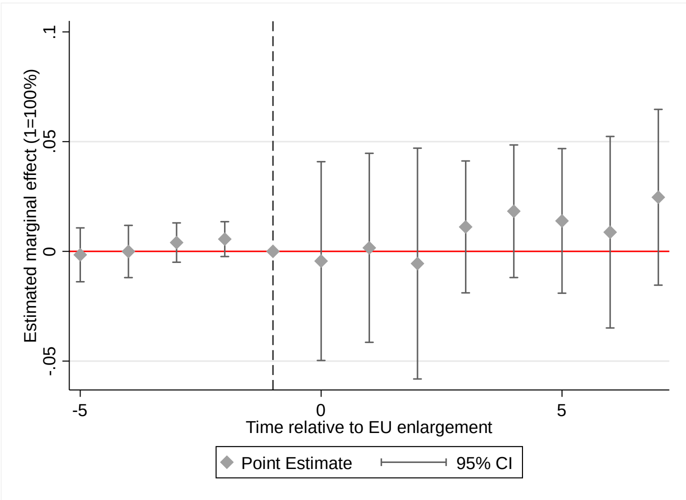
Panel E: 300km

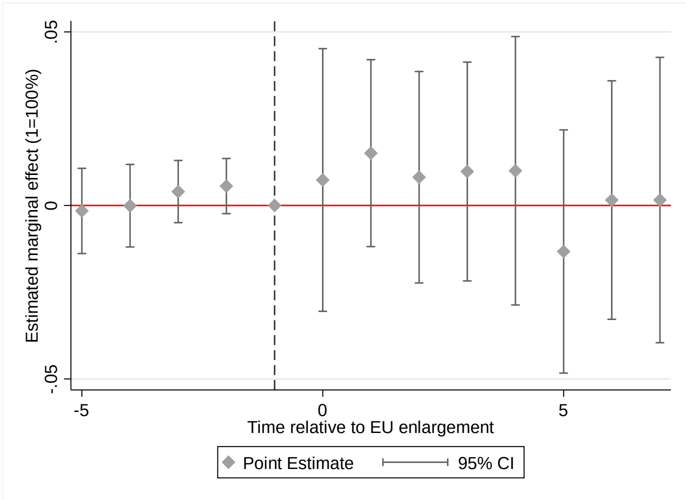


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

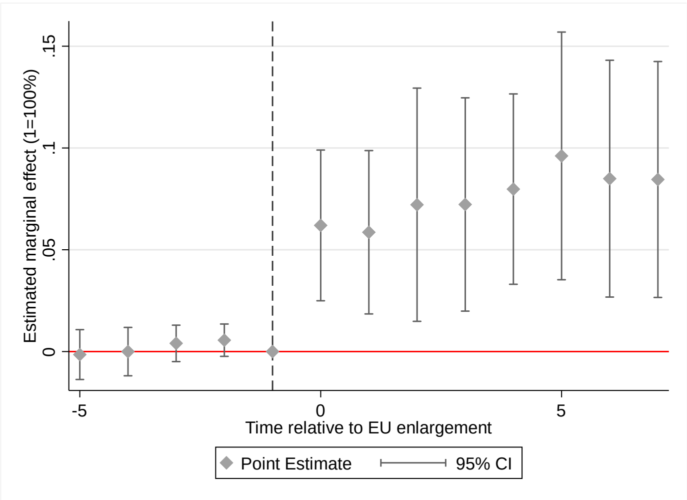
Figure A7: Dynamic treatment effects of EU enlargement on border regions (GDP per capita)

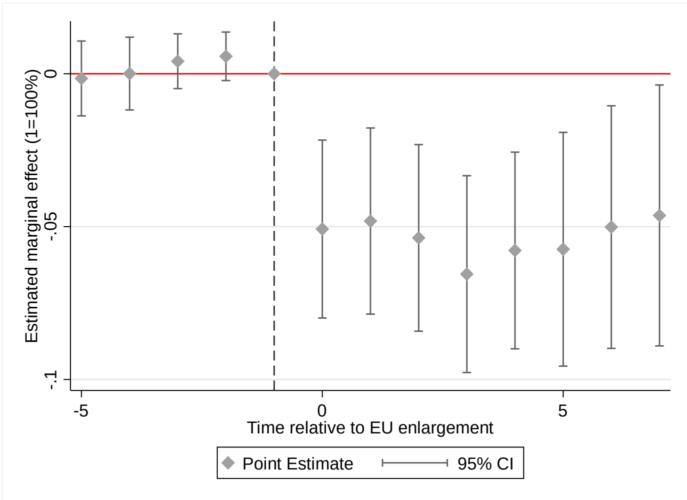
Panel A: Old member states, 1986 Panel B: New member states, 1986





Panel A: Old member states, 1995 Panel B: New member states, 1995

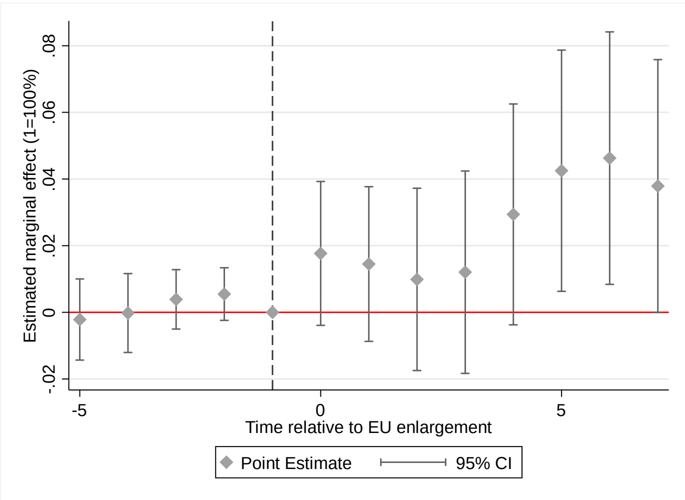




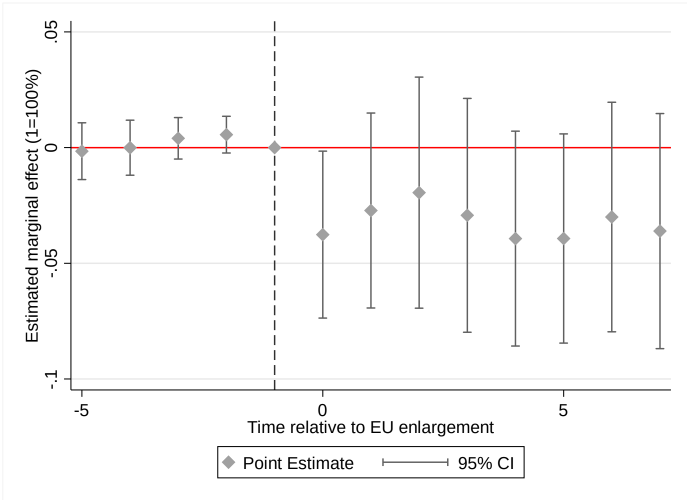
Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Figure A7 (continued): Dynamic treatment effects of EU enlargement on border regions (GDP per capita)

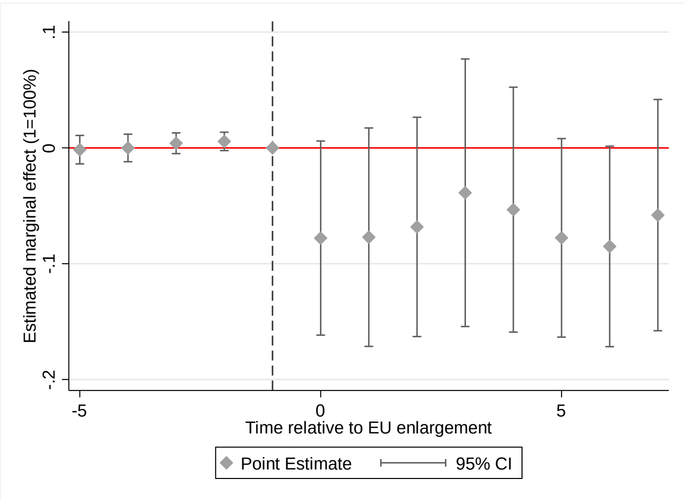
Panel C: Old member states, 2004



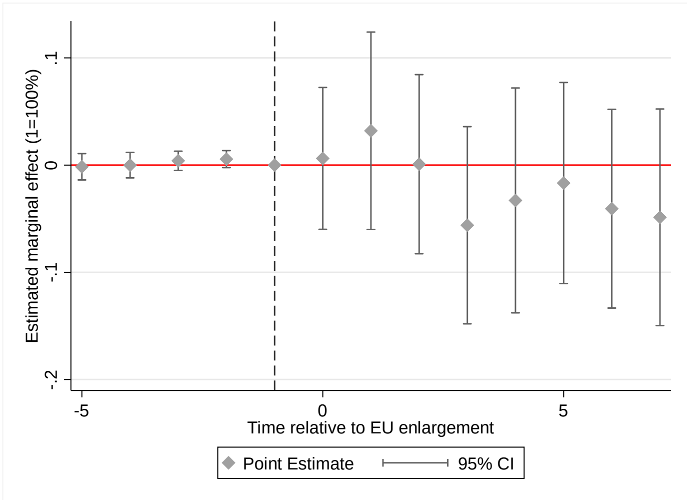
Panel D: New member states, 2004



Panel E: Old member states, 2007



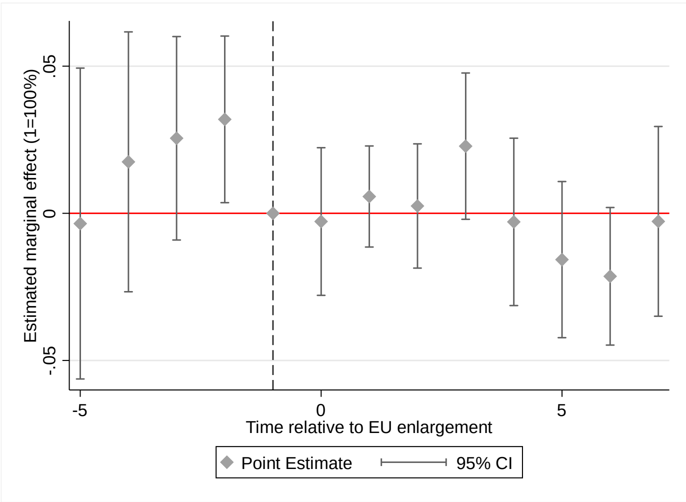
Panel F: New member states, 2007



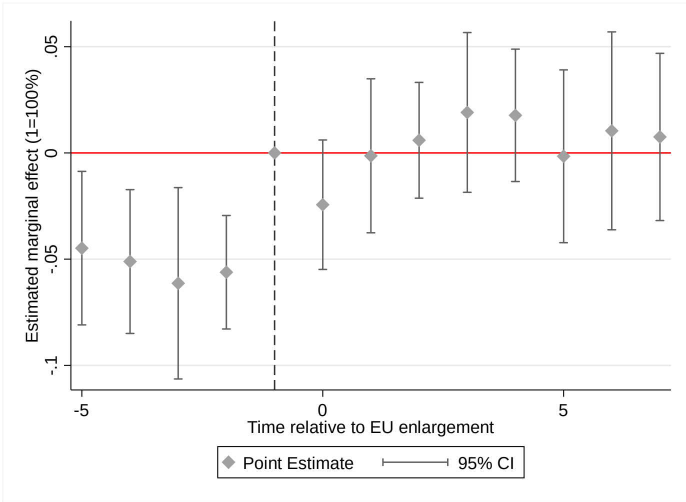
Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Figure A8: Dynamic treatment effects of EU enlargement on border regions (labor productivity)

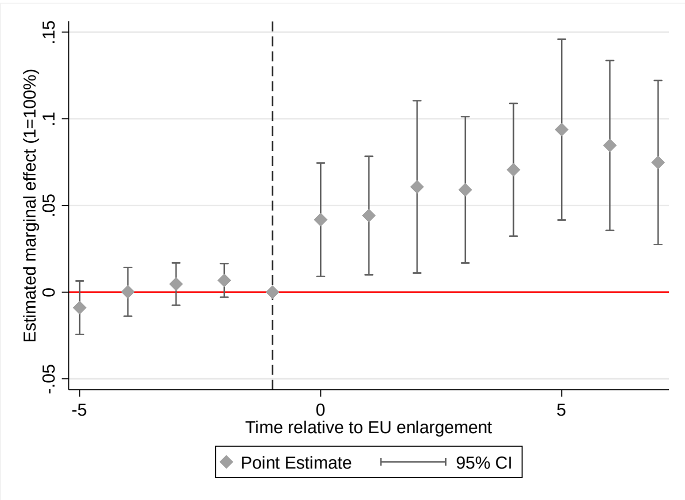
Panel A: Old member states, 1986



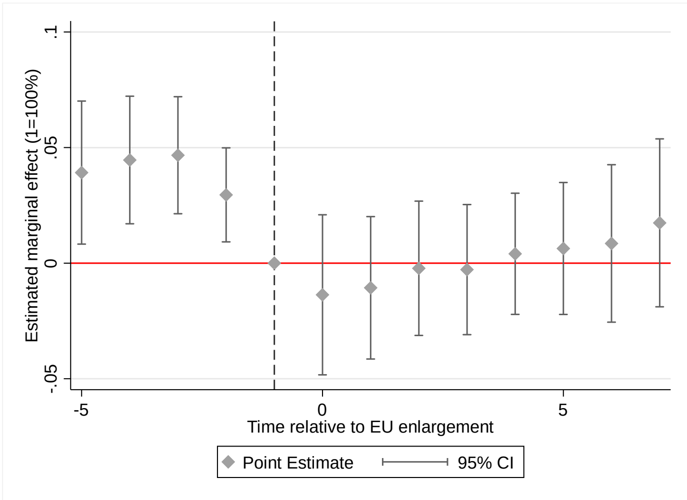
Panel B: New member states, 1986



Panel A: Old member states, 1995



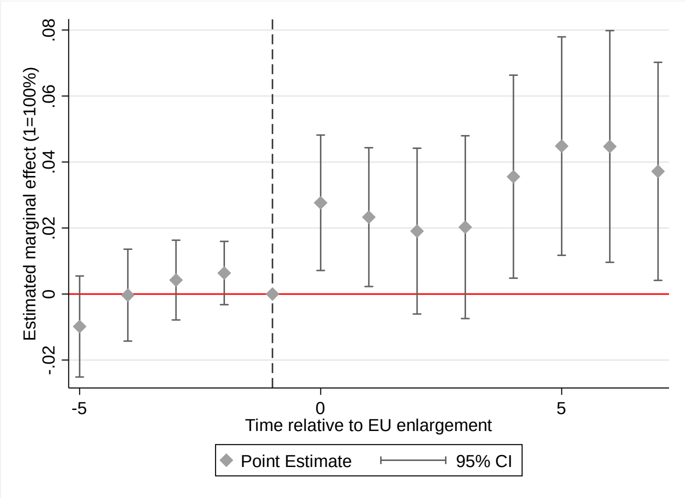
Panel B: New member states, 1995

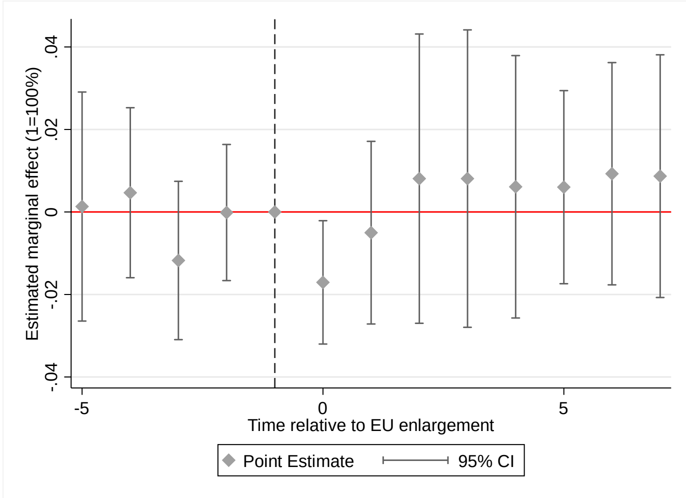


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

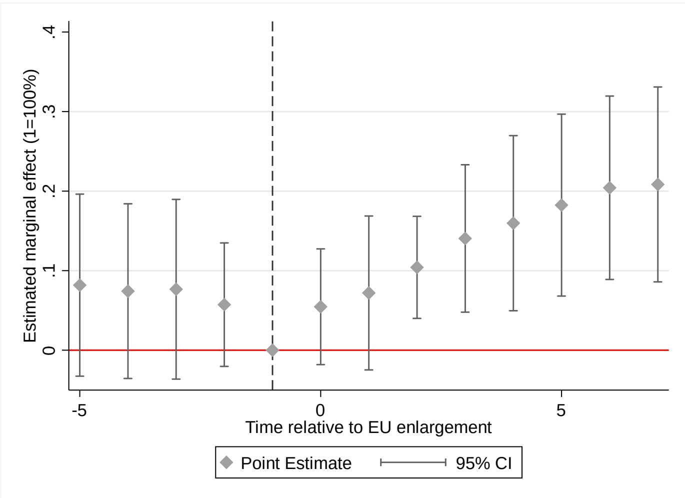
Figure A8 (continued): Dynamic treatment effects of EU enlargement on border regions (labor productivity)

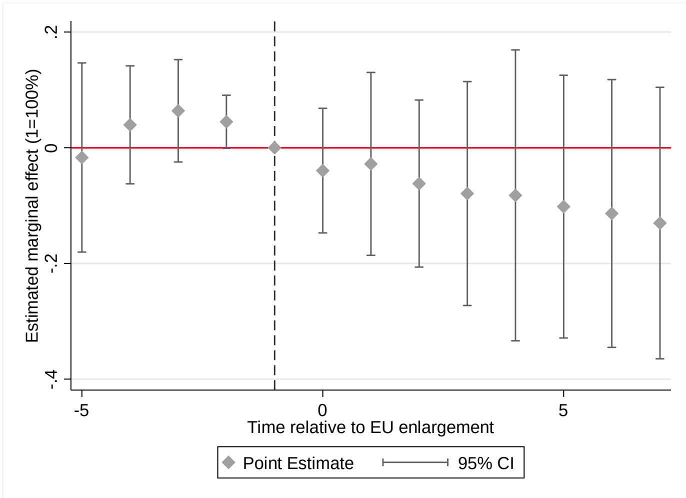
Panel C: Old member states, 2004 Panel D: New member states, 2004





Panel E: Old member states, 2007 Panel F: New member states, 2007

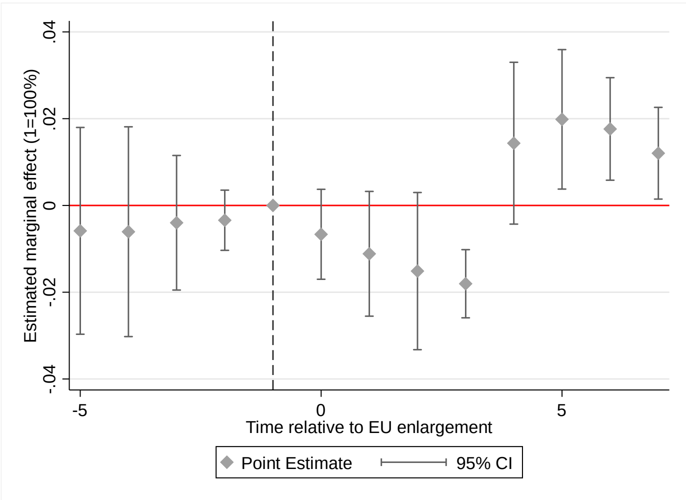


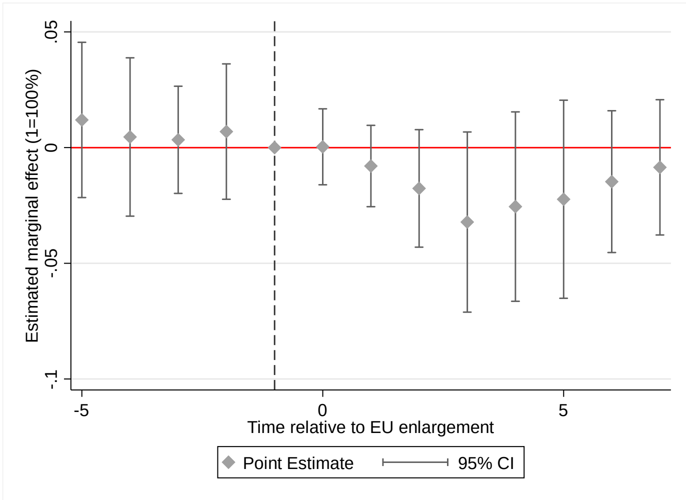


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

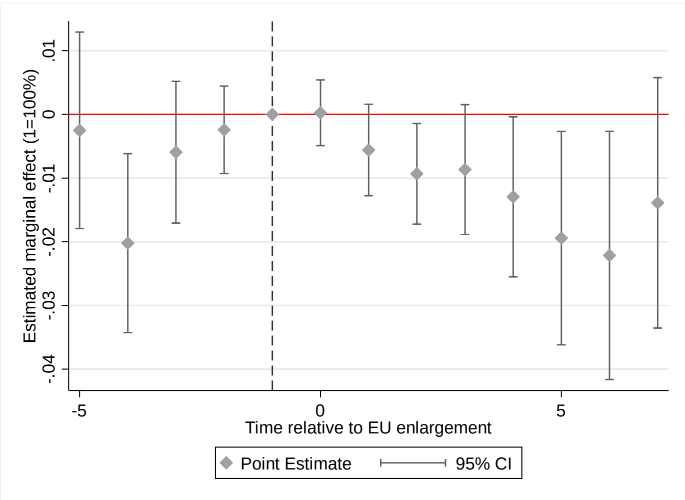
Figure A9: Dynamic treatment effects of EU enlargement on border regions (Employment rate)

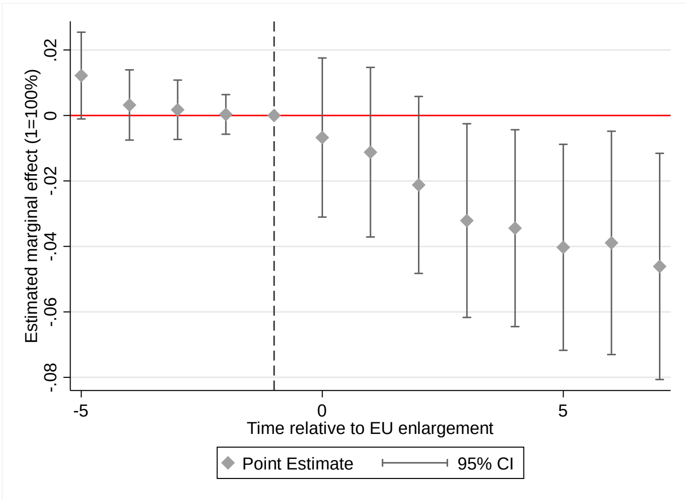
Panel A: Old member states, 1986 Panel B: New member states, 1986





Panel A: Old member states, 1995 Panel B: New member states, 1995

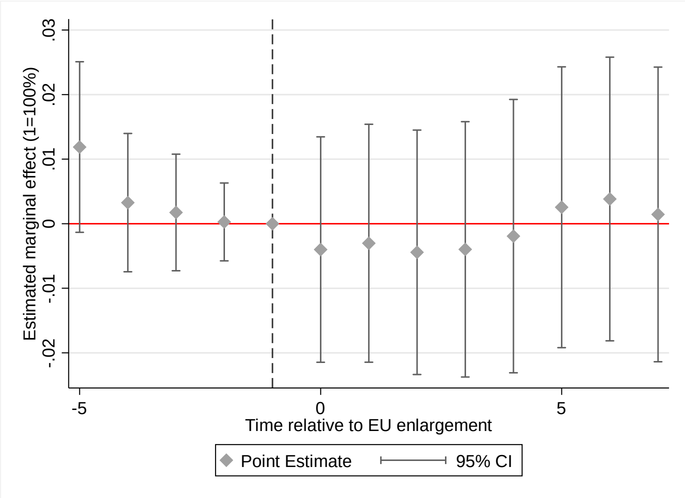




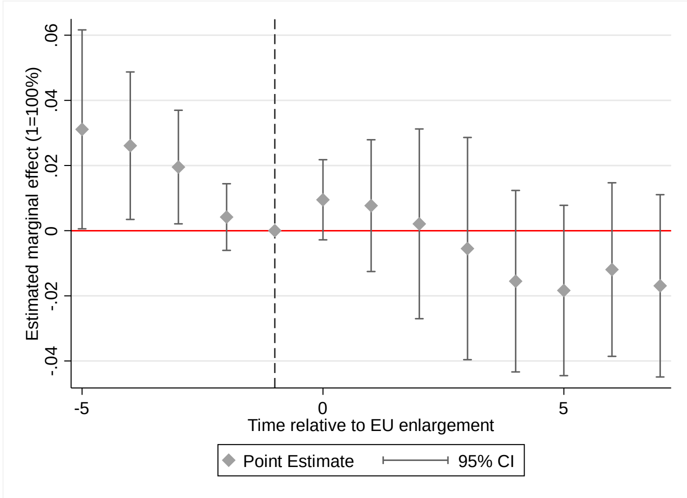
Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Figure A9 (continued): Dynamic treatment effects of EU enlargement on border regions (Employment rate)

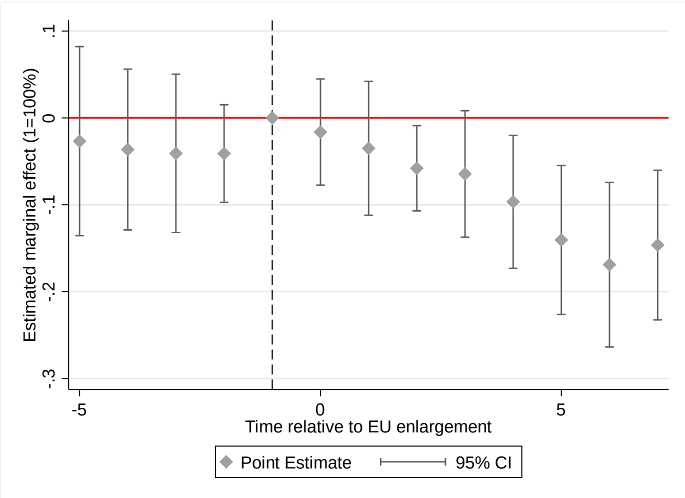
Panel C: Old member states, 2004



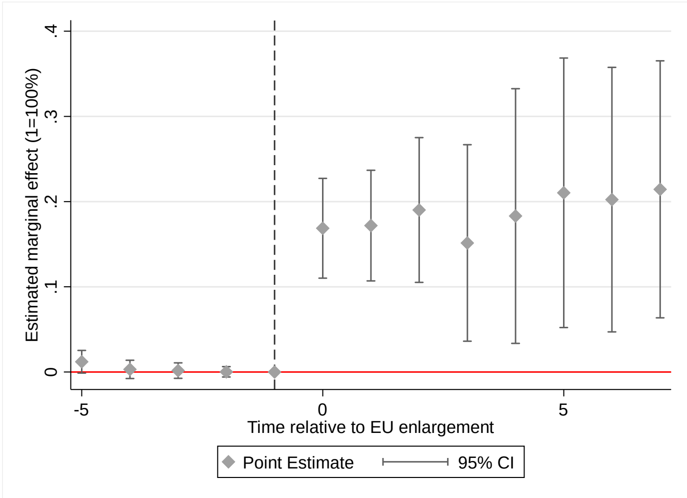
Panel D: New member states, 2004



Panel E: Old member states, 2007



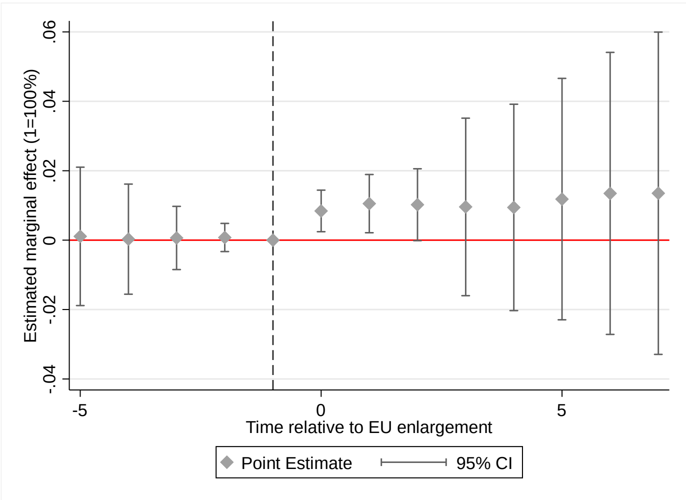
Panel F: New member states, 2007

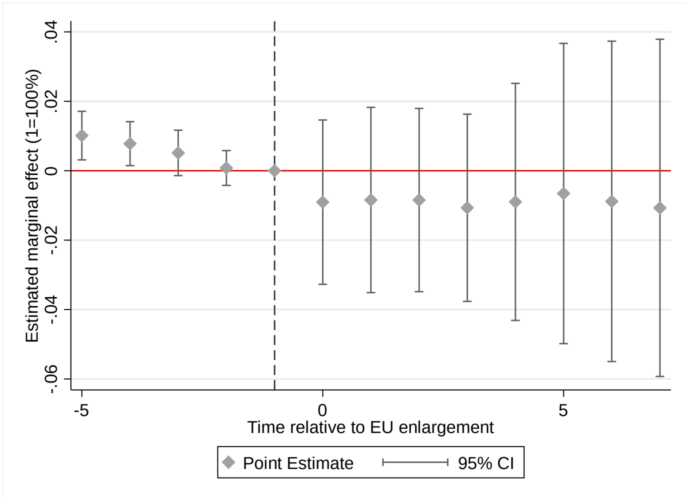


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

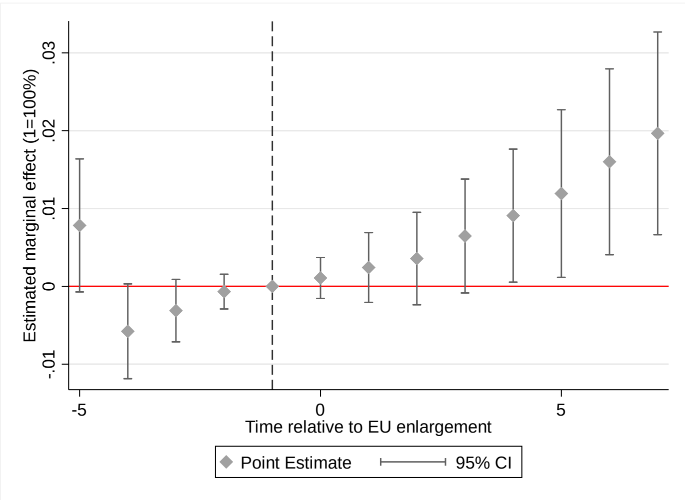
Figure A10: Dynamic treatment effects of EU enlargement on border regions (population)

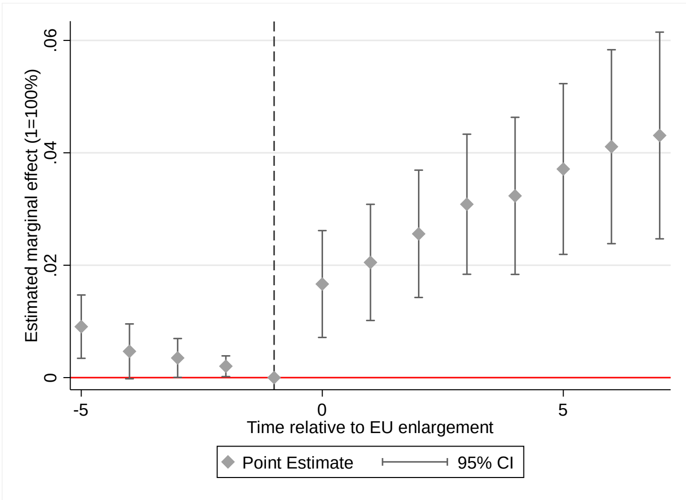
Panel A: Old member states, 1986 Panel B: New member states, 1986





Panel A: Old member states, 1995 Panel B: New member states, 1995

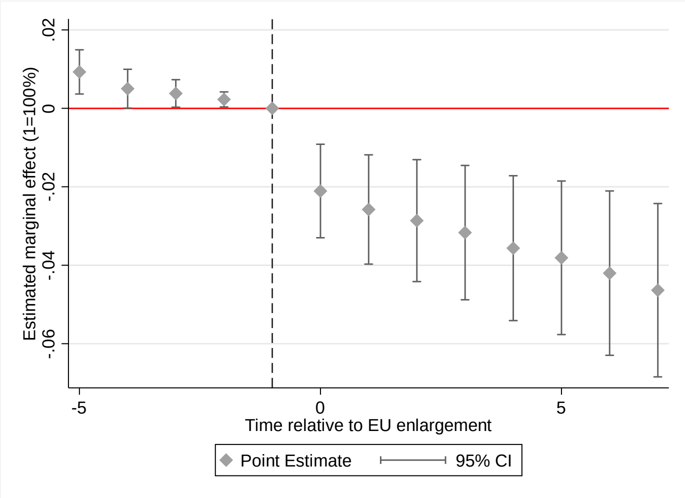


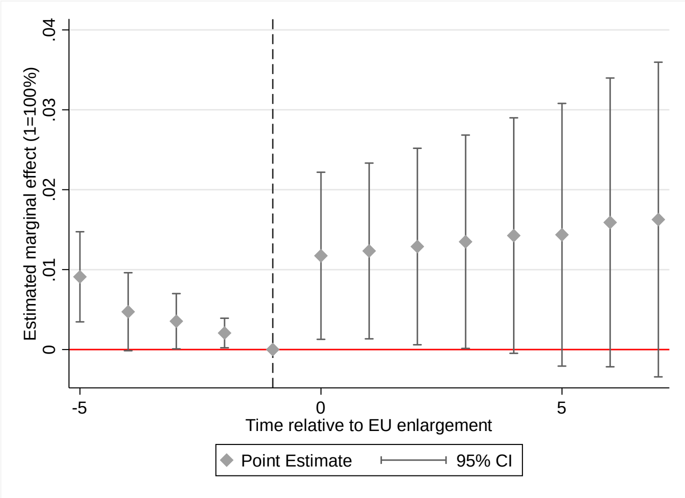


Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

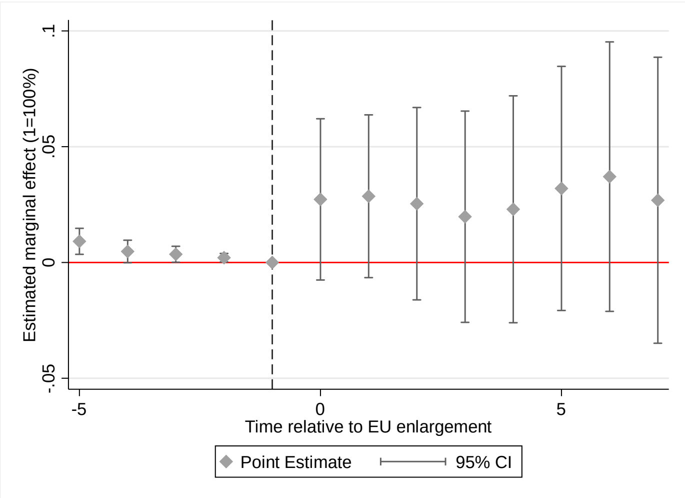
Figure A10 (continued): Dynamic treatment effects of EU enlargement on border regions (population)

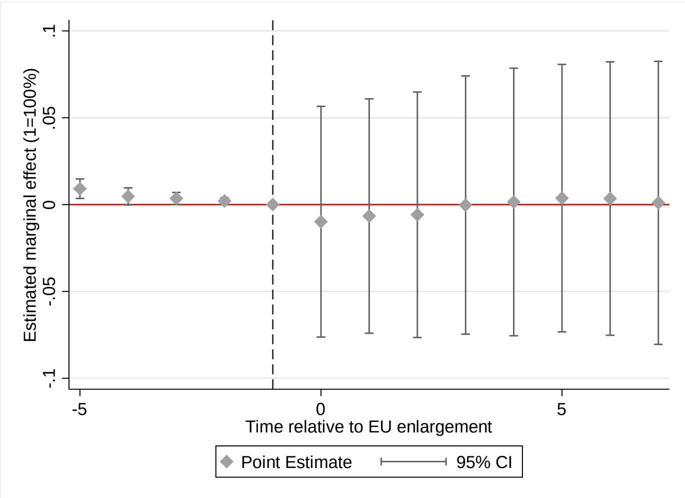
Panel C: Old member states, 2004 Panel D: New member states, 2004





Panel E: Old member states, 2007 Panel F: New member states, 2007

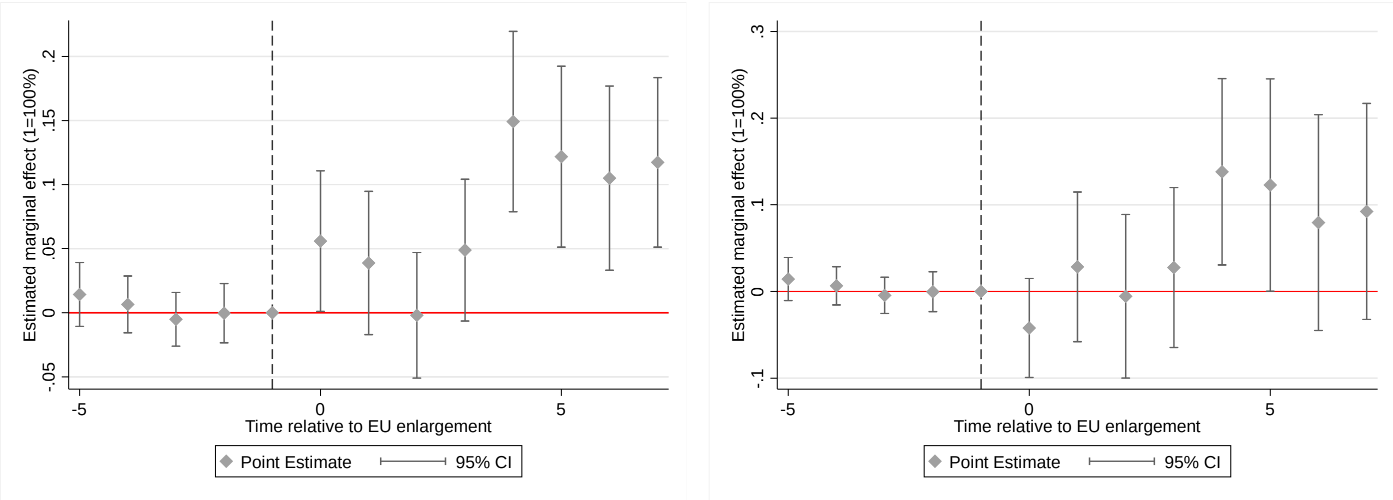




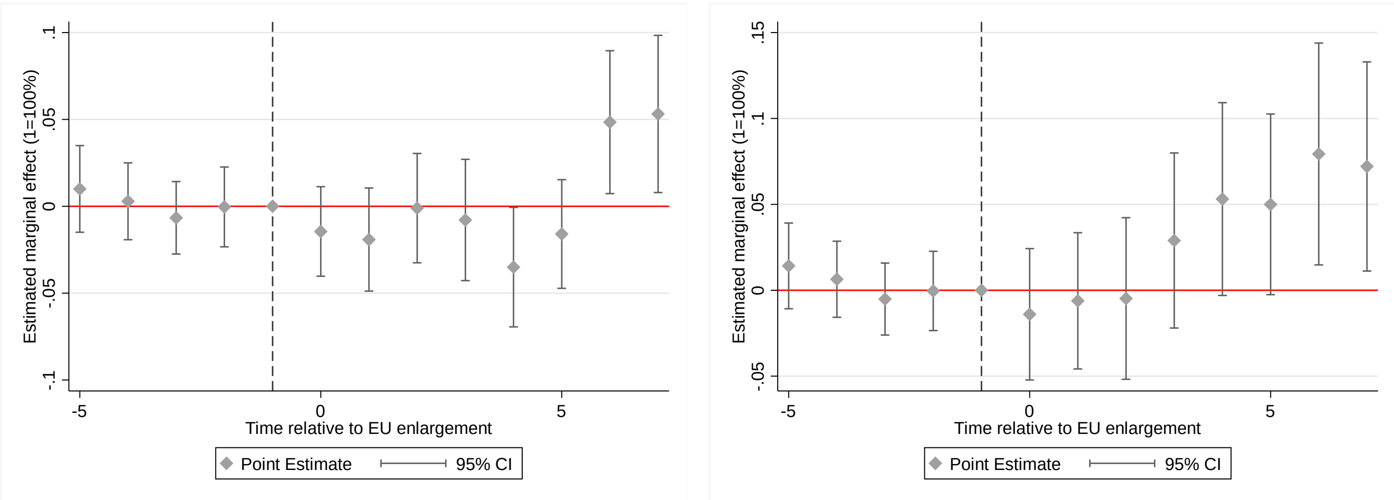
Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Figure A11: Dynamic treatment effects of EU enlargement on border regions (night light emissions)

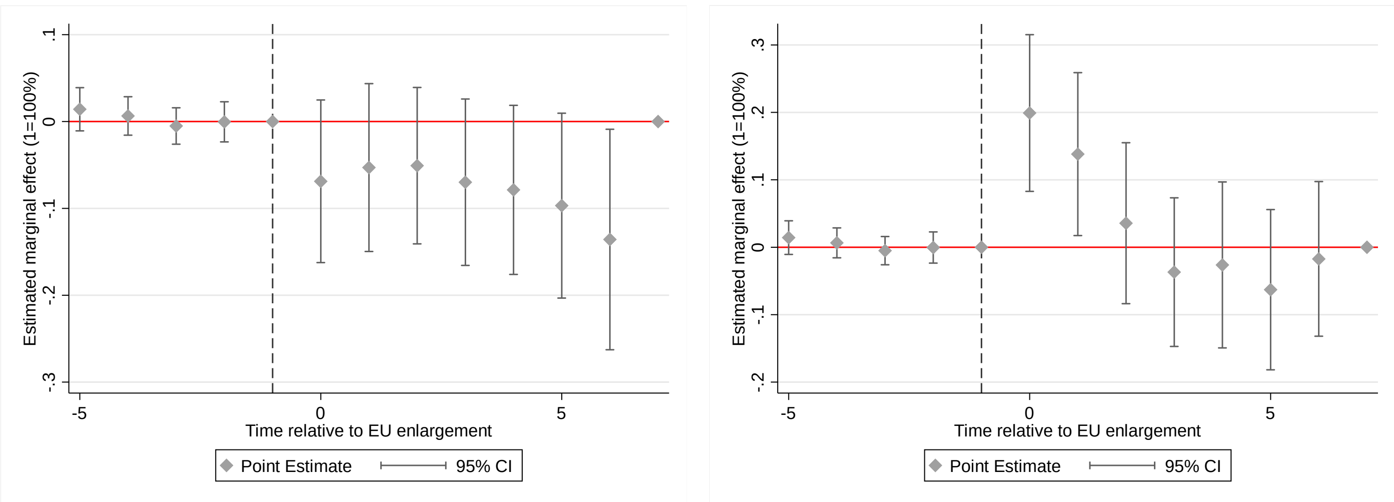
Panel A: Old member states, 1995 Panel B: New member states, 1995



Panel C: Old member states, 2004 Panel D: New member states, 2004



Panel E: Old member states, 2007 Panel F: New member states, 2007



Notes: Diamonds show point estimates for annual treatment effects of EU enlargement in border regions together with 95% confidence intervals (vertical lines; based on robust standard errors clustered at the regional level). Underlying flexible DiD estimates include region FE, year FE, country-year FE and regional controls (sectoral employment shares=. For further details see main text. Sample period 1980-2014; 1289 NUTS3 regions.

Table A1: Disaggregated treatment effects for labor productivity and employment by sectors

Specification	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Sectors	**A**	**C**	**B-E**	**G-J**	**K-N**	**O-U**
PANEL A: Labor productivity						
Border (old) ×	0.1438	0.0717	0.0265	-0.0702	-0.1013**	0.1379***
Enlargement 1986	(0.28747)	(0.09984)	(0.08256)	(0.05997)	(0.04938)	(0.02236)
Border (new) ×	-0.0082	0.0702	-0.0328	0.1124	0.0661*	0.0129
Enlargement 1986	(0.10455)	(0.06666)	(0.05983)	(0.06908)	(0.03733)	(0.05213)
Border (old) ×	-0.2029**	0.1217**	0.1179**	0.0986**	0.0943*	0.1224***
Enlargement 1995	(0.09629)	(0.05109)	(0.05289)	(0.03987)	(0.05035)	(0.02005)
Border (new) ×	0.1036	-0.0982	-0.048	-0.0401	-0.006	-0.0569
Enlargement 1995	(0.15560)	(0.05971)	(0.05677)	(0.03655)	(0.05260)	(0.04166)
Border (old) ×	0.0398	0.0527	0.1267***	0.007	0.0598*	0.0429**
Enlargement 2004	(0.04446)	(0.04066)	(0.03315)	(0.02031)	(0.03081)	(0.01728)
Border (new) ×	0.0139	0.0724*	0.0426	0.017	0.0584*	0.0208
Enlargement 2004	(0.05868)	(0.04372)	(0.04415)	(0.02329)	(0.03537)	(0.02681)
Border (old) ×	0.0308	-0.2614*	0.7526***	-0.191	0.5542***	-0.0155
Enlargement 2007	(0.15499)	(0.13627)	(0.21977)	(0.15469)	(0.19878)	(0.13208)
Border (new) ×	-0.2929*	-0.0452	-0.2347**	-0.050	-0.0921*	-0.1904***
Enlargement 2007	(0.16312)	(0.09229)	(0.10750)	(0.07878)	(0.05553)	(0.03591)
R^2	0.50	0.45	0.71	0.54	0.60	0.60
Obs.	41,974	41,974	41,974	41,974	41,974	41,974
Region FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Time FE × Ctry FE	YES	YES	YES	YES	YES	YES
Regional controls	YES	YES	YES	YES	YES	YES

Table A1 (cont'd.): Disaggregated treatment effects for labor productivity and employment by sectors

Specification	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Sectors	**A**	**C**	**B-E**	**G-J**	**K-N**	**O-U**
PANEL B: Employment rate						
Border (old) ×	-0.1334***	0.0273	0.0278	0.0006	-0.0135	-0.0051
Enlargement 1986	(0.04462)	(0.05473)	(0.02914)	(0.01844)	(0.09535)	(0.06938)
Border (new) ×	-0.1188	0.009	-0.0393	0.0597	0.0442	-0.0376
Enlargement 1986	(0.11610)	(0.08871)	(0.08315)	(0.03928)	(0.08926)	(0.03139)
Border (old) ×	-0.0944	-0.0513	0.0206	-0.0496	-0.0066	-0.0655**
Enlargement 1995	(0.07049)	(0.06407)	(0.05018)	(0.03148)	(0.06548)	(0.03007)
Border (new) ×	-0.1878***	0.1053**	0.0822*	0.0013	-0.2243***	-0.0593**
Enlargement 1995	(0.03753)	(0.05225)	(0.04266)	(0.02680)	(0.05197)	(0.02342)
Border (old) ×	-0.0161	-0.0683**	0.0333	0.0253	0.0136	-0.0186
Enlargement 2004	(0.03158)	(0.03371)	(0.02842)	(0.01921)	(0.03450)	(0.01475)
Border (new) ×	-0.0574	0.0335	-0.0193	-0.0952**	-0.1049**	-0.0806***
Enlargement 2004	(0.04615)	(0.05783)	(0.04246)	(0.04225)	(0.04929)	(0.02849)
Border (old) ×	-0.1306	-0.6082***	-0.2449	-0.0206	0.4793	-0.2004
Enlargement 2007	(0.10389)	(0.16437)	(0.19176)	(0.19545)	(0.33901)	(0.17305)
Border (new) ×	0.9968***	0.1233	0.2148***	0.1798**	-0.0464	-0.0852***
Enlargement 2007	(0.29214)	(0.10973)	(0.07263)	(0.07340)	(0.14424)	(0.03148)
R^2	0.49	0.40	0.41	0.59	0.62	0.67
Obs.	41,975	42,011	42,012	42,012	42,012	42,012
Region FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Time FE × Ctry FE	YES	YES	YES	YES	YES	YES
Regional controls	YES	YES	YES	YES	YES	YES

Notes: ***,**,*= denote significance at the 1%, 5% and 10% critical level; robust standard errors clustered at the regional level are given in brackets. Sample period 1980-2014; 1289 NUTS3 regions. Sector codes (NACE, Rev. 2) are: A = Agriculture; C = Construction; B-E = Industry excl. Construction; G-J = Wholesale, retail, transport, accommodation & food services, information and communication; K-N = Financial & business services; O-U = Non-market Services.