Europe, We Have a Problem!
Local Economic Winners and Losers of Border Closures

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Abstract

In response to the COVID-19 pandemic, Schengen countries temporarily reintroduced internal border controls, reversing a decades-long trend of European integration. While existing research has focused mainly on national-level effects of border closures, localized economic consequences remain underexplored. This paper leverages the disruption of cross-border mobility as a natural experiment to study the short-run economic impacts of border closures on European municipalities. Using monthly nighttime lights data, we find that border closures reduced economic activity in border municipalities by approximately 2% relative to interior municipalities. The effects are highly heterogeneous. Small municipalities, Eastern border municipalities, and Western municipalities bordering Eastern countries experienced losses, whereas Western border municipalities bordering other Western countries benefited from increased domestic demand. Importantly, we show that the economic impact of cross-border mobility depends on why people cross borders. When mobility supports production - by providing labor, services, or inputs - border closures disrupt supply chains and local economic activities suffer *(productive mobility)*. However, when mobility is mainly for leisure or social visits, restrictions tend to redirect spending toward domestic alternatives, creating localized benefits *(discretionary mobility)*. These findings highlight the importance of place-sensitive policy responses in times of crisis.

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1 Introduction

The Schengen Agreement, by removing systematic internal border controls on people within participating European countries, substantially reduced mobility frictions across national borders. While trade liberalization is governed by the EU Single Market, Schengen facilitated cross-border commuting, services, shopping, and business travel, allowing many border regions to function as highly integrated local economies. For nearly two decades, the absence of routine internal border controls shaped labor markets, consumption patterns, and everyday economic interactions in European border areas.

This long-standing arrangement was unexpectedly disrupted during the COVID-19 pandemic, when European governments reintroduced internal border controls as part of emergency public health measures. Unlike restrictions at external borders or nationwide lockdowns, internal Schengen border closures imposed a highly localized shock. By sharply increasing mobility and transaction costs, they disproportionately affected municipalities located along national borders, whose economies are tightly linked through cross-border labor markets, service provision, and consumption flows.

The unexpected reintroduction of internal border controls during the first wave of the COVID-19 pandemic created a natural experiment that allows us to identify the causal impact of border closures on local economic activity. While existing research has largely focused on the aggregate macroeconomic effects of lockdowns and travel restrictions at the national level, much less is known about how these policies translated into heterogeneous outcomes across municipalities. Even less is known about why some places experienced economic losses while others saw gains during the pandemic.

Using monthly nighttime lights data at the municipal (LAU-2) level for 17 European countries, combined with information on pre-pandemic cross-border mobility patterns, we address two central questions: *(1) What were the short-run local economic effects of internal Schengen border closures during the COVID-19 pandemic?* and *(2) do the economic effects of border closures (if any) vary across border regions, and how did the pre-existing function of cross-border mobility contribute to this heterogeneity?* Comparing municipalities located along internal Schengen borders with those further inland, we find that border closures reduced nighttime luminosity by approximately 2% on average. This aggregate effect conceals substantial spatial heterogeneity, reflecting differences in how local economies relied on cross-border interactions prior to the pandemic. In particular, we show that the economic consequences of border closures depend critically on the function of cross-border mobility. We find that border municipalities where cross-border movement primarily supported productive activities – such as commuting for work, access to services, and shopping

– experienced significant economic losses following border closures. In contrast, municipalities where cross-border mobility was largely discretionary, driven by leisure and social visits, benefited from localized demand reallocation toward domestic alternatives. These mechanisms generate distinct spatial patterns that depend on economic asymmetries across borders: municipalities located along borders connecting economically similar regions tend to benefit from substitution toward domestic activities, while municipalities along borders characterized by large income and labor-market asymmetries experience substantial losses due to disruptions in productive cross-border mobility..

Our analysis builds on a well-established literature in economics that uses remotely sensed nighttime lights to proxy economic activity. Early studies relied on DMSP–OLS satellite data to study regional development and spatial inequality (Henderson et al., 2012; Hodler and Raschky, 2014; Alesina et al., 2016), while more recent work has increasingly employed VIIRS data (Gibson et al., 2021).A growing methodological literature emphasizes, however, that both DMSP–OLS and raw VIIRS data require substantial correction and preprocessing to reliably capture changes in economic activity particularly in low-light areas and during winter months.. To address these concerns, we use NASA's Black Marble nighttime lights product, a harmonized VIIRS-based dataset that applies corrections for lunar illumination, stray light, atmospheric conditions, and snow cover. These adjustments substantially improve signal reliability and temporal comparability, which is essential for identifying localized and short-lived economic shocks. Most importantly for our setting, satellite data provide monthly, near–real-time measures of economic activity that are unavailable in conventional administrative sources.

This study contributes to the growing literature on the economic effects of the COVID-19 pandemics. Early evidence primarily focuses on aggregate outcomes at the country level, including national economic activity and financial vulnerability (Demirgüç-Kunt et al., 2021). More recent work adopts finer spatial resolution, often using nighttime lights to study subnational economic effects, including evidence from Indian districts (Beyer et al., 2023), global megacities (Xu et al., 2021), and cities worldwide (Khan et al., 2023). While this literature documents substantial declines in economic activity during the pandemic, it primarily examines the effects of lockdowns and broad public health measures on the economies of interior cities, districts, or aggregate spatial units. As a result, it does not isolate the economic effects of international border closures, even though these policies directly increased cross-border mobility costs and disrupted economic interactions in highly integrated border regions. Ex-

Both DMSP–OLS and raw VIIRS nighttime lights data suffer from well-known limitations, including saturation and blooming in DMSP–OLS and sensitivity to lunar illumination, stray light, and atmospheric conditions in raw VIIRS, which introduce non-economic noise and limit their suitability for fine-grained economic analysis without extensive preprocessing.

isting studies therefore provide limited insight into how sudden interruptions to international mobility affect local economic activity.

For Europe, fine-grained evidence remains particularly scarce. Existing sub-national studies mainly focus on health outcomes at the NUTS-3 level rather than observed economic activity (Eckardt et al., 2020; Rodríguez-Pose and Burlina, 2021; Coulson et al., 2021). The closest contribution is Capello et al. (2023), who study the economic implications of COVID-19 border closures across European regions using simulated data at the NUTS-3 level, reflecting the lack of timely regional economic statistics during the pandemic. Crucially, however, there is no causal evidence based on observed outcomes on how abrupt changes in international border openness affect local economic activity in border regions.

The temporary reintroduction of internal Schengen border controls during the COVID-19 pandemic provides a rare natural experiment to identify these effects. By exploiting this setting, the paper provides municipality-level causal evidence on the local economic consequences of internal border closures and thus advances our understanding of regional vulnerability and resilience to sudden international mobility shocks.

The paper makes four main contributions. First, it identifies the causal effects of internal border closures at the municipality level by exploiting the unexpected and largely synchronized reintroduction of Schengen border controls during the first wave of the pandemic. Second, it uses monthly Black Marble nighttime lights data for more than 75,000 municipalities across 17 countries, allowing us to study short-run local economic responses at an unusually fine spatial scale. Third, it documents systematic heterogeneity in border effects related to municipality size, East–West border orientation, and economic asymmetries between neighboring countries. Finally, by empirically distinguishing between productive and discretionary cross-border mobility, the paper sheds light on the mechanisms through which border closures affect local economic activity, helping to explain why some border regions were more vulnerable while others exhibited short-run resilience.

The remainder of the paper is organized as follows. Section 2 describes the institutional background of internal Schengen border closures and introduces the theoretical framework. Section 3 presents the data. Section 4 outlines the empirical strategy and baseline results. Section 5 examines mechanisms and heterogeneity. Section 6 concludes.

2 Institutional Setting of Border Closures

For nearly two decades, the Schengen Agreement made internal borders largely invisible in everyday life. People crossed national boundaries freely for work, shopping, and social activities, and border regions gradually became tightly integrated spaces rather than divided territories.

The COVID-19 pandemic abruptly disrupted this arrangement. During the first wave in early 2020, European governments swiftly reintroduced internal border controls in response to urgent public health concerns. As Figure 1 shows, most internal borders closed within a few days in mid-March. Although the exact timing varied across border pairs, the overall response was rapid and broadly synchronized across Europe. Internal border controls were reintroduced with little warning, differed in their strictness and duration, and were explicitly framed as temporary emergency measures rather than permanent policy changes. By the end of June 2020, most countries had reopened their internal borders. While subsequent waves of the pandemic led to renewed restrictions later in the year, these developments were largely anticipated. As a result, the first wave of border closures constitutes a uniquely sudden and unexpected shock.

Unlike domestic lockdowns, which affected entire countries, internal border closures had a highly localized impact. Municipalities near internal borders were hit hardest, as their economies rely heavily on cross-border movement. As a result, closed borders generated a spatially uneven shock, concentrated in specific places rather than spread evenly across national economies.

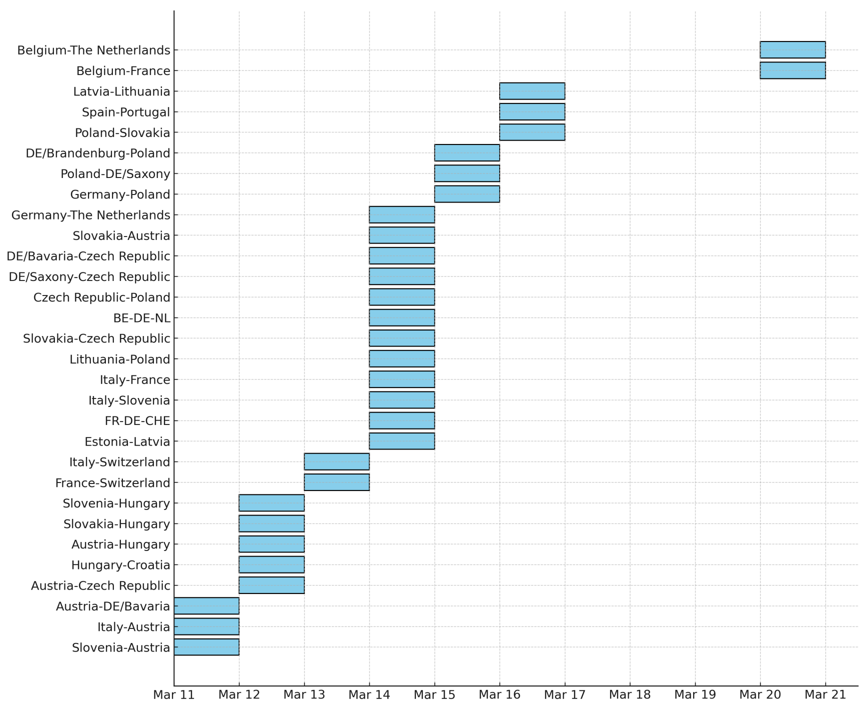

Figure 1: Timing of Internal Border Closures during the First Wave

2.1 Theoretical Framework

We follow a multi-region, market-access-based model from New Economic Geography (NEG) to establish the empirical analysis. The framework builds on Krugman (1991), Fujita et al. (1999), Redding and Sturm (2008), and Brakman et al. (2012), but departs from the standard focus on gradual and persistent improvements in market access associated with economic integration. Instead, we study the opposite type of shock: a sudden and temporary increase in trade and mobility costs triggered by the reintroduction of internal border controls during the COVID-19 pandemic.

Much of the NEG literature focuses on long-run adjustments to persistent trade-cost changes, such as firm relocation and population sorting. In contrast, pandemic border closures constituted an abrupt and unexpected shock. Firms and households had limited scope to reoptimize location decisions. We therefore interpret the model in a *short-run equilibrium*, in which locations, population stocks, and infrastructure are fixed, while market access, prices, and the utilization of local services adjust immediately.

The economy consists of a set of locations indexed by $a \in \{1, \ldots, A\}$, corresponding to municipalities. Each municipality is endowed with a fixed stock of nontradable services and amenities, denoted by $\bar{H}_a$. In much of the existing literature, this component is treated as fixed and fully utilized. However, in the context of short-run border closures, what matters is not only the availability of local amenities but also how intensively they are used.

We therefore distinguish between the fixed stock of nontradable infrastructure, $\bar{H}_a$, and its effective utilization, $u_a(T_a)$, which depends on mobility costs. Changes in cross-border mobility affect where consumption takes place and how intensively local services are used, even though the underlying infrastructure stock remains unchanged. Accordingly, we write effective nontradable activity as

$$H_a(T_a) \equiv \bar{H}_a \cdot u_a(T_a),$$

where $u_a(T_a)$ captures short-run demand and utilization responses to changes in border openness.

Consumers allocate a fraction $\mu \in (0, 1)$ of income to tradable goods, while the remaining share $1 - \mu$ is spent on nontradable services. Firms operate under monopolistic competition with increasing returns to scale and a constant elasticity of substitution $\epsilon > 1$. Trade between municipalities is subject to iceberg trade costs $T_{ai} > 1$. Internal border closures raise T_{ai} for cross-border links. Because border municipalities rely more heavily on cross-border commuting, services, and consumption, they are disproportionately exposed to this shock.

Let w_a denote nominal wages, L_a employment, P_a^M the Dixit–Stiglitz price index, n_a the number of firms, and p_a the free-on-board price of a variety produced in municipality a. In the short run, equilibrium real economic activity can be written as

$$EA_a = \Omega \underbrace{\left(\sum_i \frac{w_i L_i P_i^M}{T_{ai}^{\epsilon-1}} \right)^{\theta_1}}_{\text{FMA}} \underbrace{\left(\sum_j \frac{n_j p_j P_j^M}{T_{ja}^{\epsilon}} \right)^{\theta_2}}_{\text{CMA}} \underbrace{\frac{1}{\bar{H}_a \, u_a(T_a)}}_{\text{NTA}} . \tag{1}$$

where θ_1, θ_2, and Ω are functions of structural parameters and the common real wage.

This expression highlights three channels through which border closures affect local economic activity. The first is firm market access (FMA), which captures how easily firms can reach consumers and markets elsewhere. The second is consumer market access (CMA), reflecting how easily consumers can access varieties produced in other locations. The third is local nontradable activity (NTA), which reflects short-run changes in the utilization and demand for locally provided services and amenities, rather than changes in the underlying infrastructure stock. Although infrastructure itself does not adjust in the short run, changes in mobility costs alter where consumption takes place. Higher cross-border mobility costs can redirect spending toward locally provided services, increasing their utilization, or reduce overall demand when cross-border mobility supplies productive interactions. As a result, local nontradable activity responds endogenously to border closures through demand reallocation, rather than through changes in population, firms, or infrastructure.

Taking logs and differentiating with respect to trade costs yields the short-run decomposition:

$$d \ln EA_a = \theta_1 \frac{dFMA_a}{FMA_a} + \theta_2 \frac{dCMA_a}{CMA_a} - \frac{du_a(T_a)}{u_a(T_a)}. \tag{2}$$

This decomposition makes clear that border closures affect local economic activity through firm market access, consumer market access, and the endogenous utilization of local nontradable services. The short-run implications of these channels depend on the purpose of cross-border mobility prior to the pandemic. When mobility primarily supports *productive* interactions, such as commuting, business travel, or access to customers, higher trade and mobility costs reduce market access and lead to a contraction in local economic activity. By contrast, when cross-border mobility is mainly *discretionary*, such as social visits or leisure, border closures can redirect consumption toward locally provided nontradable services, potentially offsetting the market-access loss and generating smaller declines or even short-run gains. The Appendix A provides derivation steps, documenting how both the sign of these effects arise from the model.

3 Data

3.1 NASA's Black Marble Nighttime Lights

Remotely sensed nighttime lights are increasingly used in economics as a proxy for human and economic activity (Gibson et al., 2021). To overcome satellite-related limitations, we use NASA's Black Marble nighttime lights data from the Visible Infrared Imaging Radiometer Suite (VIIRS). The VIIRS day–night band provides improvements over DMSP-OLS, including higher spatial resolution (approximately 750 meters), greater radiometric sensitivity, minimal saturation, and onboard calibration. These features make VIIRS particularly well suited for capturing short-run economic dynamics, such as those induced by sudden internal border closures during the COVID-19 pandemic.

Our main outcome variable is nighttime light intensity derived from NASA's Black Marble product. We utilize the VNP46A3 Lunar BRDF-adjusted monthly nighttime lights dataset, which corrects for the effects of moonlight, atmospheric conditions, and sensor viewing angle. We collected data for 2018, 2019, and 2020 at a 500 $\times$ 500 meter resolution. We aggregate pixel-level radiance to the municipality (LAU-2) level using zonal statistics in QGIS. Black Marble data are distributed in Hierarchical Data Format (HDF5) and were converted to GeoTIFF format to enable spatial processing in GIS software. We use the snow-free, all-angle radiance composite and corresponding quality flags. Pixels affected by cloud contamination, sensor issues, or missing data are excluded.

Several features make nighttime lights particularly appropriate for our research design. First, the monthly frequency allows us to capture short-run economic responses to border closures. Second, because VIIRS satellite overpasses occur at approximately 1:30 a.m. local time, the recorded luminosity primarily captures persistent economic activity rather than transient population movements.

3.2 Interreg-A Cross-border Cooperation Survey

To study the mechanisms and heterogeneities in the effects of border closures, we merge nighttime lights data with administrative data from the European Commission's ARDECO database. These data provide information on population size, population density, and geographic area at the municipality level.

Most existing studies rely on data from the Defense Meteorological Satellite Program (DMSP-OLS), which has been extensively used to study long-run relationships between luminosity and socioeconomic outcomes since the early 1990s. Despite its usefulness for long-run analysis, DMSP-OLS suffers from coarse spatial resolution, saturation, blooming, and the absence of onboard radiometric calibration, limiting its suitability for studying short-run and localized economic shocks.

Additionally, we utilize data from the Interreg A Cross-Border Cooperation (CBC) surveys from 2020. These surveys cover roughly 40,000 respondents in European border regions. Respondents report the frequency and purpose of cross-border interactions. We differentiate between *productive mobility* (work, shopping, and services) and *discretionary mobility* (leisure and social visits).

For preliminary analysis and descriptive purposes, we merge CBC data with nighttime lights and show changes in monthly luminosity before and after the enactment of border controls across cross-border cooperation areas in Figure 2. There is a sharp decline in nighttime lights following border closures highlighted in red, consistent with a contraction in local economic activity.

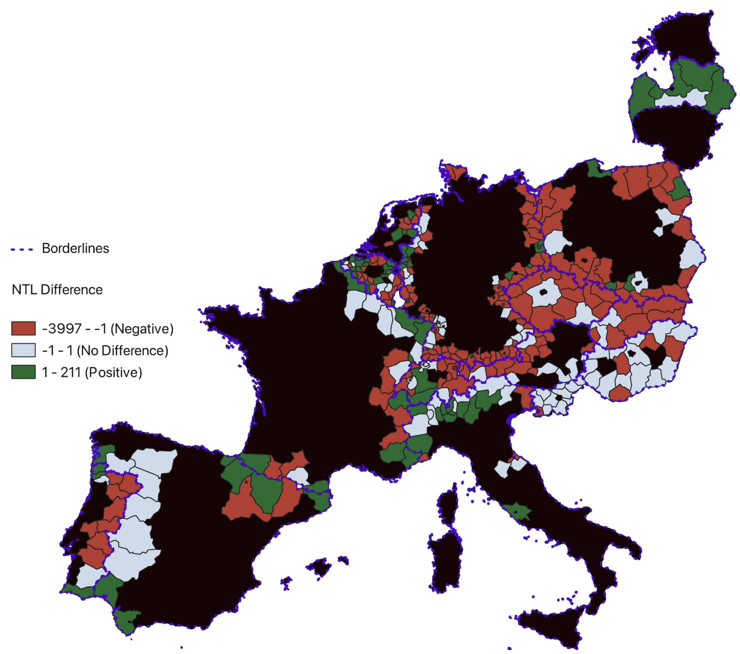

Figure 2: Difference in Nighttime Lights (Post vs. Pre)

Notes: The figure shows the difference in average nighttime lights between the post- and pre-periods using VIIRS NTL data. Values are aggregated at the regional level. Positive values indicate increases in luminosity, negative values indicate declines, and values between -1 and 1 are classified as no difference. Dashed lines denote international borders.

Although the data were collected during the pandemic, respondents were asked to report on the previous year, when conditions were still normal in 2019. This is important because COVID-19 did not affect the survey responses.

4 Empirical Strategy

We exploit the sudden and temporary reintroduction of internal Schengen border controls during the first wave of the COVID-19 pandemic as a localized mobility shock. Our empirical strategy compares changes in economic activity between municipalities located near internal borders and municipalities further inland, before and during periods in which internal borders were closed. This difference-in-differences design allows us to isolate the short-run causal effects of border closures on local economic activity.

Our analysis focuses on municipalities in 17 Schengen countries. We differentiate between Old EU Member States that entered the Schengen Area in 1995 (Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal, and Spain) and New Member States that entered Schengen in 2008 (Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, and Switzerland). We exclude European microstates, island countries, and Scandinavian countries because of their distinct geographic characteristics and COVID-19 policy regimes. These exclusions enhance cross-country comparability and limit heterogeneity unrelated to exposure to internal border closures.

We implement a difference-in-differences (DiD) framework that compares changes in nighttime light intensity between border municipalities (the treatment group) and interior municipalities (the control group) before, during, and after the implementation of border closures.

Let NTL_{it} denote the log-transformed nighttime light intensity observed in municipality i at time t. Our baseline empirical specification is:

$$NTL_{it} = \beta \text{Closed}_t + \gamma(\text{Border}_i \times \text{Closed}_t) + \delta_t + \alpha_i + \varepsilon_{it}, \tag{3}$$

where Border_i is an indicator equal to one if municipality i is located along an internal Schengen borderline within 25km, and Closed_t equals one during periods in which borders were closed. These closure periods correspond to March, April, May, and June 2020, after which Schengen countries gradually began to reopen their internal borders. The pre-treatment period consists of the same calendar months in year 2018 (or in years 2018–2019), when borders were fully open. This choice ensures a clean comparison by holding seasonal patterns constant.

The interaction term $(\text{Border}_i \times \text{Closed}_t)$ captures the differential effect of border closures on border municipalities relative to interior municipalities. A negative and statistically significant estimate of γ indicates that border municipalities experienced a disproportionately larger decline in economic activity following the reintroduction of internal border controls.

The empirical specification includes time fixed effects δ_t, which control for common shocks affecting all municipalities, and municipality fixed effects α_i, which absorb time-invariant differences across municipalities, including persistent institutional and geographic characteristics. The error term ε_{it} captures idiosyncratic shocks. Standard errors are clustered at the municipality level.

4.1 Baseline Results

Table 1 reports the baseline estimates from Equation (1), which quantify the effect of internal Schengen border closures on nighttime light intensity. The table presents results also from alternative model specifications that differ in the inclusion of municipality and month fixed effects, as well as in the choice of pre-treatment periods. The treatment period corresponds to March, April, and May 2020, when internal border closures were in place. The counterfactual periods are defined as the same calendar months in 2018, or in 2018–2019, when borders were fully open.

Across all model specifications, the interaction term between border municipality status and the border closure period is consistently negative and statistically significant. The estimated magnitude implies that nighttime light intensity in border municipalities declined by approximately 2% relative to interior municipalities during the closure period. This result is robust to alternative fixed-effects specifications and to the choice of pre-treatment years, indicating a persistent and economically meaningful decline in local economic activity following the reintroduction of internal border controls.

5 Heterogeneity and Mechanisms

The average effect documented in the previous section masks substantial variation in how local economies responded to internal border closures. Border municipalities differ markedly in their economic structure, size, and reliance on cross-border interactions, suggesting that the incidence of border closures is unlikely to be uniform across space. In this section, we examine how the effects of border closures vary across municipalities and investigate the mechanisms underlying this heterogeneity. We first analyze differences related to municipality size and local adjustment capacity, then explore how economic asymmetries across borders shape outcomes, and finally provide direct evidence on mechanisms using data on the pre-pandemic purpose of cross-border mobility.

Table 1: The Effects of Border Closures on Nightlights

	(1) ln(NTL)	(2) ln(NTL)	(3) ln(NTL)	(4) ln(NTL)
Closed	-0.576***	0.204***	-0.482***	0.199***
	(0.003)	(0.005)	(0.003)	(0.005)
Border × Closed	-0.043***	-0.025***	-0.022***	-0.016***
	(0.005)	(0.005)	(0.004)	(0.004)
Observations	518,309	518,309	781,544	781,544
# LAU	74,421	74,421	74,421	74,421
Within R^2	0.2153	0.3172	0.1228	0.3187
FE: LAU	NO	YES	NO	YES
FE: Year	NO	YES	NO	YES
Reference Year	2018	2018	2018 & 2019	2018 & 2019

Notes: The dependent variable is the monthly log-transformed nighttime light intensity measured at the municipality (LAU-2) level. Border municipalities are defined as those located within 25 km of an internal national border. The treatment indicator equals 1 during periods of internal border closures and 0 otherwise. Standard errors clustered at the municipality level are reported in parentheses. The reference period consists of the same calendar months in the specified pre-pandemic years. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.1 Municipality Size and Local Adjustment Capacity

Table 2 examines how the effects of border closures vary with municipality size and population. Columns (1) and (2) interact the border-closure effect with inverse measures of geographic area and population density, respectively. The negative and statistically significant interaction terms indicate that the adverse impact of border closures is more pronounced in smaller and less densely populated municipalities. Specifically, column (1) shows that border municipalities with smaller geographic area experience approximately a 20% decline in nighttime light intensity following border closures. Likewise, column (2) demonstrates that less populated border municipalities are negatively affected, exhibiting about a 40% reduction in nighttime lights relative to larger municipalities.

These findings suggest that small local economies are vulnerable to sudden disruptions in cross-border mobility. Smaller municipalities typically rely more heavily on cross-border commuting, shopping, and service provision, and they have fewer domestic alternatives to replace lost cross-border demand. In contrast, larger municipalities benefit from thicker local markets, greater economic diversification, and stronger internal demand, which make them more resilient to mobility restrictions.

Overall, the results highlight that the economic costs of border closures are not evenly distributed across space. They disproportionately affect smaller and sparsely populated border municipalities, amplifying existing spatial inequalities between border and interior areas in the Schengen Area following border closures.

Table 2: Border Closure Effects by Municipality Size and Population

	(1) ln(NTL)	(2) ln(NTL)
Closed	0.207***	0.219***
	(0.006)	(0.006)
Border × Closed	-0.000	-0.012
	(0.010)	(0.010)
Closed × Size	-0.035	-0.239***
	(0.034)	(0.051)
Border × Closed × Size	-0.215***	-0.397**
	(0.083)	(0.194)
Observations	518,309	512,851
Within R^2	0.3177	0.3197
Size	Inverse Area	Inverse Density
FE: LAU	Yes	Yes
FE: Month	Yes	Yes

Notes: This table examines heterogeneity in the effects of border closures by municipality size. Column (1) interacts border status and border closure with inverse municipality area, while column (2) uses inverse population. The dependent variable is monthly nighttime light intensity at the municipality (LAU) level. All specifications include municipality and month fixed effects. Standard errors clustered at the municipality level are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.2 Border Orientation and Economic Asymmetries

Beyond differences in local adjustment capacity, the effects of border closures may vary systematically with the economic characteristics of neighboring countries. In particular, cross-border mobility differs substantially across borders that connect economically similar regions and those that connect regions with large income and labor-market asymmetries. Table 3 examines this dimension by distinguishing between western and eastern border regions, as well as between West–West and West–East border pairs.

The results show that municipalities located along the eastern border experienced significantly larger declines in nighttime light intensity relative to interior areas. In Column (2), the coefficient on *Border* $\times$ *Closed*, is negative and statistically significant, corresponding to an 18% decline relative to interior municipalities. This pattern indicates a high sensitivity of Eastern border regions to mobility disruptions, and is consistent with their strong dependence on cross-border labor markets and consumption flows. By contrast, western border municipalities exhibit a small but statistically significant positive differential effect - approximately a 2.5% increase relative to interior municipalities - suggesting relatively better economic outcomes during border closures.

Disaggregating western border regions further between West–West and West–East borders, reveals important differences. Western border municipalities adjacent to other Western countries experienced relative increases in nighttime light intensity during border closures, as indicated by the positive and statistically significant interaction coefficient. This pattern is consistent with substitution toward domestic activities in economically symmetric border regions, where cross-border mobility is more likely to be *discretionary* and can be more easily redirected toward domestic alternatives when borders close.

In contrast, Western border municipalities neighboring Eastern countries experienced a large and statistically significant declines in nighttime light intensity relative to interior municipalities. These regions often depend on cross-border labor supply and service provision from lower-income neighboring countries. In such settings, border closures disrupt *productive* cross-border interactions that function as inputs into local production, leading to pronounced economic losses.

Taken together, these results indicate that the economic impact of border closures depends not only on local characteristics, such as municipality size, but also on economic asymmetries across borders and the nature of cross-border mobility. While West-West border regions benefited from border closures, Eastern and West–East border regions experienced economic losses. This suggest that borders connecting economically similar regions tend to exhibit substitution effects that mitigate losses, while borders characterized by strong asymmetries are more vulnerable to disruptions in productive cross-border mobility.

5.3 Purpose of Cross-Border Mobility Channels

The heterogeneity documented above suggests that the economic effects of border closures depend critically on the role that cross-border mobility plays in local economies. In this subsection, we move beyond reduced-form evidence and directly examine the mechanisms through which border closures affect local economic activity. Building on the theoretical framework in Section 2.1, we test whether the economic impact of border closures depends on the functional purpose of cross-border mobility. In particular, we distinguish between

Table 3: Border Closure Effects by Border Orientation

	(1) West	(2) East	(3) West–West	(4) West–East
Closed	0.193***	0.743***	-0.023*	-0.113***
	(0.005)	(0.026)	(0.014)	(0.015)
Border × Closed	0.025***	-0.188***	0.139***	-0.307***
	(0.005)	(0.015)	(0.012)	(0.017)
Observations	428,064	90,245	149,438	28,390
Within R^2	0.308	9 0.3986	0.3313	0.3027
FE: LAU	YES	YES	YES	YES
FE: Month	YES	YES	YES	YES
Partner Border	All	All	West	East

Notes: This table examines heterogeneity in the effects of border closures by border type. Columns distinguish between western and eastern border municipalities, as well as between West–West and West–East border pairs. The dependent variable is monthly nighttime light intensity at the municipality (LAU) level. All specifications include municipality and month fixed effects. Standard errors clustered at the municipality level are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

productive mobility or input-driven mobility, which directly supports production and consumption (e.g. work, services, shopping, and business travel), and *discretionary mobility*, which reflects choice-driven activities such as leisure and social visits.

Table 4 reports estimates from regressions that interact the border-closure indicator with measures of cross-border mobility purpose derived from the Interreg A Cross-Border Cooperation surveys. The coefficients therefore capture how exposure to different types of cross-border mobility mediates the economic response to border closures.

Border municipalities characterized by higher levels of productive mobility (e.g. work, services, shopping) experienced statistically significant declines in nighttime light intensity following border closures. The largest negative effect is observed for services-related mobility, followed by shopping and business travel. These findings indicate that border closures disrupted cross-border interactions that function as productive inputs into local economies, leading topronounced reductions in economic activity.

In contrast, discretionary mobility (e.g. leisure and social visits) is associated with positive and statistically significant coefficients. Border municipalities where cross-border mobility is primarily driven by leisure or social interactions before the pandemic experienced relative increases in nighttime light intensity during border closures. When discretionary cross-border activities are restricted, time and spending are reallocated toward domestic alternatives, which might partially offset the negative market-access shock.

Table 4: Mechanisms: Purpose of Cross-Border Mobility

Mobility Purpose	Coefficient	Std. Error
Discretionary mobility		
Social (Family & Friends)	0.052***	(0.017)
Leisure	0.225***	(0.020)
Productive mobility		
Services	-0.421***	(0.043)
Shopping	-0.138***	(0.017)
Business	-0.077**	(0.037)
Observations	252,467	
Within R^2	0.32 -0.34	
FE: LAU	Yes	
FE: Month	Yes	

Notes: This table reports estimates from regressions that interact border closure exposure with measures of cross-border mobility by purpose. Each coefficient corresponds to a separate specification in which the treatment is interacted with the share of cross-border trips undertaken for the indicated purpose. The dependent variable is monthly nighttime light intensity at the municipality (LAU) level. All specifications include municipality and month fixed effects. Standard errors clustered at the municipality level are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Overall, the heterogeneity and mechanism analyses reveal that the economic impact of internal border closures is highly context-dependent. Local vulnerability depends not only on municipality size and adjustment capacity, but also on economic asymmetries across borders and the functional role of cross-border mobility. Where cross-border interactions primarily support production, border closures generate substantial economic losses; where mobility is largely discretionary, losses are mitigated or even reversed through domestic substitution. As a result, border closures created both relative economic losers and relative winners across municipalities, underscoring that internal border closures operate through distinct economic channels and generate uneven spatial effects across highly integrated regions.

6 Conclusion

The temporary reintroduction of internal border controls during the COVID-19 pandemic provides a unique natural experiment to examine how sudden increases in cross-border mobility costs affected local economic activity across European municipalities. Using monthly

NASA Black Marble nighttime lights data for more than 75,000 municipalities across 17 countries, we show that border municipalities experienced a significant decline in economic activity - around 2% on average - relative to interior locations during the first wave of border closures. This finding is consistent with existing regional-level evidence suggesting that border regions were particularly exposed to the economic consequences of mobility restrictions Capello et al. (2023), but provides the first municipality-level causal evidence based on observed outcomes.

Importantly, the average conceals substantial spatial heterogeneity. Economic losses were most pronounced in smaller border municipalities, which tend to have thinner local markets and more limited adjustment capacity. Losses were also concentrated in Eastern border regions and in Western municipalities bordering Eastern countries, while Western border municipalities adjacent to other Western countries experienced relatively better economic outcomes than interior areas. These contrasting patterns reflect differences in how local economies depended on cross-border mobility prior to the pandemic. Where cross-border movement primarily supported routine economic activities -such as commuting, services, and shopping- border closures disrupted local production and supply chains, leading to pronounced declines in economic activity. Where cross-border mobility was more discretionary, restrictions tended to redirect spending toward domestic alternatives, buffering the local economy and, in some cases, generating short-run gains.

By combining high-frequency satellite data with independent survey evidence on the purpose of cross-border mobility, this paper makes three main contributions. First, it provides causal evidence on the local economic effects of internal international border closures, a policy instrument that has played a central role in crisis responses but has received limited empirical scrutiny. Second, it shows that the economic impact of border closures depends strongly on local economic structure, cross-border asymmetries, and how cross-border mobility is used. Third, it offers direct evidence on the mechanisms at work, distinguishing between productive forms of mobility that support local economic activity and discretionary forms that are more easily substituted domestically.

These findings have implications beyond the COVID-19 pandemic. They show that even in a highly integrated area such as the Schengen zone—where internal borders are largely invisible in normal times—borders become economically consequential once mobility is restricted. Border openness is therefore not only a legal or institutional feature of integration, but also a key factor shaping local economic resilience. From a policy perspective, the results suggest that uniform border closure policies can have highly uneven regional effects, creating relative economic winners and losers across municipalities. Future crisis responses—whether driven by public health, security, or other concerns—would benefit from more place-sensitive approaches that account for the economic functions of cross-border mobility and seek to preserve economically essential interactions where possible.

More broadly, the results underscore the importance of considering regional heterogeneity and functional economic linkages when designing policies that affect mobility and market access. Understanding how and why border closures affect local economies is essential for building resilience in integrated economic spaces and for safeguarding the long-run benefits of European integration in times of crisis.

Data availability:

The data and replication package that support the findings of this study are available.

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Appendices

A Short-Run Equilibrium

This appendix presents the derivation of the short-run response of local economic activity to increases in mobility costs. Throughout, we interpret the equilibrium as strictly short-run: population stocks, firm locations, and the underlying stock of non-tradable services are fixed, while prices, market access, and the utilization of local services adjust immediately.

Market Access and Economic Activity

Firm and consumer market access are defined as

$$FMA_a \equiv \sum_i \frac{w_i L_i P_i^M}{T_{ai}^{\epsilon-1}}, \qquad CMA_a \equiv \sum_j \frac{n_j p_j P_j^M}{T_{ja}^{\epsilon}}. \tag{4}$$

Short-run real economic activity in municipality a is given by

$$EA_a = \Omega FMA_a^{\theta_1} CMA_a^{\theta_2} H_a^{-1}, \tag{5}$$

where Ω is a function of structural parameters and the common real wage.

Taking logs and totally differentiating with respect to trade costs yields

$$d \ln EA_a = \theta_1 \frac{dFMA_a}{FMA_a} + \theta_2 \frac{dCMA_a}{CMA_a} - \frac{dH_a}{H_a}. \tag{6}$$

Mobility Purpose and the Sign of the Short-Run Response

We derive the sign of the short-run response of local economic activity to increases in mobility costs using the log-differentiated equilibrium condition:

$$d \ln EA_a = \theta_1 \frac{dFMA_a}{FMA_a} + \theta_2 \frac{dCMA_a}{CMA_a} - \frac{dH_a}{H_a}. \tag{7}$$

Throughout, we interpret the equilibrium as short run. Population stocks, firm locations, and the underlying stock of nontradable infrastructure are fixed:

$$\frac{dL_i}{dT} = 0, \qquad \frac{dn_j}{dT} = 0, \qquad H_a = \bar{H}_a \cdot u_a(T),$$

where $\bar{H}_a$ denotes the fixed infrastructure stock and $u_a(T)$ captures its endogenous utilization.

Case 1: Market-access effects. Firm market access is defined as

$$FMA_a = \sum_i w_i L_i P_i^M T_{ai}^{-(\epsilon-1)}. \tag{8}$$

Differentiating with respect to trade costs yields

$$\frac{\partial FMA_a}{\partial T_{ai}} = -(\epsilon-1)\frac{w_i L_i P_i^M}{T_{ai}^{\epsilon}} < 0. \tag{9}$$

Since population and firm locations are fixed in the short run,

$$\frac{dFMA_a}{dT} < 0. \tag{10}$$

Similarly, consumer market access is

$$CMA_a = \sum_j n_j p_j P_j^M T_{ja}^{-\epsilon}, \tag{11}$$

with

$$\frac{\partial CMA_a}{\partial T_{ja}} = -\epsilon \frac{n_j p_j P_j^M}{T_{ja}^{\epsilon+1}} < 0, \tag{12}$$

implying

$$\frac{dCMA_a}{dT} < 0. \tag{13}$$

Thus, increases in mobility costs generate a negative market-access effect common to all municipalities.

Case 2: Productive mobility. When cross-border mobility supplies productive interactions, such as commuting, business travel, or access to customers, border closures do not reallocate activity toward local nontradables. Instead, they reduce effective productive capacity. In this case, utilization of local nontradable services does not increase:

$$\frac{du_a(T)}{dT} \approx 0 \quad \Rightarrow \quad \frac{dH_a}{dT} \approx 0. \tag{14}$$

Substituting into equation (7) yields

$$d\ln EA_a = \underbrace{\theta_1 \frac{dFMA_a}{FMA_a}}_{<0} + \underbrace{\theta_2 \frac{dCMA_a}{CMA_a}}_{<0} - \underbrace{\frac{dH_a}{H_a}}_{\approx 0} < 0. \tag{15}$$

Hence,

$$\frac{dEA_a}{dT} < 0. \tag{16}$$

Case 3: Discretionary mobility. When cross-border mobility is primarily discretionary, such as leisure or social visits, higher mobility costs redirect consumption toward locally provided nontradable services. Although the infrastructure stock $\bar{H}_a$ is fixed, its utilization increases:

$$\frac{du_a(T)}{dT} > 0 \quad \Rightarrow \quad \frac{dH_a}{dT} < 0. \tag{17}$$

Substituting into equation (7) gives

$$d \ln EA_a = \underbrace{\theta_1 \frac{dFMA_a}{FMA_a}}_{<0} + \underbrace{\theta_2 \frac{dCMA_a}{CMA_a}}_{<0} + \underbrace{\left(-\frac{dH_a}{H_a}\right)}_{>0}. \tag{18}$$

If the increase in local nontradable utilization is sufficiently strong, the positive demand reallocation term can offset the negative market-access effects:

$$-\frac{dH_a}{H_a} \;\geq\; \left|\theta_1 \frac{dFMA_a}{FMA_a} + \theta_2 \frac{dCMA_a}{CMA_a}\right|. \tag{19}$$

In this case,

$$\frac{dEA_a}{dT} \geq 0. \tag{20}$$

In a short-run equilibrium with fixed population, firm locations, and infrastructure stocks, the sign of the local economic response to border closures depends on whether cross-border mobility supplies productive interactions or discretionary consumption. This distinction determines whether changes in local nontradable utilization amplify or offset the market-access shock.

B Summary Statistics

Table 1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Population density (per km^2)	4,158,672	190.39	681.31	0	27,380.66
Area (km^2)	4,207,168	31.42	57.05	0.02	2,524.13
Population (2016)	4,158,672	4,538.32	32,127.71	0	3,520,031
Log nighttime lights	3,852,814	-0.68	1.82	-4.61	6.37
Social mobility share	2,096,864	0.36	0.18	0	1.05
Leisure mobility share	2,096,864	0.57	0.16	0	1.00
Services mobility share	2,096,864	0.11	0.07	0	0.50
Shopping mobility share	2,096,864	0.36	0.19	0	1.00
Business mobility share	2,096,864	0.15	0.08	0	0.53
Border municipality	4,167,576	0.46	0.50	0	1
Western municipality	4,207,168	0.81	0.39	0	1
Eastern municipality	4,207,168	0.19	0.39	0	1
West partner	4,207,168	0.33	0.47	0	1
East partner	4,207,168	0.16	0.36	0	1
Treatment (Post)	601,024	0.50	0.50	0	1
Alternative treatment (Post$_2$)	901,536	0.33	0.47	0	1
Year	4,207,168	2019	2.29	2018	2020
Month	4,207,168	4.0	2.0	1	7

Notes: This table reports summary statistics for the main variables used in the analysis. The unit of observation is a municipality (LAU)–month. Mobility shares represent the fraction of cross-border trips by purpose.