Executive Summary

Goal. Construct a defensible, reproducible **Track B** capital proxy (**K**) and **mediator** $\ln(K/L)$ for Israel's ports (Haifa, Ashdod, Eilat), leveraging **financial/accounting data** (PPE, net fixed assets, depreciation, investment/CapEx) and standard capital-measurement practice. This document explains the economics, the math, the implementation design for our case, data sources and transformations, QA, and deliverables.

Why Track B. Accounting-based K captures the **economic value** of the asset base (land, berths, cranes, yards, IT) and its **quality upgrades**, complements Track C (engineering capacity) and Track A (counts), and supplies smoother dynamics suitable for mediation and first-stage strength.

What we will build. Two monthly port-level K series (plus optional terminal splits): 1) **Real PPE Stock** K^{PPE} : deflated book value of net fixed assets. 2) **PIM Stock/Services** K^{PIM} : perpetual-inventory stock from real investment and depreciation; optional **services** flow $S_t \propto (r+\delta)K_{t-1}$.

Then compute $\ln(K/L)$ by joining to our **authoritative L** (work-hours proxy) at the **port×month** grain. Output tables include metadata, break flags, parameter choices, and QA.

Data we'll use (Israel-specific). Company financial statements (Haifa Port Co., Ashdod Port Co.; Eilat where available), prospectuses/press for CapEx, and CBS deflators. We will handle **privatization/revaluation breaks** (Haifa 2023) via growth-rate–preserving splice variants. For the new private terminals (Bayport/SIPG, Southport/TIL), Track B either (i) aggregates at **port** using infrastructure owner info/CapEx where observable, or (ii) remains **legacy-company** only, with Track C capturing entrant capacity. Both choices are documented and compared.

Deliverables. - `Data/K_proxy/K_B_monthly_port.tsv` (PPE & PIM), `Data/K_proxy/Mediator_K_over_L.tsv` (Track B variants), META JSON, and QA/plots. Contracts match our LP/L setup (keys, names, spans).

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1) Economic Rationale and Conceptual Framing

Capital as a production input. In ports, capital is multi-form: quay walls and dredging, STS/yard cranes, yards/rail, IT/automation. Accounting aggregates these as **Property, Plant & Equipment (PPE)** and related intangibles.

Why accounting K. - **Value-weighted**: incorporates quality/technology (new STS cranes, deeper berths) via cost and revaluation. - **Comparability over time** after deflation: tracks true changes rather than nominal inflation. - **Complements Track C**: Track B's value lens + Track C's engineering lens → stronger triangulation and instruments.

Mediator $\ln(K/L)$. Our **L** is already constructed as **terminal×month work-hours** consistent with annual KPI identities. Using **port×month K** joined to **port×month L (hours)** yields $\ln(K/L)$ measuring **capital deepening per unit labor time**, with a straightforward interpretation in mediation and IV.

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2) Definitions and Units

Let t index **months**, y years, **p** ports $p \in \{\text{Ashdod}, \text{Haifa}, \text{Eilat}\}$.

- **Nominal PPE** (book): Net fixed assets on balance sheet (land, buildings, infrastructure, machinery, IT), typically under **IFRS cost or revaluation model**. Unit: **NIS**.
- **Real PPE**: $\text{PPE}^{real}_{p,y} = \text{PPE}^{nominal}_{p,y} / P^K_y$, where P^K_y is a **capital deflator** (baseline 2015=100). We will variant-test alternative deflators.
- **Gross/Net/Productive capital**: We will primarily use **net stock**; PIM also provides **productive** stock/services when weighting by rental price $r + \delta$.
- **Labor L**: **work-hours** from `L_Proxy.tsv` aggregated to **port×month** (sum over terminals). Units: **hours**.
- **Mediator**: $\ln(K/L) = \ln K_{p,t} - \ln L_{p,t}$. We compute this for **each K variant**.

Base units & conventions. - Currency: **NIS, real 2015** (primary). We keep a parallel **index (2015=100)** for ease of plotting. - Time: **monthly** series (interpolated/allocated from annual/semiannual financials). - Names/keys: Canonical `Ashdod`, `Haifa`, `Eilat` with **terminal-aware notes** kept in metadata.

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3) Mathematical Construction (Track B)

3.1 Real PPE Stock (book) — K^{PPE}

1) **Deflation**

$$K^{PPE,real}_{p,y} \equiv \frac{\text{PPE}^{nominal}_{p,y}}{P^K_y}, \quad P^K_{2015} = 1$$

Deflators to candidate-test: (i) **CBS capital goods** index; (ii) **construction input** index; (iii) **headline CPI** as fallback. We will log the chosen deflator in META and re-run sensitivity bands.

2) **Frequency lift to months** - If only annual: create a **step** at the report date (Dec) or allocate intra-year using **CapEx timing** if available. Baseline: **linear monthly interpolation** within $[y, y+1)$. Where known commissioning months exist (e.g., crane deliveries), we **re-weight** the within-year path to put more of the annual change near those months while preserving the **annual average**. - If semiannual/quarterly: piecewise-linear within subperiods.

3) **Breaks and revaluations** - Privatization or IFRS revaluation can create a **level break** at y^* . Define a growth-rate–preserving **splice**:

$$\tilde{K}^{PPE,real}_{p,y} = c \cdot K^{PPE,real}_{p,y} \quad \text{for } y \geq y^*, \text{ where } c = \frac{K^{PPE,real}_{p,y^*-1}}{K^{PPE,real}_{p,y^*-1\,(new\ basis)}}$$

We produce **two variants**: `raw` (as reported) and `spliced` (break-adjusted). Downstream models can use either; default is **spliced**.

4) **Monthly series** $K^{PPE,real}_{p,t}$ after steps (1)–(3).

3.2 PIM Stock and Services — K^{PIM} and S

We compute a perpetual inventory from **real investment** $I_{p,t}$ (CapEx deflated) and depreciation δ .

1) **Real investment** I - From CapEx (cash-flow or additions), deflate by P^K_t . If only annual CapEx $I_{p,y}$, convert to monthly via (i) equal split; or (ii) **front-load** into documented commissioning months.

2) **Depreciation rates** δ - Choose **asset-class rates** (STS cranes, yard equipment, civil works). When not disaggregated, use a **blended** δ and run **sensitivity** (e.g., 4%, 6%, 8%). Record chosen δ in META.

3) **Initialization** - Seed with first observation of $K^{PPE,real}$ or backcast with a steady-state $K_0 = I_0/(g+\delta)$ using early investment and a drift g . We emit both **seeded** and **steady-state** variants when feasible.

4) **Law of motion** (monthly):

$$K^{PIM}_{p,t} = (1-\delta_m)\,K^{PIM}_{p,t-1} + I_{p,t}, \quad \delta_m \equiv 1-(1-\delta)^{1/12}$$

5) **Capital services** (optional mediator alternative): $S_{p,t} = (r+\delta_m)\,K^{PIM}_{p,t-1}$, where r is a reference monthly real rate (e.g., annual 3% $\Rightarrow$ monthly 0.25%). We primarily use $\ln K$, but $\ln S$ can be a robustness mediator.

3.3 Mediator $\ln(K/L)$

Using port-month **L (hours)** from `L_Proxy.tsv` aggregated to port, construct

$$\ln(K/L)^{(v)}_{p,t} = \ln K^{(v)}_{p,t} - \ln L_{p,t}, \quad v \in \{PPE\text{-}raw,\ PPE\text{-}spliced,\ PIM\text{-}seeded,\ PIM\text{-}ss,\ S\}$$

Guard: if $L_{p,t} \leq 0$, set mediator **NA**. For **Eilat** in container analysis, Track B is still defined (it owns capital), but we ensure consistency with L basis (hours).

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4) Data for Israel: Sources, Fields, and Extraction Plan

4.1 Core financials

Haifa Port Company (legacy) — Annual reports (Hebrew, PDF): extract - **PPE (net)** by year (and if available: gross, accumulated depreciation; sub-classes). - **Additions/Disposals** (CapEx), **Depreciation expense**. - **Employee headcount** (cross-check with our L proxy), for narrative only.

Ashdod Port Company (legacy) — Prospectus/financials (Hebrew): extract same fields as above; note **major CapEx programs** (e.g., cranes, Platform 21).

Eilat Port Company — Privatization/tender dossiers: baseline PPE/asset value (small scale), later annuals if available.

New private terminals (SIPG Bayport, TIL/HCT Southport): direct financials may be limited. We will: - If **operator reports** CapEx or asset values → incorporate into **port-level** series for **Haifa**/**Ashdod**. - Else, maintain **legacy-company K** as one **Track B** variant; let **Track C** absorb entrant capacity explicitly.

4.2 Deflators and rates

- **Primary deflator**: Capital-goods or construction-input price index (CBS). **Fallback**: CPI.
- **Rates**: δ by asset class (civil works $\leq$3%–4%; cranes 6%–10%; yard equipment 8%–12%) → we will implement **low/central/high** bands.
- **Reference rate** r : 3% real annual (baseline) for capital services; sensitivity ±200 bps.

4.3 Event calendars and allocation

- **Commissioning months** for cranes/berths (from press/IPC) → use to **time-weight** within-year ΔK and I_t .
- **Break flags**: Haifa privatization (2023), any IFRS revaluation notes → set `break_flag=1` and create `spliced` variants.

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5) Implementation: Pipelines, Contracts, and Schemas

5.1 File inputs

- `Data/raw_financials/haifa_port_YYYY.pdf` (and parsed CSVs)
- `Data/raw_financials/ashdod_port_YYYY.pdf` (and parsed CSVs)

- `Data/raw_financials/eilat_port_*.pdf`
- `Data/deflators/deflators_cbs.csv` (columns: `year, month, deflator_capital, deflator_construction, cpi`)
- `Data/L_proxy/L_Proxy.tsv` (authoritative labor hours; **do not overwrite**)
- (Optional) `Data/events/commissioning_calendar.csv` (dated cranes/berths entries)

5.2 Scripts and CLI

Single entry point (**Track B**): `Data/K_proxy/build_k_proxy_trackB.py`

Example usage:

```
python Data/K_proxy/build_k_proxy_trackB.py
  --haifa-fin Data/raw_financials/haifa_port_financials.csv
  --ashdod-fin Data/raw_financials/ashdod_port_financials.csv
  --eilat-fin Data/raw_financials/eilat_port_financials.csv
  --deflators Data/deflators/deflators_cbs.csv
  --events Data/events/commissioning_calendar.csv
  --l-proxy Data/L_proxy/L_Proxy.tsv
  --out-dir Data/K_proxy/out
  --base-year 2015
  --delta-central 0.06 --delta-low 0.04 --delta-high 0.08
  --rate-annual 0.03
```

5.3 Output tables (primary)

a) `Data/K_proxy/K_B_monthly_port.tsv`

Grain: `port, year, month` (unique). **Columns** - Keys: `port, year, month, month_index` - Deflators: `deflator_used` (`capital_goods` / `construction` / `cpi`), `deflator_value` - **PPE (real)**: `K_PPE_real_raw`, `K_PPE_real_spliced` - **PIM (real)**: `K_PIM_stock_central`, `K_PIM_stock_low`, `K_PIM_stock_high` - **Services (optional)**: `K_services_central` - Source/flags: `ppe_source_year`, `capex_source_year`, `break_flag`, `notes` - Convenience: `K_PPE_index_2015=100`, `K_PIM_index_central_2015=100`

b) `Data/K_proxy/Mediator_K_over_L.tsv`

Grain: `port, year, month` (unique). **Columns** - Keys: `port, year, month, month_index` - **Labor**: `L_hours_port_m` (from `L_Proxy.tsv`, port-aggregated) - Mediators: `ln_KPPEraw_over_L`, `ln_KPPEspliced_over_L`, `ln_KPIM_central_over_L`, `ln_KPIM_low_over_L`, `ln_KPIM_high_over_L`, `ln_Kservices_over_L` - Guards: `is_L_zero`, `is_K_zero` - Links: `tons_source` (optional join), `events_active` (optional IV convenience)

c) META and QA

- `_meta_k_proxy_trackB.json`: input hashes, deflator choice, δ set, r , rows per table, coverage span, ports included, execution timestamp.
- `qa_k_proxy_trackB.tsv`: see §6.

Contracts. - **No destructive overwrites** of authoritative sources. - **Keys uniqueness**: one row per `port,year,month`. - **Naming**: `Ashdod`, `Haifa`, `Eilat` (port-level). Terminal splits, when available, use `Ashdod-Legacy`, `Ashdod-HCT`, `Haifa-Legacy`, `Haifa-Bayport`.

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6) Algorithms and Pseudocode

6.1 Port-level PPE (real, monthly) with break splice

```
for port in [Ashdod, Haifa, Eilat]:
  load nominal PPE by year (net) -> ppe_nom[y]
  load deflator P^K[y] -> Pk[y]
  K_PPE_real[y] = ppe_nom[y] / Pk[y]

  # Monthly path within each year y → y+1
  for each year y:
    if events for port in year y (commissioning months m*):
      allocate ΔK within year with weights w_m (sum w_m = 1) skewed to m*
    else:
      linear interpolation between K_PPE_real[y] and K_PPE_real[y+1]

  # Handle break (e.g., privatization):
  if break_year exists:
    compute scaling c to match level at y*-1
    K_PPE_real_spliced[t >= y*Jan] = c * K_PPE_real_raw[t >= y*Jan]
```

6.2 PIM (monthly)

```
choose δ_low, δ_central, δ_high; compute δ_m = 1 - (1-δ)^(1/12)
construct monthly real investment I_t from CapEx_y and events
seed K_0 using first PPE_real (or steady-state)
for t in months:
  K_t = (1 - δ_m) * K_{t-1} + I_t
  S_t = (r_m + δ_m) * K_{t-1}
```

6.3 Join to L and form mediators

```
L_port_m = sum_i L_hours_i_m from L_Proxy.tsv by port,month
for each K variant v:
  if L_port_m > 0 and K_{p,t} > 0:
    ln_K_over_L^{(v)} = ln(K_{p,t}^{(v)}) - ln(L_port_m)
  else:
    ln_K_over_L^{(v)} = NA
```

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7) QA, Diagnostics, and Acceptance Criteria

Coverage & keys - No duplicates; months span **2018–2024** (or available range). Count rows per port.

Deflator sanity - Plot deflator series; ensure monotone(ish) and plausible.

PPE vs PIM alignment - Correlation of growth rates; large divergences flagged with reasons (timing vs valuation).

Break handling - Report **level jump** at break; `raw` vs `spliced` overlays. If splicing removes jump while preserving pre/post growth, **pass**.

Event responsiveness - Around crane/berth commissioning months, K^{PIM} shows uptick; K^{PPE} shows within-year allocation toward those months.

Mediator stability - $\ln(K/L)$ finite (no zeros); outlier months examined (e.g., war/shock) with notes.

Sensitivity bands - Show δ low/central/high; demonstrate qualitative robustness of findings.

Acceptance - All tables generated; META filled; QA flags $\leq$ predefined thresholds. Plots included in analysis notebook (not required to ship).

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8) How We Will Use Track B in Econometrics

- **Mediator**: Use $\ln(K/L)$ (central variant: `ln_KPIM_central_over_L`) in mediation/2SLS where instruments are commissioning/privatization events (as specified in our design).
- **Robustness**: Swap mediator for `ln_KPPEspliced_over_L` and `ln_Kservices_over_L`.
- **Controls/FE**: Port FE and time FE (month or port×month), COVID and 2023/24 shock dummies, consistent with our LP setup.

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9) Practical Notes and Edge Cases

- **Entrant terminals**: If Bayport/HCT financials are unavailable, Track B reflects **legacy-company** K. We will (i) report this clearly; (ii) rely on **Track C** for entrant capacity; (iii) optionally add **ported entrant CapEx** if reliable project costs emerge (with transparent imputation).
- **Land & concessions**: Land revaluation can dominate PPE. Splicing mitigates misleading level shifts; keep both `raw` and `spliced` for transparency.
- **Eilat**: Small port; we include it for completeness but may analyze separately in container-focused models.
- **Units**: Prefer real NIS; provide index versions to keep confidentiality if needed.

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10) Step-by-Step To-Do (Immediately Actionable)

1. **Parse financials** (Haifa, Ashdod, Eilat) → CSV with `year, PPE_net_nominal, additions_nominal, depreciation_nominal`.
2. **Build deflator table** (2015–2025 monthly; include 3 candidates). Choose primary (capital-goods or construction).
3. **Generate K^{PPE}** (real, monthly), create **spliced** variant for break years.
4. **Generate K^{PIM}** (monthly) with δ bands and services S.
5. **Aggregate L to port×month** from `L_Proxy.tsv` and compute mediators.
6. **Emit outputs** + META + QA. Plot sanity charts (overlay PPE vs PIM; mediators over time with event lines).

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11) Output Dictionary (Columns and Meanings)

`K_B_monthly_port.tsv` - `port` — {Ashdod, Haifa, Eilat} - `year, month, month_index` — calendar keys - `deflator_used, deflator_value` - `K_PPE_real_raw` — real net PPE (monthly path), not spliced - `K_PPE_real_spliced` — break-adjusted level splice - `K_PIM_stock_central` — PIM with $\delta = \delta_{central}$ - `K_PIM_stock_low`, `K_PIM_stock_high` — sensitivity bands - `K_services_central` — services flow proxy - `ppe_source_year, capex_source_year` — most recent report used - `break_flag` — 1 during/after identified accounting break - `notes` — free text for anomalies - `K_PPE_index_2015=100`, `K_PIM_index_central_2015=100`

`Mediator_K_over_L.tsv` - `port, year, month, month_index` - `L_hours_port_m` - `ln_KPPEraw_over_L`, `ln_KPPEspliced_over_L` - `ln_KPIM_central_over_L`, `ln_KPIM_low_over_L`, `ln_KPIM_high_over_L` - `ln_Kservices_over_L` - `is_L_zero`, `is_K_zero`

`_meta_k_proxy_trackB.json` - `inputs`: file paths + hashes - `params`: base year, deflator choice, δ set, r, splice years - `rows`: counts per table - `ports`: list - `timestamp`

`qa_k_proxy_trackB.tsv` - `check_name, port, year, month, value, status, note`

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12) Example (Illustrative, Not Real Numbers)

Suppose Ashdod PPE net (nominal) rises from ₪2,000m (2021) to ₪2,300m (2022). With construction deflator 1.10→1.15:

$$K_{2021}^{PPE,real} = 2000/1.10 = 1818, \quad K_{2022}^{PPE,real} = 2300/1.15 = 2000$$

Monthly interpolation yields ~+10.0 real units per month; if cranes delivered in **2022-03**, we re-weight months Jan–Jun with higher increments. PIM with $\delta = 6\%$ and $I_{2022} = 400/1.15 = 348$ allocates I_t monthly; K_t follows the law of motion. Join to L_t to form $\ln(K/L)_t$.

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13) How Track B Interacts with Tracks A and C

- **A (counts)**: Step-wise, often flat between projects → excellent for **event timing**; less smooth for mediation. Use A for IV dummies and as a component in composite K.
- **C (capacity)**: Engineering-based capacity upsides (depth, quay, cranes) → captures **usable services**. Track B + C together provide **value × capacity** triangulation.
- **Composite**: Later, standardize B, C (and A) and combine (z-average or PCA) as robustness.

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14) Risks, Mitigations, and Notes

- **Data opacity for entrants**: If Bayport/HCT accounting is unavailable, keep port-level K reflecting legacy-company assets; document exclusion; rely on Track C for total capacity.
- **Accounting policy changes**: Use `raw` vs `spliced` pair; note in META; run models on both.
- **Deflator choice**: Ship with three deflators; default to capital/construction; report robustness.
- **Depreciation** δ uncertainty: Provide bands; draw on engineering lifetimes for priors.
- **Endogeneity**: We will **instrument** $\ln(K/L)$ with pre-announced commissioning/privatization events in the econometric stage.

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15) Summary

Track B converts **financial statements** into a **monthly, real capital stock/services** series at the **port** level, produces multiple variants (PPE raw/spliced, PIM stock/services with δ bands), and constructs $\ln(K/L)$ by joining to our established **L**. The pipeline is transparent, parameterized, and QA'd—ready for estimation and for blending later with Track C (engineering capacity) and Track A (counts) into a composite capital measure.