Research Design and Econometric Models (pages 6–7)

This section answers the prompt: which concrete econometric models we will estimate (with equations), which control variables we include and why (with data availability), how to interpret the main coefficients, and how the models answer the research question. We proceed in two steps. First—and principally—we estimate the dynamic effect of each reform on productivity. Second, we quantify the share of that effect that operates through capital deepening by treating $\ln(K/L)$ as a mediator. Throughout we use high-frequency fixed effects, explicit “not-yet-treated” comparisons, and staggered-adoption event-study estimators.

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1. Setup, variables, and treatment/control logic

Units and horizon. Two ports, $p \in \{\text{Haifa}, \text{Ashdod}\}$, observed at time t (monthly preferred; quarterly when dictated by measurement) over 2018–2024.

Outcomes. $Y_{p,t} = \ln(\text{LP}_{p,t})$, where $\text{LP}_{p,t}$ is constructed at the native frequency (and replaced by TEU/hours if granular hours arrive).

Mediator. $M_{p,t} = \ln\big((K/L)_{p,t}\big)$, formed from the K tracks (A/B composite) and L as described in the data section.

Treatments. Two reform types, each with its own port-specific date: competition entry (go-live) T_p^{comp} and privatization T_p^{priv} . Define event time for reform $r \in \{\text{comp}, \text{priv}\}$ as $\tau_{p,t}^r = t - T_p^r$.

Identification: treatment vs. control at each t . For a given reform r and a given calendar month/quarter t : - **Treated** observations are those ports with $\tau_{p,t}^r \geq 0$ (at/after their own reform date). - **Within-port controls** are the same port’s $\tau_{p,t}^r < 0$ periods; the omitted last pre bin is the reference. - **Cross-port concurrent controls** are months when the other port is **not yet treated** ($\tau_{p',t}^r < 0$). Months when both ports are treated do not contribute to identifying contrasts in the staggered-robust event-study aggregators; we explicitly rely on not-yet-treated observations for identification.

We always include **port fixed effects** α_p (difference out time-invariant port characteristics) and **time fixed effects** δ_t (absorb month-specific nationwide shocks affecting both ports).

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2. Model 1 — Reform → Productivity (primary effect)

We estimate a staggered-adoption event-study for each reform r separately. Partition event time into bins $\{\mathcal{B}_j\}$ (e.g., pre: $[-12, -1]$, event: $[0]$, early post: $[1, 6]$, later post: $[7, 12]$, long-run: $[\geq 13]$) and omit the last pre bin as the reference. The baseline specification is:

$$\boxed{Y_{p,t} = \alpha_p + \delta_t + \sum_{j \neq -1} \theta_j \, \mathbf{1}\{\tau^r_{p,t} \in \mathcal{B}_j\} + \psi \, S_{p,t} + X'_{p,t}\kappa + \varepsilon_{p,t}.}$$

Terms. α_p : port FE. δ_t : time FE (month-of-sample or quarter-of-sample). $\mathbf{1}\{\tau^r_{p,t} \in \mathcal{B}_j\}$: lead/lag bin indicators around reform r with coefficients θ_j measured relative to the omitted last pre bin. $S_{p,t}$: spillover flag that equals 1 if the other port is already post-reform at t (mitigates cross-port interference). $X_{p,t}$: observed covariates—month-of-year seasonality; crisis indicators (COVID; late-2023/2024 disruptions); composition proxies (average vessel size/mix, transshipment share) where available. Errors $\varepsilon_{p,t}$ are allowed to be serially correlated; inference uses small-sample-robust wild bootstrap.

Identification. With parallel pre-trends, the pre-bin coefficients should be jointly near zero. The post-bin coefficients $\{\theta_j\}$ trace the dynamic **total effect** of reform r on productivity. Because Y is a log, $\theta = 0.20$ indicates $\approx 22\%$ higher productivity relative to the reference bin. We summarize dynamics by averaging post bins over pre-declared windows (e.g., 12 or 24 months) to report $\mathrm{TE}^r(1\,\mathrm{y})$ and $\mathrm{TE}^r(2\,\mathrm{y})$.

Estimator choice. In addition to the two-way FE form above, we will implement event-study estimators robust to staggered adoption (Sun–Abraham; Callaway–Sant'Anna), which construct each θ_j from comparisons to **not-yet-treated** observations only. As a local design, we will also estimate a regression discontinuity in time (RDiT) within ± 12 months of $\tau^r = 0$.

Data and controls (Model 1). We have high-frequency throughput and the KPIs required to construct $\mathrm{LP}_{p,t}$. Seasonality and crisis controls are available. $S_{p,t}$ is coded from the rival port's reform dates. Composition controls will be included as data permit; otherwise δ_t absorb common shocks.

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3. Model 2 — Mediation: $\ln(K/L)$ as mediator for productivity

To quantify how much of the productivity response is explained by capital deepening, we treat $M_{p,t} = \ln(K/L)_{p,t}$ as the mediator and estimate a calendar-time 2SLS system with port and time fixed effects.

First stage (calendar time).

$$\boxed{M_{p,t} = \alpha^M_p + \delta^M_t + \Pi' Z_{p,t} + T^{\mathrm{comp}}_{p,t} + T^{\mathrm{priv}}_{p,t} + W'_{p,t}\pi + e_{p,t}.}$$

Second stage.

$$\boxed{Y_{p,t} = \alpha^Y_p + \delta^Y_t + \beta_M \, \widehat{M}_{p,t} + T^{\mathrm{comp}}_{p,t} + T^{\mathrm{priv}}_{p,t} + W'_{p,t}\beta + \xi_{p,t}.}$$

Terms. $Z_{p,t}$: dated, plausibly exogenous engineering milestones that move K/L (e.g., crane commissioning, berth deepening completions, equipment go-live). $T^{\mathrm{comp}}_{p,t}, T^{\mathrm{priv}}_{p,t}$: calendar-time reform indicators (equal 1 on/after the port's own date). $W_{p,t}$: the same control set as in Model 1. β_M is the IV elasticity of productivity with respect to $\ln(K/L)$.

Effects and decomposition. Let $\Delta_M^r(\mathcal{W})$ denote the average effect of reform r on the mediator over post window $\mathcal{W}$ (obtained from an event-study for M , mirroring Model 1, or from the first stage if modeled with post indicators). The **indirect (mediated) effect** of reform r on productivity over $\mathcal{W}$ is:

$$\mathrm{IE}_{\mathcal{W}}^r = \Delta_M^r(\mathcal{W}) \times \beta_M.$$

The **direct effect** is the difference between the total effect from Model 1 and the indirect component, $\mathrm{DE}_{\mathcal{W}}^r = \mathrm{TE}_{\mathcal{W}}^r - \mathrm{IE}_{\mathcal{W}}^r$. Confidence intervals will be constructed via delta method or bootstrap.

Identification (Model 2). The instruments $Z_{p,t}$ shift K/L via engineering supply shocks and are excluded from $Y_{p,t}$ except through $M_{p,t}$. Port and time FE absorb time-invariant port characteristics and common shocks; inclusion of T -dummies ensures β_M captures the productivity–K/L link net of any direct reform effects.

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4. Why this answers the question

Model 1 provides the causal, time-path estimate of how reforms changed productivity in Haifa and Ashdod, using within-port pre-periods and the other port's not-yet-treated months as controls while netting out nationwide shocks. Model 2 then decomposes that response into an **indirect component via capital deepening** and a **direct component** (e.g., incentives/management, congestion relief). Together, the models identify both the magnitude and the mechanism of reform impacts in a staggered-adoption environment.

Note on LP measurement. Our baseline assumes we observe $\mathrm{LP}_{p,t}$ at the panel frequency; if not, we will use our best available LP series, and in sensitivity, a hybrid of proxies. As administrative hours arrive, we will recompute $\mathrm{LP} = \mathrm{TEU}/\mathrm{hours}$ and re-estimate.