Port Competition and Hinterland Reconfiguration in the GMS: A Tripolar Balance

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Abstract

This paper studies how integration shocks reshape cross-border spatial equilibria in the Greater Mekong Subregion (GMS). Specifically, we examine whether new gateway capacity generates winner-takes-all dominance or stabilizes a polycentric (tripolar) configuration. Exploiting the 2015 deep-water expansion of Sihanoukville Port (SHV), we quantify hinterland responses across 47 inland provinces in Cambodia, Lao PDR, and Northeast Thailand over 2012–2021. To overcome cross-country data scarcity, we combine harmonized VIIRS night-time lights with a multi-period event-study difference-in-differences design, defining treatment intensity by pre-event road distance to SHV. Robustness analyses explicitly address local port-city confounding (donut restrictions) and spatial dependence. Empirically, we document persistent post-2015 growth concentrated along intermediate-distance corridor belts, confirming network-mediated spillovers rather than localized port-city shocks. This emergence of an additional growth pole refutes zero-sum displacement, motivating a governance approach that leverages gateway expansions to institutionalize regional balance and resilience in the GMS.

Keywords: Port competition; hinterland reconfiguration; night-time lights; event-study DID; Greater Mekong Subregion

Background and Statement of the problem

Regional integration in the Greater Mekong Subregion (GMS) is increasingly driven by logistics corridors rather than national borders. Transport connectivity—roads, border checkpoints, and port access—has become a central mechanism that reallocates economic activity and alters the regional geography of growth (Fujita et al., 1999; Redding and Turner, 2015). A defining feature of the southern GMS is its contested hinterland: interior provinces across Cambodia, Lao PDR, and Northeast Thailand are simultaneously connected to multiple international deep-water gateways, including Laem Chabang (Thailand), Ho Chi Minh City (Vietnam), and Sihanoukville (Cambodia). As these gateways expand capacity, a fundamental spatial-economic question arises: does integration produce a dominant hub that pulls activity toward one gateway (a winner-takes-all outcome), or can multiple gateways coexist in a stable, polycentric system where benefits diffuse across inland corridors (Krugman, 1991; Baldwin, 2016)?

While the theoretical tension between agglomeration (concentration) and dispersion (polycentricity) is well-established in New Economic Geography and transport economics (Krugman, 1991; Donaldson, 2018), empirical evidence on how port investments reshape inland economic distribution remains fragmented. The port competition literature frequently focuses on aggregate cargo flows and gateway selection (Ducruet and Notteboom, 2012), whereas recent corridor economics emphasizes localized "growth belts" driven by firm reallocation (Banerjee et al., 2020). However, evaluating these dynamics in a contested, cross-border region requires moving beyond national-level trade statistics to observe subnational spatial adjustments.

This objective faces three persistent empirical challenges, which are particularly binding in the GMS. First, standard regional accounts are often incomplete or lack cross-border comparability, limiting the tracking of consistent subnational outcomes. Second, infrastructure expansion is frequently endogenous; ports and corridors are upgraded where growth is already anticipated, confounding causal interpretation (Redding and Turner, 2015). Third, spatial dependence is intrinsic to transport networks, as gateway shocks propagate across neighboring provinces, complicating inference if spatial correlation is ignored (Conley, 1999). Consequently, while the regional policy debate on corridor development is fast-moving, rigorous subnational, cross-border evidence regarding the spatial effects of gateway capacity expansions remains notably scarce.

Statement of the Problem

The 2015 deep-water expansion of Sihanoukville Port (SHV) provides a discrete shock to evaluate how gateway capacity affects the spatial distribution of economic activity across a contested cross-border hinterland. This triggers two competing spatial adjustment hypotheses: does improved market access drive agglomeration toward a single dominant hub (a winner-takes-all hierarchy), or does it operate through network spillovers to foster a polycentric, tripolar balance across the southern GMS?

The practical stakes are high: a winner-takes-all equilibrium amplifies spatial inequality and vulnerability to localized disruptions, whereas a polycentric system strengthens regional resilience. Yet, current policy debates rely heavily on aggregate port-level throughput or national trade statistics. These macro-metrics obscure whether economic growth is genuinely diffusing inland or merely reflecting localized port-city dynamics, leaving a critical gap in our understanding of corridor-led integration.

Motivated by these gaps, this paper formulates the research problem as follows:

Motivated by this gap, this paper formulates the following research questions:

Causal impact: Did the 2015 SHV expansion increase economic activity in more exposed inland provinces relative to less exposed ones?

Spatial mechanism: Are post-expansion gains concentrated near the port (indicating local construction dynamics) or distributed along intermediate-distance corridor belts (indicating network spillovers)?

Equilibrium & Governance: Do these spatial responses support a winner-takes-all hierarchy or the emergence of an additional growth pole? Consequently, how can corridor governance be structured to sustain polycentric growth rather than excessive concentration?

By applying a robust identification strategy to harmonized subnational data, this study reframes port expansion from a purely competitive throughput narrative to a regional governance challenge of stabilizing cross-border balance.

Objective

The purpose of this research is to identify and interpret how a major gateway-capacity shock reshapes the cross-border spatial distribution of economic activity in the Greater Mekong Subregion (GMS), and to assess whether the resulting adjustment is consistent with a winner-takes-all hierarchy or a stable, polycentric (tripolar) regional equilibrium.

Specifically, this study aims to:

Estimate the causal impact of the 2015 Sihanoukville Port (SHV) deep-water expansion on hinterland economic activity across inland provinces in Cambodia, Lao PDR, and Northeast Thailand, using harmonized VIIRS night-time lights as a comparable proxy outcome.

Characterize the spatial gradient and corridor structure of the effects, distinguishing corridor-mediated spillovers (intermediate-distance belts and route-aligned patterns) from purely local port-city dynamics or construction-related noise near the port.

Test the robustness and credibility of inference by directly addressing key empirical threats differential pre-trends, alternative exposure definitions, local confounding around the port (donut restrictions), and spatial dependence so that results are not driven by coincident macroeconomic conditions or simple light–economy correlations.

Derive implications for regional-balance governance in the GMS, evaluating whether gateway expansions can be understood as instruments that institutionalize polycentric development and resilience, rather than mechanisms that intensify zero-sum displacement and concentration.

Expected benefits

1. Strategic Guidance for GMS Regional Development Policy

This study provides subnational, cross-border evidence that equips GMS policymakers to evaluate whether corridor-led integration fosters broad-based growth or exacerbates spatial inequality. By distinguishing a winner-takes-all dynamic from the formation of a stable polycentric (tripolar) system, the findings directly inform governance strategies aimed at sustaining regional balance across Cambodia, Lao PDR, and Thailand.

2. Actionable Investments for Corridor and Border Governance

Addressing the practical need for regional planning, the spatial-gradient findings—differentiating intermediate-distance corridor belts from localized port-city effects—offer a concrete roadmap for infrastructure prioritization. This guides where regional authorities should target complementary investments, such as dry ports, lastmile road upgrades, and customs modernization, ensuring that gateway capacity expansions translate into resilient inland spillovers rather than isolated coastal gains.

3. Improved Risk Management and Resilience Assessment

By identifying whether economic activity diversifies across multiple gateways or becomes dependent on a single dominant node, the findings provide a framework for governments and firms to stress-test regional supply chains. This supports proactive diversification strategies to mitigate vulnerabilities to congestion, policy shocks, or geopolitical disruptions.

4. Methodological and Academic Contributions

Academically, the research advances theories of market access, agglomeration, and port competition by detailing how gateway shocks reshape cross-border spatial equilibria. Methodologically, it offers a replicable empirical template—combining harmonized VIIRS night-time lights, continuous exposure measures, event-study DID, and spatial dependence diagnostics—for rigorously evaluating infrastructure impacts in data-constrained, multi-country regions.

Conceptual Framework

1. Conceptual Motivation and Operationalization

This research addresses a core question in economic geography: when trade and transport costs fall, does economic activity concentrate in a small number of dominant nodes (winner-takes-all), or can multiple nodes coexist in a stable, polycentric equilibrium? The Greater Mekong Subregion (GMS) provides a natural laboratory for this question, as inland provinces face competing access to several international gateways.

To operationalize this, we conceptualize the 2015 Sihanoukville Port (SHV) deep-water expansion as a discrete gateway-capacity shock. This shock lowers generalized trade costs and reorders effective market access for connected hinterlands. We measure exposure (treatment intensity) via pre-event road-distance accessibility to SHV, interpreting post-shock effects as a market-access gradient that attenuates with distance and corridor frictions. The resulting spatial equilibrium—whether winner-takes-all concentration or corridor-mediated polycentric diffusion—is captured by the post-2015 reallocation of economic activity, proxied by harmonized VIIRS night-time lights.

2. Theoretical Foundations

Our empirical strategy is grounded in three complementary strands of theory.

1. New Economic Geography (NEG) and Market Access

In NEG, reductions in trade and transport costs trigger spatial reallocations of firms by changing regional market access. Depending on the balance between agglomeration and dispersion forces, a system may move toward core-periphery concentration or maintain a polycentric distribution. In our context, SHV's expansion reduces trade costs for highly connected provinces, directly improving their effective market access.

2. Corridor Economics and Network-Mediated Spillovers

Transport infrastructure generates non-linear spatial responses because benefits transmit through networks. Corridor improvements often create "growth belts" where connectivity gains intersect with complementary inputs. This mechanism suggests that gateway shocks may not concentrate purely at the port city, but rather along intermediate-distance corridors where marginal market-access gains are largest.

3. Port Competition and Hinterland Reconfiguration

In transport economics, gateways continuously compete for hinterland cargo. Capacity expansions can either attract investment away from incumbent gateways (displacement) or enlarge total logistics activity (complementarity). In a multi-gateway region like the GMS, the spatial outcome hinges on whether these connectivity changes generate zero-sum diversion or sustain network expansion across multiple gateways.

3. Core Concepts Used in This Study

To operationalize the conceptual framework (illustrated in the diagram below), we treat the 2015 Sihanoukville Port (SHV) deep-water expansion as a discrete gateway-capacity shock that lowers generalized trade costs and reorders effective market access for connected hinterlands. Following regional economics theory, we measure exposure—or treatment intensity—using pre-event road-distance accessibility to SHV, interpreting post-shock effects as a market-access gradient where gains attenuate with distance and corridor frictions. The resulting spatial equilibrium shift is captured by the post-2015 reallocation of economic activity across the inland provinces, consistently proxied across borders by harmonized VIIRS night-time lights. Ultimately, this design allows us to rigorously evaluate competing hypotheses: whether the shock produces localized concentration indicative of a winner-takes-all hierarchy, or corridor-mediated diffusion that stabilizes a polycentric, tripolar balance with multiple growth poles in the southern GMS.

4. Conceptual Mechanism and Testable Implications

The conceptual framework implies a corridor-based adjustment mechanism: the discrete SHV capacity expansion disproportionately lowers generalized access costs for provinces with higher pre-event exposure, directly improving their effective market access and logistics feasibility. If this mechanism is operative, it yields distinct testable implications. First, the empirical response must be heterogeneous in exposure intensity; more exposed provinces should experience larger post-2015 increases in economic activity relative to less exposed ones, even after netting out common shocks and time-invariant characteristics. Second, because transmission flows through transport networks, the spatial pattern of gains should be corridor-shaped rather than purely local. Specifically, effects should concentrate along route-aligned, intermediate-distance belts where trade genuinely reorganizes, rather than remaining confined to the port province. Third, this mechanism sharply distinguishes the two spatial equilibrium hypotheses: a winner-takes-all outcome would manifest as extreme localized concentration and diversion from rival gateways, whereas a tripolar balance would appear as a new, complementary growth pole characterized by broader corridor diffusion. Finally, because logistics spillovers inherently propagate across borders, credible inference requires that these estimated post-2015 effects remain robust when explicitly accounting for spatial dependence and alternative definitions of neighborhood connectivity.

5. Key Assumptions

The conceptual framework motivates the empirical strategy under the following assumptions:

1. Relevance of exposure: Pre-event road-distance-based exposure captures meaningful variation in how much provinces benefit from SHV's capacity expansion through changes in generalized access costs.

2. Comparability of outcome proxy: VIIRS night-time lights provide a harmonized measure of relative changes in local economic activity across borders and over time.

3. No differential pre-trends conditional on controls: In the absence of the SHV expansion, high- and low-exposure provinces would have followed similar trends, after accounting for province and year fixed effects and standard controls.

4. Local confounding can be mitigated: Any port-city construction or localized shocks around SHV can be addressed through exclusion (donut) restrictions and robustness checks, allowing the analysis to focus on hinterland reallocation rather than local construction noise.

Research Methodology

1. Study Area and Sample Design

This study focuses on the landlocked and semi-inland hinterland of the Greater Mekong Subregion (GMS) where inland producers can plausibly choose among three competing deep-sea gateways—Laem Chabang (Thailand), Ho Chi Minh City/Cai Mep–Thi Vai (Vietnam), and Sihanoukville (Cambodia). The empirical sample covers 47 inland provinces: 18 in Lao PDR, 18 in Northeast Thailand, and 11 in Cambodia, observed annually from 2012–2021 (balanced panel).

2. Data Sources and Outcome Construction (Night-time Lights)

We use annual VIIRS night-time lights (NTL) as a harmonized proxy for subnational economic activity in a cross-country setting where provincial GDP series are incomplete or not strictly comparable. Provincial outcomes are constructed by overlaying administrative polygons for the 47 provinces onto the VIIRS grid and aggregating radiance values to the province-year level, standard cleaning procedures are applied to address transient light sources and sensor artefacts, with adjustments around known discontinuities.

Main outcome (panel): $y_{it} \equiv \ln(NTL_{it})$

Normalized change outcome (for distance-gradient diagnostics): $\Delta y_{it} \equiv \ln(NTL_{it}) - \ln(NTL_{i,2015})$.

This transformation differences out province-specific levels at the 2015 reference point and is used in non-parametric and donut-gradient checks.

3. Treatment Definition and Exposure Measures

We treat the 2015 deep-water expansion of Sihanoukville Port (SHV) as the policy/infrastructure shock and measure provincial exposure using pre-event road-distance-based accessibility to SHV (and, for benchmarking, to Laem Chabang). The core identification logic is that provinces with higher pre-2015 SHV accessibility should experience larger post-2015 gains if the expansion reconfigures hinterland market access.

We operationalize treatment intensity in two complementary ways:Continuous exposure: $\text{Exposure}_i = \text{Dist}^{2014}_{i\to \text{SHV}}$, road distance in km; lower values imply higher exposure. And distance-band exposure (coarse heterogeneity): provinces are partitioned into mutually exclusive distance bands (near/middle/far), with the far band omitted as reference in event-study DID.

4. Baseline Identification: Dynamic Event-Study DID

To estimate the dynamic impact of the 2015 shock, we implement an event-study DID with province and year fixed effects

(A) Event-study DID with discrete treated group (catchment indicator): $quad y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1} \beta_k \left(⊮\{t-2015=k\} \times \text{Treat}_i \right) + \varepsilon_{it}$

α_i:province fixed effects (time-invariant heterogeneity)

γ_t:year fixed effects (common shocks)

k:event time relative to 2015

Baseline year omitted: k=−1 (2014)

Parallel-trends test: The identifying assumption requires β≈0 for pre-event years.

(B) Event-study DID with continuous exposure (distance intensity):

$$y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1} \theta_k \left(⊮\{t-2015=k\} \times \text{Exposure}_i \right) + \varepsilon_{it}$$

Here, θ traces how the slope of the exposure–outcome relationship changes after 2015.

$$y_{it} = \alpha_i + \gamma_t + \lambda_i t + \sum_{k\neq -1} \beta_k(\cdot) + \varepsilon_{it}$$

Optional province trends (robustness):

where λit allows province-specific linear trends.

5. Distance-Band Event Study (Interpretability Check)

To provide an easily interpretable heterogeneity profile, we estimate a banded event study:

$$y_{it} = \alpha_i + \gamma_t + \sum_{k \neq -1} \left[\beta_k^N \left(⊮\{t - 2015 = k\} \times \text{Near}_i \right) + \beta_k^M \left(⊮\{t - 2015 = k\} \times \text{Middle}_i \right) \right] + \varepsilon_{it}$$

The coefficients capture the additional post-2015 change in the near and middle bands relative to the far band.

6. Non-Parametric Distance Gradients (Binned Means)

To avoid functional-form dependence and visualize ripple effects, we construct binned means of by distance to SHV for each year t. Provinces are sorted partitioned into equal-width bins (e.g., 25/50/100 km), and the within-bin mean of is plotted against the bin midpoint. This yields a non-parametric estimate of the spatial decay profile.

7. Donut Regressions: Port-Specific Gradient and Slope Evolution

To summarize the distance gradient compactly and mitigate local construction confounding, we estimate donut-type cross-sectional regressions for post-event years (main text focuses on 2019), excluding provinces within an inner radius around SHV (e.g., 0–100 km):

$$\Delta y_{it} = a_t + \beta_t \cdot \text{Dist}_{i \to \text{SHV}}^{2014} + u_{it}, \qquad i \in \mathcal{D}(\text{donut})$$

8. Spatial Dependence Diagnostics and Robustness Design

Because provinces are connected through corridors and cross-border production networks, outcomes may exhibit spatial autocorrelation. We diagnose this using Global Moran's I with fixed spatial weights over time (e.g., contiguity or KNN), and we check that the main conclusions are not artefacts of a particular neighbour definition.

In robustness, we vary spatial weight matrices (e.g., KNN with different k) and perform influence diagnostics (leave-one-out) to verify that results are not driven by a small number of observations.

Global Moran's I $I = \frac{N}{S_0} \cdot \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$ formula:

where $S_0 = \sum_i \sum_j w_{ij}$ is row-normalized spatial weights.

9. Statistical Inference

We report heteroskedasticity-robust standard errors for cross-sectional donut regressions and cluster-robust standard errors for panel DID/event-study specifications. Where cluster counts are limited, we complement conventional clustering with conservative procedures (e.g., wild bootstrap) and, when appropriate, distance-based spatial corrections for residual correlation.

Research Results

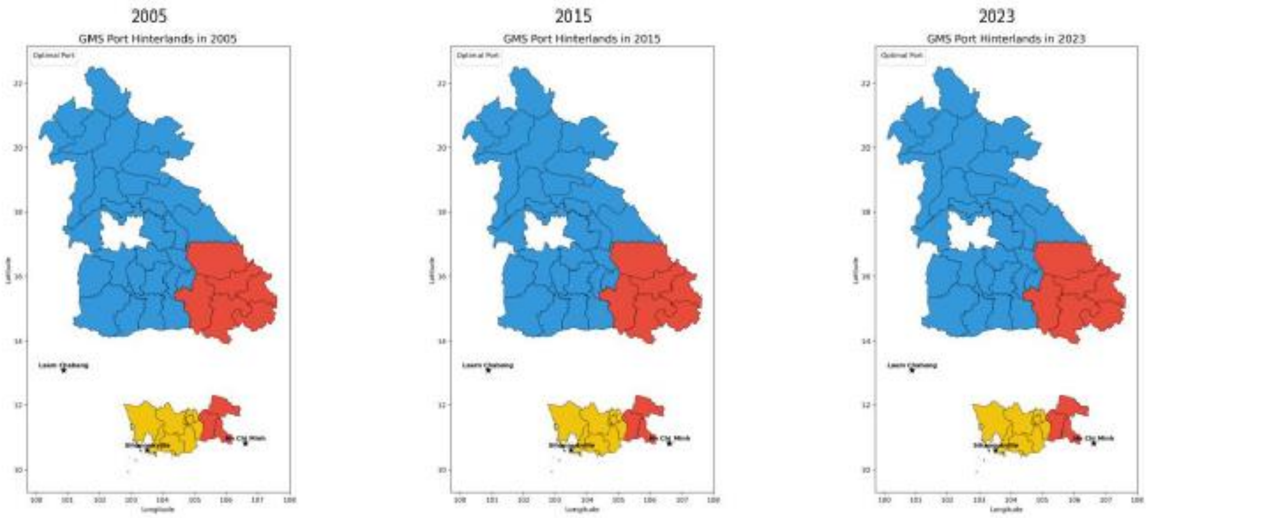

Figure 1 (GMS Port Hinterlands: 2005, 2015, 2023)

The hinterland assignment maps show a persistent tripolar structure in the southern GMS: most inland provinces in Lao PDR and Northeast Thailand remain primarily aligned with Laem Chabang, while Ho Chi Minh City retains a stable catchment over the eastern/southeastern portion of the contested hinterland, and Sihanoukville anchors the western/central Cambodian side of the system. Importantly, the overall partition is remarkably stable between 2005, 2015, and 2023, suggesting that (i) hinterland competition is structured by durable corridor geography rather than short-lived fluctuations, and (ii) any post-2015 reconfiguration associated with SHV is more likely to appear as intensity changes within a broadly stable spatial partition (i.e., growth and corridor spillovers) rather than an immediate, wholesale redrawing of port dominance boundaries.

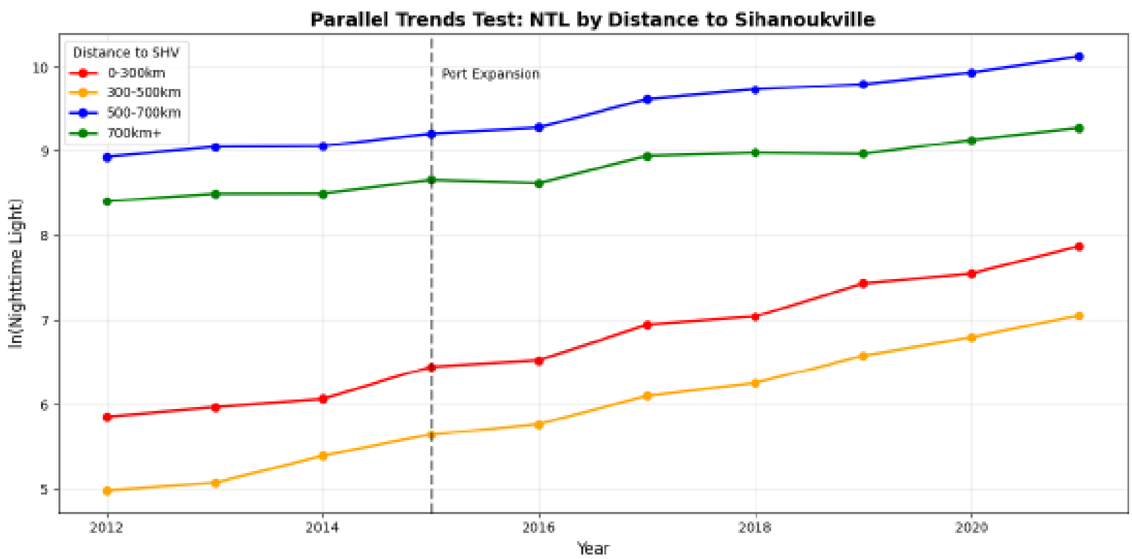

Figure 2 (Parallel Trends Test: NTL by Distance to Sihanoukville)

The distance-binned NTL series provides a transparent diagnostic for the identifying assumption. Prior to 2015, the trajectories of ln (NTL) across distance bands are broadly parallel in slope, indicating no sharp divergence in pre-trends between provinces closer to SHV and those farther away. After the 2015 expansion (vertical dashed line), the lines continue to rise across all groups, but the growth profile becomes more differentiated: the 0–300 km and 300–500 km bands exhibit a clearer post-2015 acceleration relative to more distant groups, consistent with the idea that the SHV capacity shock operated through corridor-linked accessibility and benefited more exposed hinterland locations. This figure therefore supports the event-study DID strategy by showing that the post-2015 divergence is not simply the continuation of a pre-existing differential trend.

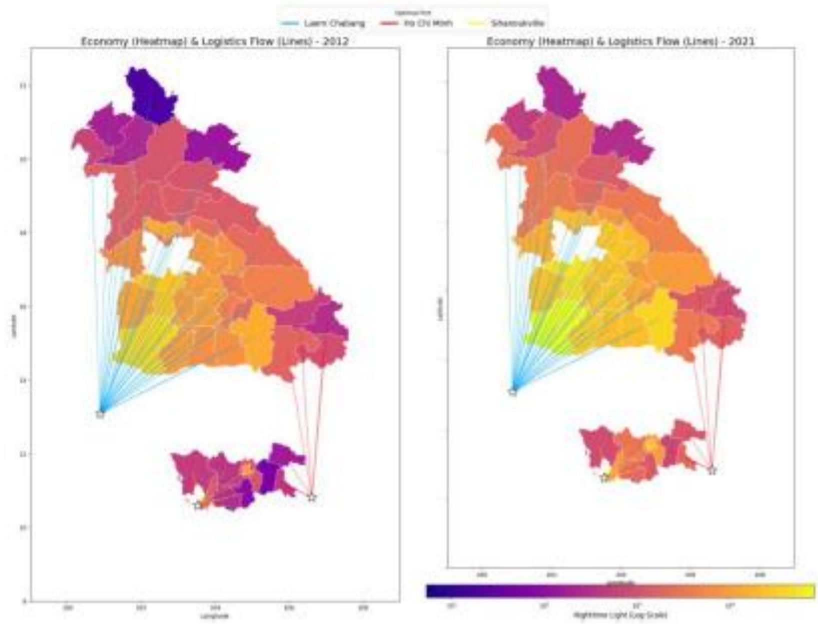

Figure 3 (Economy Heatmap & Logistics Flow: 2012 vs 2021)

Comparing 2012 with 2021, the NTL heatmaps indicate a broad rise in economic activity across the sample, but with a spatial pattern that is strongly corridor-shaped. The interior provinces, especially those lying along the connectivity fan radiating from SHV and linking inland Cambodia and adjacent border areas shift from darker (lower) to warmer (higher) intensity, while the far-periphery changes are more muted. The overlaid logistics flow rays reinforce this interpretation: the post-2015 period is characterized less by a purely local brightening around the port city and more by an inland diffusion pattern aligned with corridor directions. Taken together, the map-based evidence is consistent with network-mediated spillovers, an additional growth pole supported by corridor integration rather than a purely port-city construction effect or a simple, static relocation of the hinterland boundary.

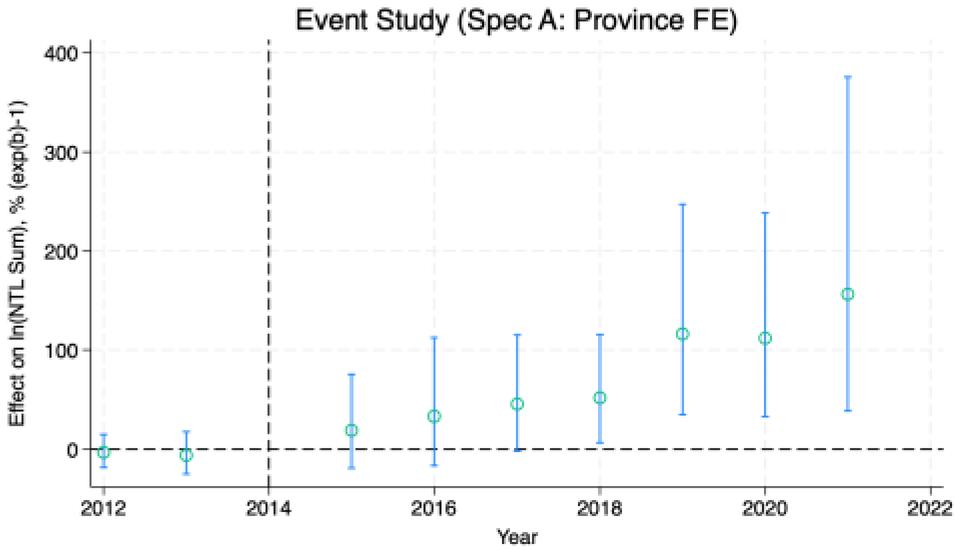

Figure 4: Event Study, Spec A: Province FE

This reports the event-study estimates from Specification A with province and year fixed effects. The pre-treatment coefficients in 2012–2013 are small and statistically indistinguishable from zero, which supports the parallel-trends assumption between the SHV catchment and control provinces prior to the expansion. Beginning in 2015, the estimated effects turn positive and then grow steadily over time. The first post-treatment years (2015–2016) show moderate gains on the order of roughly 20-40 percent higher ln(NTLsum) relative to the 2014 baseline, consistent with an initial adjustment phase in which corridor connectivity and logistics reallocation start to materialize but remain imprecisely estimated (as reflected in relatively wide confidence intervals). From 2017 onward, the effects become both larger and more precisely estimated: coefficients rise into the 50 -120 percent range through the mid-to-late 2010s, and by 2018–2019 the point estimates exceed approximately one additional log point, implying more than a doubling of nighttime lights relative to the counterfactual. The profile continues to increase up to 2021, where the implied effect reaches the order of 150 percent (and, in percentage terms, can amount to several hundred percent depending on the exact coefficient), although the confidence intervals widen as the event window extends further from the treatment year. Overall, Specification A indicates a gradual but sizable build-up of luminosity in SHV catchment provinces, with statistically meaningful gaps emerging a few years after the expansion and persisting thereafter consistent with a sustained corridor-mediated reconfiguration rather than a one-off, transitory shock.

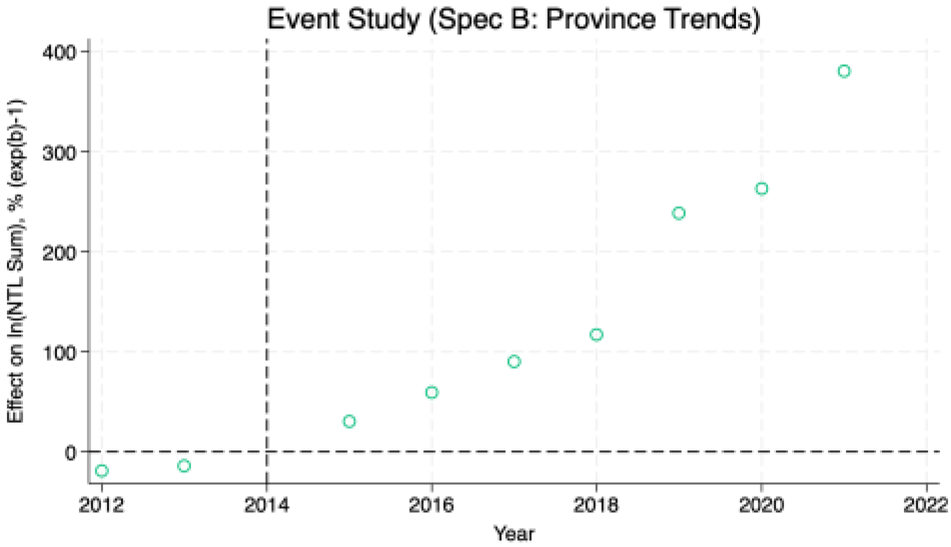

Figure 5: Event Study, Spec B: Province Trends

Figure 5 reports the event-study estimates from Specification B, which extends the baseline model by adding province-specific linear trends so that identification comes from post-2015 deviations relative to each province's own underlying trajectory rather than from level differences alone. The pre-expansion coefficients (2012–2013) remain small and close to zero, providing no evidence of differential pre-trends once province trends are accounted for. Beginning in 2015, the estimated effects turn positive and rise monotonically over time: the early post-treatment years (2015–2016) show moderate gains, the mid-period coefficients (2017–2018) increase further into roughly the 90–120 percent range in exp(β)–1 terms, and the late post period displays a pronounced acceleration, with effects around 240–270 percent in 2019–2020 and approaching roughly 380 percent by 2021. Although this specification is more conservative, the persistence and steepening of the post-2015 profile closely mirror the baseline pattern, indicating that the estimated SHV-catchment uplift is not driven by pre-existing province-specific growth paths but reflects a substantial and sustained divergence after the expansion.

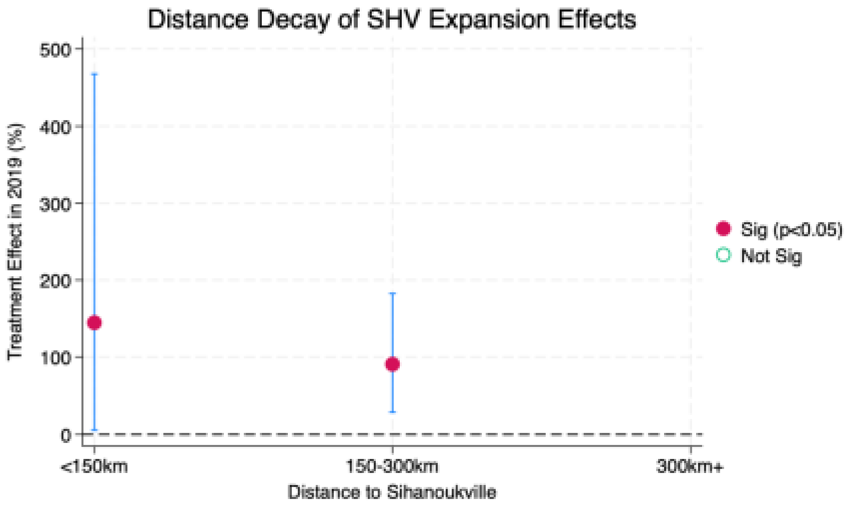

Figure 6. Distance Decay of SHV Expansion Effects

Figure 6 summarizes the spatial decay pattern of the SHV expansion effects by reporting estimated treatment impacts in 2019 across distance bands to Sihanoukville. The results indicate a clear distance gradient: provinces within 150–300 km of SHV exhibit a positive and statistically significant effect ($p < 0.05$), on the order of roughly 90–100 percent, while the <150 km group also shows a positive and statistically significant point estimate of roughly 150 percent but with substantially wider confidence intervals, reflecting greater uncertainty likely driven by fewer observations and the presence of local idiosyncratic factors near the port. By contrast, provinces located beyond 300 km serve as the reference category and show no comparable uplift. Two implications follow. First, the economically meaningful gains are not confined to the immediate port province; instead, the strongest and most precisely estimated effects appear in the intermediate-distance belt, consistent with corridor-mediated spillovers and hinterland reallocation rather than purely local port-city construction activity. Second, the imprecision in the closest band motivates the donut-style restrictions used elsewhere in the analysis to separate localized port-area dynamics from broader hinterland responses.

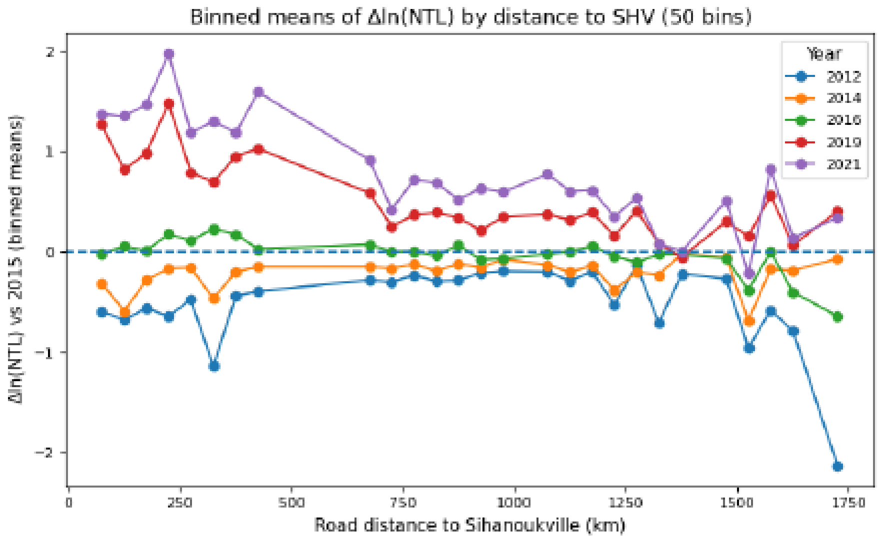

Figure 7. Binned Means of Δln(NTL) by Road Distance to Sihanoukville (50 Bins)

Figure 7 provides a non-parametric view of the distance gradient by plotting binned means of Δln(NTL) relative to the 2015 baseline against pre-event road distance to Sihanoukville (50 bins), separately for selected years. Two patterns stand out. First, the pre-expansion year (2012) lies predominantly below zero across most distances, reflecting lower luminosity relative to 2015 and serving as a visual benchmark for pre-period differences rather than a post-shock response. Second, after the 2015 expansion the profile shifts upward and becomes increasingly positive for later years: the 2016 series is close to zero with modest positive deviations at shorter distances, while the 2019 and 2021 series are clearly above zero over a wide range of distances, indicating substantial post-2015 increases in nighttime lights relative to the 2015 reference level. Importantly, the strongest and most stable positive deviations are concentrated in an intermediate-distance corridor range (roughly a few hundred kilometers to about 1000–1200 km), whereas the farthest distances display greater volatility and occasional negative dips, consistent with thinner bin counts and heterogeneous far-hinterland conditions. Overall, the binned-means evidence supports a corridor-mediated interpretation: the SHV shock is associated with a broad inland uplift that is not confined to the immediate port vicinity and exhibits a distance-decay structure consistent with network spillovers rather than purely local port-city dynamics.

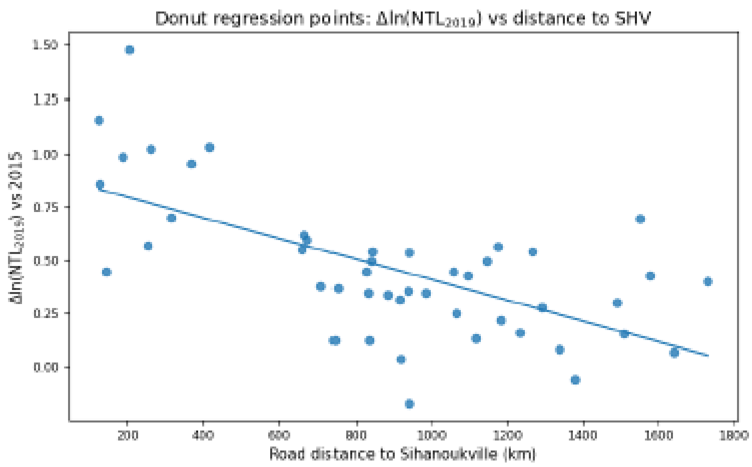

Figure 8. Donut Regression: Δln(NTL2019) vs. Road Distance to Sihanoukville (SHV)

Figure 8 reports the donut-style distance-gradient evidence by plotting province-level changes in luminosity, Δln(NTL2019) relative to 2015, against pre-event road distance to Sihanoukville, together with the fitted linear relationship. The fitted line is clearly downward sloping, indicating that provinces farther from SHV experienced smaller post-2015 gains in nighttime lights by 2019. In other words, conditional on being outside the immediate port area (the "donut" restriction designed to reduce contamination from port-city construction and other highly local shocks), the post-expansion uplift exhibits a systematic distance-decay pattern consistent with a corridor-mediated transmission mechanism: proximity to SHV predicts a larger increase in hinterland economic activity. The scatter also shows meaningful dispersion around the fitted line, which is expected in a cross-border setting where local industrial composition, border frictions, and corridor connectivity vary across provinces; nevertheless, the negative gradient is sufficiently pronounced to support the interpretation that the SHV capacity shock is associated with an inland reallocation/expansion effect that weakens with distance. Taken together with the event-study results and the binned-means profiles, Figure 8 reinforces the view that the post-2015 dynamics are not driven by a purely local port-city shock but reflect a broader spatial response structured by market access and transport-network geography.

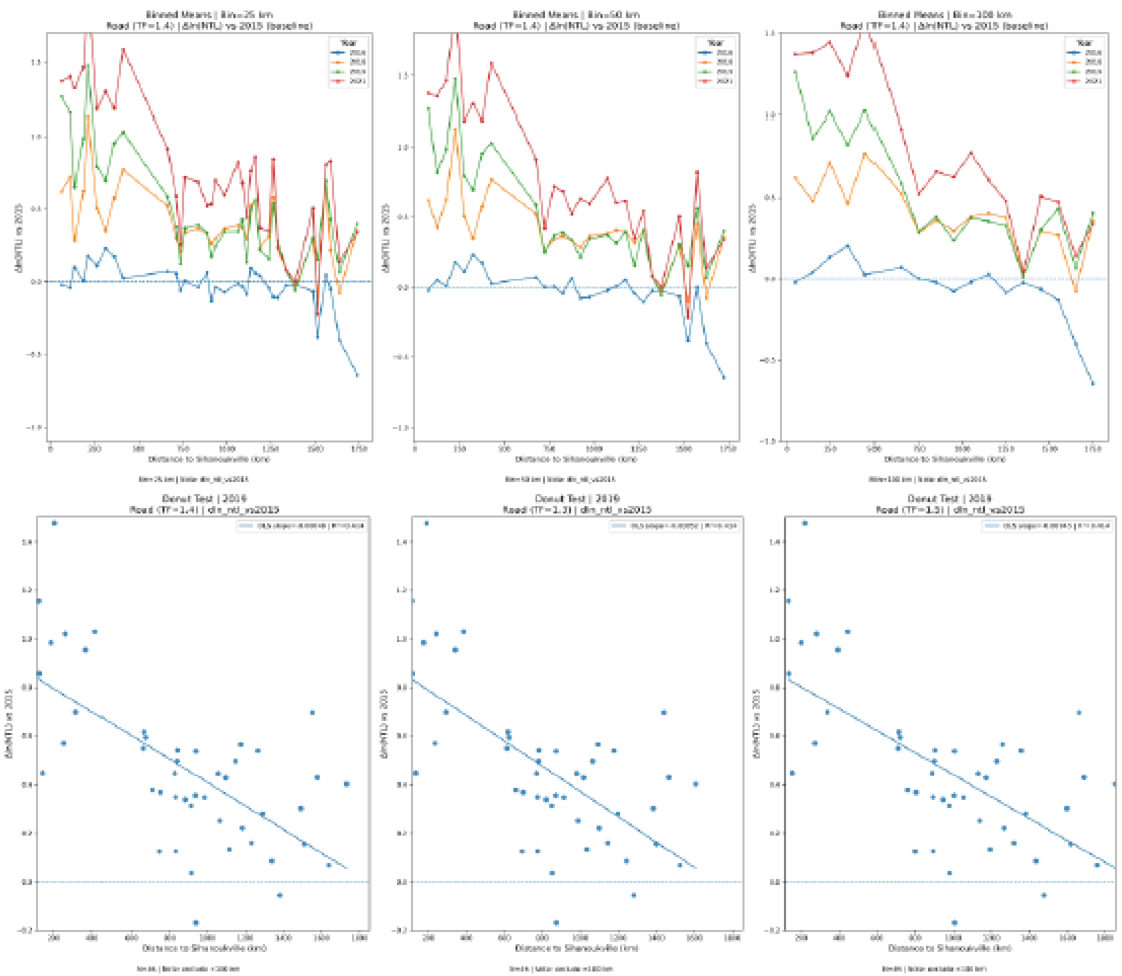

Figure 10. Robustness of the SHV Distance-Gradient: Alternative Binning and Donut Specifications

We bundles two complementary robustness exercises designed to verify that the core “distance-decay” finding is not an artefact of arbitrary smoothing choices or a particular donut cutoff. The top row replicates the binned-means distance profile of Δln(NTL) relative to the 2015 baseline using alternative bin widths (25 km, 50 km, and 100 km). Across all three binning choices, the post-expansion years (especially 2019 and 2021) remain systematically above zero over short-to-intermediate distances and decline as distance increases, while the pre-period series stays near or below zero. The stability of the overall shape across bin widths indicates that the non-parametric gradient is not driven by a particular discretization of distance; rather, the corridor-shaped uplift and its gradual attenuation with distance are a persistent feature of the data.

The bottom row reports donut regressions for 2019 under alternative inner-radius exclusions (e.g., dropping provinces within 1.4, 1.3, or 1.5 units of the cutoff as labeled in the panels). In each case, the fitted relationship between Δln(NTL2019) and road distance to SHV remains clearly negative, implying that provinces farther from SHV experience smaller post-2015 gains even when the immediate port area is excluded. This pattern supports the interpretation that the estimated effects are not dominated by port-city construction activity or highly local shocks near SHV, and it reinforces a network-mediated mechanism in which hinterland gains diffuse along corridors but decay with distance. Taken together, the binning and donut robustness checks strengthen the credibility of the spatial reallocation result: the SHV expansion is associated with a systematic, geographically structured uplift in inland economic activity rather than a fragile pattern sensitive to smoothing or cutoff choices.

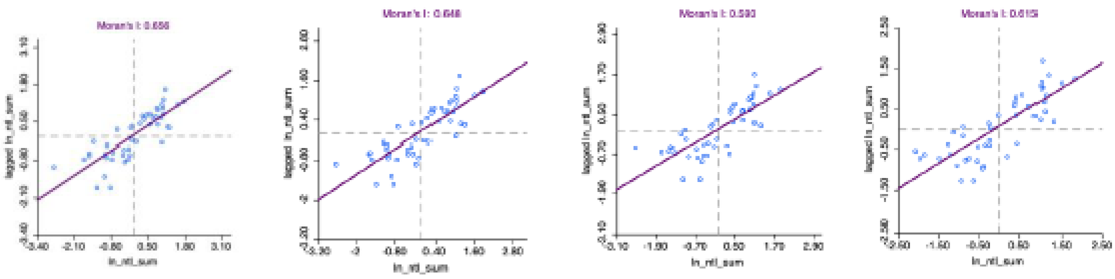

Figure 11. Spatial Autocorrelation in Night-Time Lights: Moran Scatterplots

The Moran's I scatterplots for the log of summed nighttime lights illustrate a consistently high degree of positive spatial autocorrelation across the provinces of the Greater Mekong Subregion (GMS) throughout the sample period. A first concern for our identification strategy is that nighttime economic activity is unlikely to be independently distributed across space. Provinces share production networks, urban systems, and infrastructure corridors, suggesting that both shocks and adjustment may be spatially correlated. To diagnose the extent of such dependence, we compute global measures of spatial autocorrelation in representative pre and post treatment years using a row standardised contiguity matrix that is kept fixed over time.

In 2013, the estimated Moran's I is high at 0.656, indicating that provinces with high NTL tend to be surrounded by neighbors with high NTL, and vice-versa. Similarly, in 2015, the estimated Moran's I remains high at 0.648. In both pre-treatment years, the vast majority of provinces lie in the upper-right (High-High) and lower-left (Low-Low) quadrants of the scatterplots, demonstrating the existence of a highly clustered core–periphery structure before the SHV expansion took full effect. The spatial clustering persists into the post-treatment period, albeit with a slight decline in magnitude, suggesting diffusion of activity. In 2019, the Moran's I is 0.593, and in 2021, it is 0.615. In all years tested, permutation tests robustly reject the null hypothesis of spatial randomness at conventional significance levels. Importantly, the level of global autocorrelation is very similar in the pre-treatment years and only slightly declines as activity diffuses in 2019–2021. This stability in the global Moran's I statistic suggests that the strong spatial correlation is a persistent feature of the GMS urban system—the result of long-term economic geography rather than spurious increase mechanically generated by the highly localized Sihanoukville expansion shock.

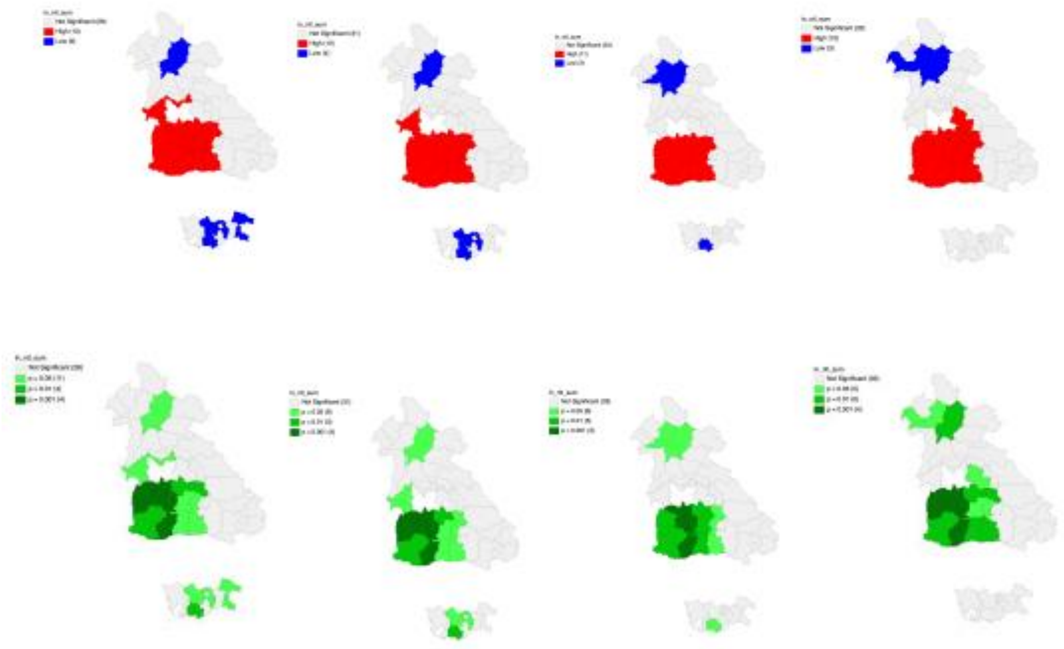

Figure 12. The Local G* for 2013, 2015, 2019 and 2021

Our identification strategy requires explicit attention to spatial dependence, since economic activity and shocks are unlikely to be independent across neighboring provinces. To diagnose the extent and structure of spatial correlation, we compute global and local measures of spatial autocorrelation using a fixed, row-standardized contiguity matrix. Two persistent features characterize the GMS spatial economy throughout the sample period: a stable High–High cluster concentrated in the central–southern provinces, representing the region's pre-existing urban and manufacturing core aligned with the established logistics axis, and a persistent Low–Low cluster in the northern periphery, reflecting a durable cold spot of remote, underdeveloped provinces consistently distant from major ports and corridor connectivity.

The key evidence relevant to the SHV upgrade emerges from the dynamic adjustment of the High–High boundary over time rather than from changes in the core's location. The 2013 and 2015 patterns are largely similar, indicating that the pre-expansion economic geography was broadly stable, with only modest incremental extension along the existing axis. After the SHV upgrade becomes operational, High–High clustering intensifies and becomes more tightly focused within the central corridor, while several southern coastal provinces near SHV, previously classified as Low–Low or non-significant transition toward non-significant or marginal High–High status. By 2021, the corridor pattern consolidates: a large share of provinces along the projected infrastructure corridor is absorbed into the High–High cluster and Low–Low presence near the southern endpoint declines sharply, consistent with diffusion of increased luminosity toward SHV. This evolutionary pattern directly matches the econometric evidence—explaining the steepening event-study profile after 2016 and the pronounced distance-decay detected in donut regressions while ruling out a generic region-wide boom (which would instead dilute Moran's I and expand High–High clustering uniformly).

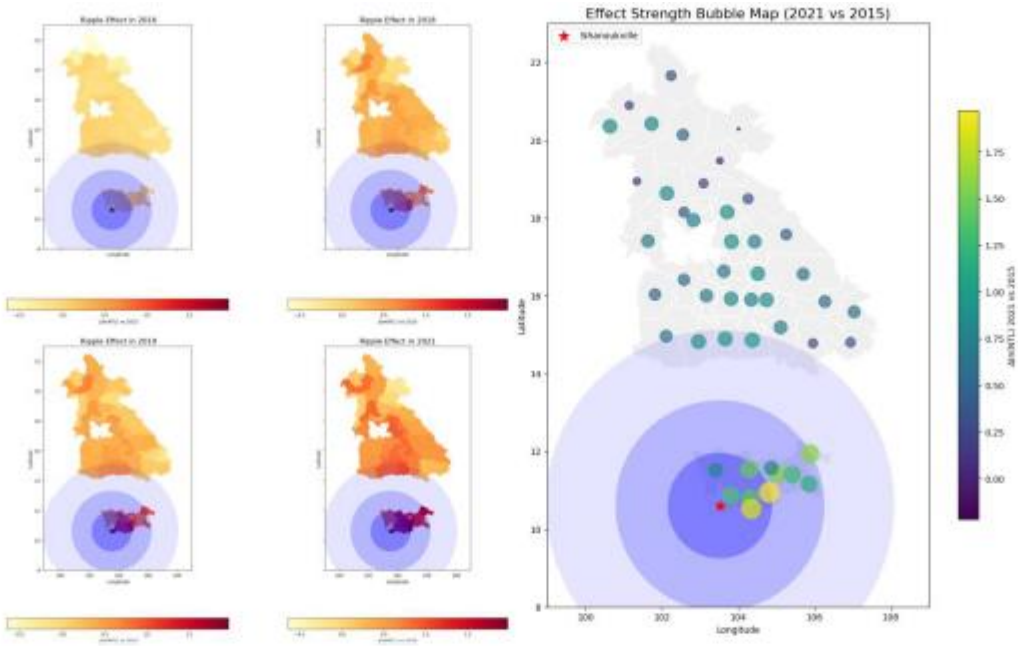

Figure 13. Spatial Diffusion of the SHV Shock

To visualize how the port shock diffuses across space, we combine province-level changes in nighttime lights with concentric distance bands around Sihanoukville and map the resulting patterns for 2016, 2018, 2019, and 2021. A modest halo of higher luminosity appears in coastal Cambodia by 2016, while most of the mainland Mekong remains close to the 2015 baseline; by 2018 the high-intensity areas strengthen and extend inland along the road corridor linking Sihanoukville to Phnom Penh and further north. The 2019 and 2021 panels reveal a clear ripple structure: provinces within the 0–150 km and 150–300 km rings experience the strongest and most persistent gains, whereas areas beyond roughly 300 km exhibit much weaker or no visible change. The 2021 bubble map sharpens this gradient by scaling each province's circle by the magnitude of post-2015 growth, showing dense clusters of large, high-intensity bubbles along the Cambodian coastal belt and adjacent inland provinces, contrasted with small, pale circles in the northern GMS. Finally, a leave-one-out influence diagnostic for the 2021 specification confirms that the estimated effect is not driven by a small number of observations: re-estimating the model while dropping one province at a time yields a tight distribution of coefficients concentrated around 0.35–0.45 (baseline =0.401), with only limited tail outliers, and no single province—aside from the expected leverage of Krong Preah Sihanouk in the extreme donut case—materially overturns the result; if anything, excluding that port province increases the estimate, reinforcing that the positive NTL response reflects broad-based corridor dynamics rather than idiosyncratic local noise.

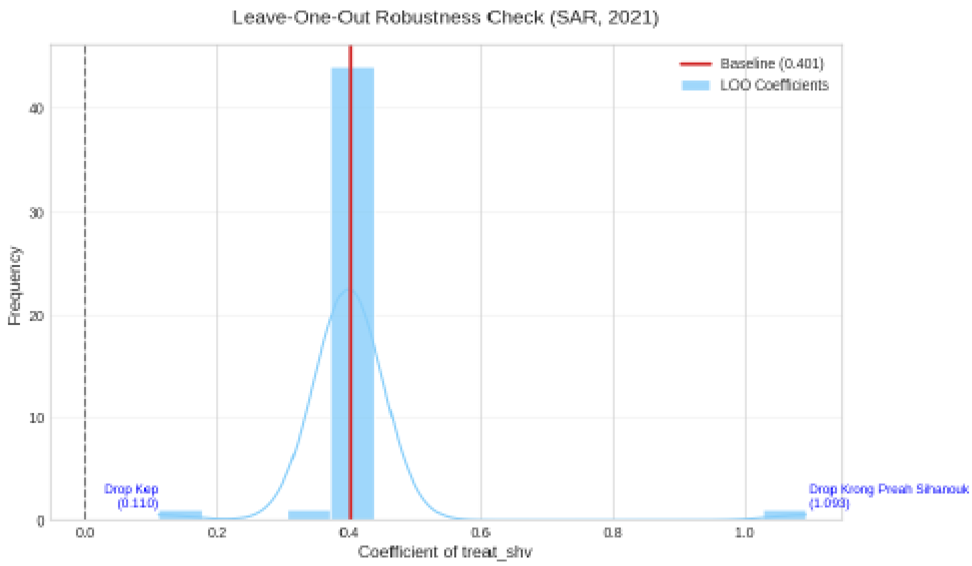

Figure 14. Influence and Donut Robustness

Evaluation sample	Evaluation		
	Coef.	*P-value*	*Significance*
1. Full sample (baseline)	*0.4009*	*0.0075*	***
2. Donut (excl. Krong Preah Sihanouk)	*1.0933*	*0.0000*	***

We next implement a spatial donut test to verify that our estimated port effect is not mechanically driven by the extreme growth of the core port province, Krong Preah Sihanouk. Column (1) of Table Z reports the baseline spatial specification including all provinces, where the estimated treatment coefficient on the Sihanoukville catchment is 0.401 (p-value = 0.0075). Interpreted in levels, this corresponds to roughly a e0.401−1≈49% increase in nighttime lights relative to non-catchment provinces. Column (2) repeats the regression after excluding Krong Preah Sihanouk from the sample; the coefficient rises to1.093 with p-value of 0.00002, implying an effect of almost e1.093−1≈200%. The fact that the point estimate becomes larger, rather than collapsing, once the port province itself is removed indicates that the baseline result is not a purely local artefact of the terminal node. Instead, the main gains are realised in the surrounding hinterland provinces, and removing the extreme core observation simply sharpens the contrast between treated and untreated areas.

Summary of the Study

The study identifies a clear and persistent hinterland response to the 2015 Sihanoukville deep-water expansion using provincial VIIRS night-time lights and a multi-period event-study DID design. In the baseline specification with province and year fixed effects, the pre-treatment coefficients (2012–2013) are close to zero, supporting parallel trends, while post-2015 effects turn positive and rise monotonically: early gains in 2015–2016 are moderate (roughly a few tenths of a log point), and the estimated uplift becomes much larger by 2019–2021 (on the order of one log point or more), implying substantial cumulative increases in luminosity in SHV-catchment provinces relative to the counterfactual. The results remain qualitatively robust when adding province-specific trends, suggesting the post-2015 divergence is not explained by pre-existing growth trajectories. Spatial diagnostics further show that the impact is structured by corridor geography rather than being confined to the port city: distance-band and binned-means evidence reveals a post-2015 in dark-to-light reversal in near-to-intermediate distance segments, and donut gradients indicate a statistically meaningful distance decay in 2019. Importantly, excluding the port province does not weaken the effect, if anything, it strengthens supporting the interpretation that the main gains occur in surrounding hinterland provinces. Taken together, the findings imply that SHV's upgrade is better understood as creating an additional growth pole and a new corridor-shaped gradient within the southern GMS, moving the regional gateway system toward a tripolar balance rather than pure displacement of existing gateways.

These results generate two direct directions for further research and policy-relevant extension. First, future work should move from hard road distance to generalized trade costs by explicitly incorporating soft frictions such as customs procedures, border management reforms, and clearance times, which likely mediate how corridor benefits are realized and may change the effective exposure ranking across provinces. Second, the analysis should expand beyond a single-mode road network to multimodal connectivity incorporating inland waterways, rail, and intermodal links to better capture the structural advantages of different gateways (especially the Mekong Delta barge network linked to the HCMC cluster) and to evaluate how new investments (e.g., expressways, rail connections, and cross-border facilitation reforms) reshape the spatial equilibrium. With longer time series and richer cargo-flow or firm-level data, the current DID/event-study framework can be embedded into spatial econometric or general-equilibrium structures, transforming this paper's empirical baseline into a platform for forecasting corridor strategies and designing governance that institutionalizes polycentric regional balance.

Discussions

The findings are consistent with a market-access and corridor-spillover interpretation from regional economics: a discrete improvement in gateway capacity can shift the spatial equilibrium by strengthening connectivity along specific routes, generating a corridor-shaped uplift rather than a purely local port-city boom. In New Economic Geography, reductions in trade and transport costs can either intensify concentration or sustain multiple nodes depending on the balance between agglomeration and dispersion forces. The stable "core" coupled with a post-2015 elongation of high-activity clusters toward the SHV corridor fits a polycentric adjustment path rather than a winner-takes-all displacement (Krugman, 1991; Fujita, Krugman and Venables, 1999; Redding and Turner, 2015). Crucially, this tripolar stabilization in the GMS provides a contrasting spatial outcome to other regions where transport integration disproportionately drained peripheral activity into a single dominant core, such as the core-periphery divergence observed following China's National Trunk Highway System expansion (Faber, 2014). Empirically, the dynamic DID/event-study profile flat pre-trends and gradually rising post-2015 effects matches the idea that infrastructure shocks operate with lags as firms, logistics providers, and complementary investments adjust over time. This pattern is consistent with spatial adjustments documented in other major transport-infrastructure settings, such as India's historical rail network (Donaldson, 2018). Furthermore, using VIIRS night-time lights provides a defensible cross-country outcome measure in data-scarce regions, and our robustness checks (province trends, donut exclusions, spatial diagnostics, and influence tests) comprehensively address the concern that lights-based work may reflect coincident macro trends or localized construction rather than causal reallocation (Henderson, Storeygard and Weil, 2012; Conley, 1999). Overall, the evidence supports an interpretation of the SHV upgrade as the formation of an additional growth pole that strengthens corridor-mediated integration while preserving a tripolar port–

hinterland structure an outcome with direct implications for governing connectivity investments to stabilize polycentric regional development.

Recommendations

To sustain a stable polycentric equilibrium rather than intensifying zero-sum port competition, corridor governance must be treated as a joint cross-border outcome. GMS policymakers should coordinate "soft" facilitation—such as customs modernization and cross-border trucking regimes with "hard" complementary infrastructure, like dry-port development and strategic industrial-zone placement along intermediate-distance belts. Crucially, while our spatial specification yields a highly significant coefficient of 1.093 (excluding the port province), which mathematically translates to a roughly 198% relative increase in local light intensity ($e^{1.093}-1 \approx 1.983$), policymakers must interpret this magnitude with caution. This figure captures a relative statistical reallocation of spatial economic activity driven by network spillovers, rather than an absolute 198% macroeconomic expansion in provincial GDP. Consequently, regional planning should utilize these findings to guide the directional placement of multi-gateway hedging strategies, avoiding the exaggeration of point estimates for absolute growth targets.

Because the same gateway shock transmits through distinct domestic institutions and border frictions, future research should be explicitly organized around the differing constraints of Cambodia, Lao PDR, and Thailand. For Cambodia, the immediate next step is to pair NTL-based results with micro-evidence from the SHV Phnom Penh corridor, such as firm entry, special economic zone (SEZ) activity, and industrial land conversion to isolate logistics-led production reallocation from localized urban construction. For Lao PDR, a landlocked economy arbitraging competing gateways, future studies should replace simple geographic distance with generalized trade costs to test whether the SHV corridor meaningfully alters Laos's optimal gateway choice relative to Laem Chabang and Vietnamese ports. Finally, for Thailand, with Laem Chabang as a dominant incumbent and the Northeast as the contested hinterland, future research should quantify whether SHV's rise produces zero-sum diversion or resilience-enhancing complementarity. Ultimately, a three-country extension should explicitly model how different combinations of infrastructure and policy interventions best institutionalize regional balance as a stable spatial equilibrium.

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