ChatGPT

Israeli Ports Reform – Productivity & Capital Deepening

1. Literature Map: Port Reforms' Impact on K/L and Labor Productivity

- **Rotenberg (2023, Knesset R&I)** – *Descriptive (Official Data); Quality: B.* A Knesset research review on port wait times and competition finds that Israel's 2005 port reform (gradual landlord model, licensing a private Haifa terminal, privatizing Eilat & Haifa ports, and building two new private ports) created **6 operating ports by 2023** [1]. The **new Bay Port (Haifa, opened Sept 2021) and South Port (Ashdod, Feb 2022)** have begun to increase competition. The report projects that removing remaining barriers (e.g. a 5% market cap on the private Israel Shipyards port, granting long-term operating licenses) will *increase efficiency (shorter ship wait times, lower import costs)* and help reduce consumer prices [2]. This underscores the expected productivity gains from competition, though it is a forward-looking policy analysis rather than an ex-post causal estimate.

- **Kohelet Policy Paper (Ancselovits & Klein, 2024)** – *Policy Analysis; Quality: B.* Provides context on Israel's port sector and the need to adjust regulation in the "age of competition." Citing the Israel Competition Authority's 2013 decision, it notes the **historic monopoly** of Haifa & Ashdod port companies led to **low utilization of capital and labor productivity** [3] [4]. The entry of new private ports is seen as crucial but must be accompanied by removing restrictive labor agreements and redundant regulation [5]. *Takeaway:* Competition and private operation are posited to improve efficiency, but rigid labor practices could blunt capital utilization gains (highlighting the importance of labor reforms alongside capital deepening).

- **Cheon, Dowall & Song (2010)** – *Panel (Malmquist TFP Index); Quality: A.* A global study (98 ports, 1991–2004) evaluating institutional reforms on port productivity [6]. Using a Malmquist Total Factor Productivity (TFP) index, it finds **ownership restructuring and corporatization contributed significantly to TFP gains**, especially in large container ports [7]. Privatizing terminals allowed specialized operators to invest in modern handling equipment and optimize operations, raising productivity [8]. *Method:* Panel DEA + regression (difference-in-differences implicitly, by comparing pre/post-reform efficiency scores). *Quality:* Published in **Transportation Research Part E** – rigorous empirical analysis. The result supports that port reforms drive productivity via both **technical change and capital-deepening investments**.

- **Yuen, Zhang & Cheung (2013)** – *DEA Efficiency + Regression; Quality: A.* Examines **Chinese container terminals** with varying ownership and competition levels [9]. Efficiency scores are computed via DEA, then regressed on factors. **Findings:** Terminals with moderate foreign ownership and those facing **greater intra- and inter-port competition are more efficient** [10]. In other words, opening the market to new entrants or competing neighbor ports improved throughput per inputs. This suggests port productivity rises when monopoly power is reduced – consistent with Israel's

expectations that Bay Port's entry forces efficiency at Haifa. *Published in Transportation Research Part A.* (Method tags: Panel DEA; Tobit/OLS regression of efficiency on competition).

- **Estache, González & Trujillo (2002)** – *Stochastic Frontier (SFA); Quality: A-.* Analyzes efficiency gains from Mexico's 1990s port privatization (11 ports, 1996–99) [11]. Using an SFA production frontier, they find **annual efficiency growth of ~3%** after reform [12]. Increased **private participation correlates with higher port efficiency** [13]. They also highlight *yardstick competition*: decentralizing ports into separate concessions created performance benchmarking that spurred productivity [14]. *Quality:* Published in **World Development**. This provides cross-country evidence that privatization + competition yield measurable labor productivity improvements, with much of the TFP gains driven by **capital investment and technology adoption** (e.g., new cargo handling equipment).

- **Kim & Sachish (1986)** – *Time-Series Case Study; Quality: B.* A classic study of Ashdod Port (Israel) from 1966–1983 (cited in González, 2004) found that **~85% of TFP increase** in that period was due to **containerization** (i.e. capital-deepening through new container cranes and equipment) [15]. This underscores how technological capital improvements dramatically raised labor output. It provides historical Israeli evidence that **capital deepening is a key mediator** for productivity gains in ports. *(Note: Though the data is older, it's directly relevant to the K/L mediation question.)*

- **Ju et al. (2023)** – *Panel Data (China); Quality: A-.* Studying Chinese port companies, Ju *et al.* find that **greater competitive pressure improves operational efficiency** of ports [16] [17]. Interestingly, purely changing ownership form *without* competition had limited effect on efficiency [18] – indicating competition is the main catalyst. *Method:* Two-stage DEA and panel Tobit. This aligns with Israel's case: simply privatizing Haifa Port may not boost productivity unless competition (via Bay Port and others) forces better resource use. *Quality:* Recent empirical study (Res. in Transp. Bus & Mgmt).

- **Figueiredo de Oliveira & Cariou (2015)** – *Cross-Sectional Inefficiency Analysis; Quality: B+.* Found that **higher inter-port competition significantly reduces inefficiency** in global container ports [19]. Essentially, competition compresses slack – ports utilize labor and capital more effectively to avoid losing business. *Published in Transportation Research Part A.* Though not focused on capital specifically, it implies competition compels investment in productivity-enhancing technologies (higher K/L) to stay competitive.

(Each source above reinforces that port reforms – whether via privatization, increased competition, or both – tend to improve labor productivity. Crucially, many attribute the gains to capital deepening: new equipment, infrastructure, and technologies that raise output per worker. We will leverage these insights, tagging them as Difference-in-Differences (DiD) where panel comparisons are made, Synthetic Control (SCM) concept for comparing treated vs. synthetic group, and Instrumental Variables (IV) where exogenous policy differences are exploited.)

2. Data Inventory: Ports, Capital, Labor & Operations

Israeli Sources:

- **Central Bureau of Statistics (CBS)** – *National Accounts & Industry Data.* Key for capital and labor metrics in the relevant industries:

- *Fixed Capital Stock by Industry:* Annual net capital stock or gross fixed assets for **Transportation and Storage (ISIC H)**, possibly disaggregated into sub-industries (e.g. land, water, support). Granularity: annual, national-level. Access: CBS publishes statistical abstracts and data tables (public).
    - *Example:* CBS National Accounts Table for Capital Stock may show **"Transport & Warehousing" capital stock (NIS, constant prices)** by year [20] (the ports reform aimed to **"increase …utilization of their capital"** [20], indicating such data is tracked).

- *Labor Input by Industry:* Number of employees and total hours worked in Transport & Storage sector (annual; available via CBS Labor Force Surveys or Annual Industry Surveys). **Frequency:** annual (with quarterly survey data available). Access: public (CBS PX-Web databases).

    - *Note:* If possible, isolate **"Water transport and port operations"** (a sub-category of ISIC H). CBS sometimes reports *sea transport* or *support activities* separately in detailed industry classification. If not, ISIC H as a whole can serve as a proxy for port/logistics sector trends.

- **Ministry of Transport – Administration of Shipping & Ports (RASP)** – *Port Operations Statistics.* The Shipping and Ports Authority publishes detailed **cargo and performance statistics**:

- **Statistical Yearbook for Shipping and Ports (2023)** – Comprehensive annual report with port throughput data and performance indicators. Granularity: by port and cargo type.
    - Contains tables for **annual cargo volumes** (total tons, by type: containers in TEUs, bulk, general cargo), **ship calls, average waiting times, berth productivity,** etc. E.g., *Figure 1* in an INSS analysis is based on RASP data showing container throughput by port [21]. **Access:** Public (often PDF/Excel on gov.il) [22].
- **Monthly/Quarterly Cargo Reports:** e.g., *"Cargo and Passenger Movement – Annual 2022"* with downloadable files [23]. These provide **port-wise breakdowns** – for instance, total cargo tonnage handled at Haifa vs Ashdod vs new ports, **TEUs handled, transshipment TEUs, vessel wait times, crane productivity**, etc. Granularity: monthly data (can aggregate to yearly). Access: public via Gov.il (RASP publications) [24].

- **Privatization Milestones:** The MoT/IPC often documents timeline events. For example, the yearbook or press releases note **Bay Port operational start (Sept 1, 2021)** [25], **South Port Ashdod start (2022)**, and **Haifa Port Company privatization (tender won late 2022, transfer Jan 2023)**. We may compile these dates from official announcements (e.g., Government press release [26] or Israel Ports Company reports).

- **Israel Ports Company (IPC)** – *Infrastructure & Assets Company Data.* IPC (a gov't landlord company) might have **periodic reports**:

- The **2022 IPC Annual Report** [27] (or an asset valuation report [28]) includes sector context: total cargo handled (e.g. *60.7 million tons in 2022* [28]) and references to data from CBS and RASP. It may also list **capital projects** (cranes purchased, berth deepening) and port company performance. Access: possibly on TASE (for bond investors) [29] (public).

- **Operating Metrics:** IPC and the individual port companies track metrics like **cranes per port, berth depth, average ship turnaround time, labor force size**. While not all are published, some appear in oversight reports (e.g., State Comptroller).

- **State Comptroller Reports (2024)** – *Audit data on port operations.* A recent audit on *"Port Sector in Israel and Service at Ashdod Port"* (Jan 2024) contains extensive data:

- E.g., Charted **total cargo trend (2000–2022)** – showing ~70% growth in volume by 2022 [30].
- **Service level and productivity indicators:** Notably, it reports that **ship wait times at Ashdod soared "hundreds of percent" since 2017, peaking in 2021, and crane output per hour fell** accordingly [31]. Such data can be used as outcome variables (e.g. vessel wait hours, tons per hour) to gauge productivity.

- **Labor and Capital Details:** May include number of workers, work-hour regulations, equipment downtime etc., especially for Ashdod. Access: public PDF in Hebrew [32].

- **Company Financial Reports (Haifa/Ashdod Ports)** – When state-owned, these companies produced financial statements (including workforce and asset info):

- **Haifa Port Co.** until 2022 (privatization) – employee count, wage costs, perhaps productivity metrics, in annual reports or privatization prospectus.
- **Ashdod Port Co.** (still state-owned) – annual reports often list **throughput per employee** or investments. Access: Possibly via Israel Government Companies Authority or company website (restricted if not publicly traded, but summary stats often quoted in media).

- These can provide **firm-level K and L** (e.g., number of cranes, yard equipment, employees, operating hours), enabling micro-productivity calculations.

- **Bank of Israel (BoI) Reports:** BoI's Annual Reports and research provide macro context:

- Recent BoI Annual Reports (2021–2023) discuss infrastructure reforms. E.g., BoI 2021 noted port competition was expected to **"increase efficiency and utilization of capital"** [20]. The 2023 Annual Report likely evaluates early outcomes post-privatization.

- The BoI may also have data on **sectoral labor productivity** (GDP per hour in transport) and capital deepening in Israel's economy. If available, we'd extract the **transport/storage sector's productivity index** and any mention of port reform impact.

- **Other Local Sources:**

- *Histadrut/Union agreements* (for context on labor flexibility and potential output changes after reform – e.g., a 2018 agreement to prevent port strikes in exchange for job guarantees).
- *Israel Competition Authority reports:* If any market study was done (the 2021 OECD submission [33] mentions major reforms including ports), or the ICA's approval of the Haifa Port sale might contain an analysis of market share and expected efficiency (likely not public, but news sources might cite it).
- *Knesset Research Center papers:* Beyond Rotenberg (2023), earlier briefs on port competition or logistics costs could have baseline data (e.g. import dwell times, port productivity relative to OECD).

International/Comparative Data:

- **World Bank – Container Port Performance Index (CPPI):** Ranks ports globally by efficiency (measured as ship time in port per container handled). Useful for benchmarking Israeli ports internationally over time:
- In **2021 CPPI**, **Haifa ranked 247th and Ashdod 329th** of 370 – very low [34], reflecting pre-reform congestion. By **2022**, Haifa (including Bay Port) jumped to **56th** while Ashdod stayed around 297th [35]. (In 2023, Haifa slipped again to ~100+ due to war disruptions [36].)
- **Data:** CPPI provides an **index score** and rank for each port/year. We can use these as outcome indicators or validation for our calculated productivity trends. Access: World Bank OpenKnowledge (reports) [35].

- Also, CPPI data could help construct a **synthetic control donor pool** – e.g., using other ports' performance as comparison.

- **OECD Structural Analysis (STAN) and Productivity Databases:**

- **OECD STAN Industry** data includes value-added, employment, and gross fixed capital formation by industry for member countries. For Israel, we can retrieve annual data for **Transportation & Storage (ISIC H)**: value-added (output), persons engaged, and capital formation. This enables computing **labor productivity (VA per worker)** and an approximation of **capital deepening (investment per worker)** over time. Frequency: annual. Access: public (OECD.Stat).
- **OECD Multi-factor Productivity** data might have capital services and labor input by sector, which would directly give K/L and productivity growth. If accessible, it provides a cross-country benchmark (e.g., how Israel's transport sector productivity growth compares to OECD average).

- We will also check **OECD's Productivity Database or I4P** (if Israel participates) for an index of capital per labor by industry.

- **World Bank World Development Indicators (WDI):**

- *Ports-related series:* "Container port traffic (TEU)" for Israel (national total) – can verify growth in container handling over time (e.g., ~2.8 million TEU in 2022).
- *Capital stock:* WDI has gross capital formation (overall economy), not by sector. But no direct K/L by sector.

- *Labor:* WDI provides total employment; not granular enough for our needs.

- **Global Port Infrastructure Data:** If needed for instruments or robustness:

- E.g., data on **maximum vessel size handled** or **berth depth** at various times (from UNCTAD or World Port Index) to instrument capital upgrades.
- **Liner Shipping Connectivity Index (LSCI)** from UNCTAD: measures how well connected a country's ports are. Could be a proxy for external demand shocks – Israel's LSCI might jump after Bay Port opening.

- **Private Participation in Infrastructure (PPI) database:** documents major port privatization investments worldwide – to identify comparable cases or use as instruments (not directly quantitative for our analysis timeframe).

- **Other Countries as Controls:** We might compile data for similar economies without such reforms during 2018–2023:

- E.g., **Portugal or Greece** (already reformed earlier), or **New Zealand** (ports corporatized in 90s) as synthetic donors for productivity trends, given Israel's unique recent reform timing.

- OECD STAN would provide those countries' Transport & Storage productivity to build a synthetic counterfactual for Israel.

- **Restricted Data (if any):**

- *Micro-data:* Worker-level or firm-level data in ports (e.g., output per worker at port company) likely not publicly available. If needed, one might request data from the port companies or use government company reports. We note that our analysis will rely on **aggregates and published figures** to avoid needing confidential data.
- *Customs data:* For downstream effects, linking firm export shares by sea might require Customs info or the Ports Authority's manifest data (restricted). Alternatively, use sector-level export modality shares from literature.

Summary: We have **high-quality, granular data** on port outputs and operations from Israeli official sources (RASP, CBS) and solid industry-level data for capital and labor. This should allow construction of **K/L series** and **labor productivity series** around the 2021–2023 reform period. International benchmarks (OECD, CPPI) exist to support comparative analyses or synthetic controls. Most data is **publicly accessible** (CBS databases, gov.il reports, World Bank/OECD sites), meaning analysis can proceed quickly without significant delays for access.

3. Preliminary Data-Exploration Plan (Next 48 Hours)

To rapidly assess labor productivity (LP) and capital deepening (K/L) around the reform, we outline the following plan:

Data Assembly Steps:

1. **Compile Industry-Level Time Series (Israel):** Using Python `pandas` or R:
2. Retrieve **annual gross value added (GVA)** and **employment** for ISIC H (Transport & Storage) from CBS or OECD.STAT. For finer granularity, attempt to get **subsector data**:
    - If available, isolate *"Water transport & port services"*. If not, use Transport & Storage as a whole (noting it includes other transport – we will later address how to isolate port-specific impacts).
3. Retrieve **gross fixed capital formation or capital stock** for ISIC H. CBS's national accounts might have *net capital stock by industry*. If unavailable, use cumulative investment as a proxy for capital trends.
4. Calculate **Labor Productivity = GVA per worker (or per hour)** and **K/L = capital stock per worker** for each year.

5. *Code stub:*

```
import pandas as pd
# Example: load OECD STAN for Israel
df = pd.read_csv('OECD_STAN_Israel.csv')  # hypothetical path or via OECD
API
sector = df[df['Industry']=='Transportation & storage']
prod = sector[['Year','ValueAdded','Employment','CapitalStock']].copy()
prod['LaborProd'] = prod['ValueAdded'] / prod['Employment']
prod['K_per_L'] = prod['CapitalStock'] / prod['Employment']
prod.tail()  # inspect recent years
```

- The above yields a baseline trend of productivity and capital per worker from, say, 2010–2024. We will specifically look for changes after **2021** and **2023**.

6. **Incorporate Port-Specific Metrics:** Augment the dataset with port performance indicators for insight into the **port sub-sector**:

7. Load **annual TEUs handled** and **port labor** if possible. For example, use RASP's stats: total TEU in Israel, or TEU per port:

```
teu = pd.read_excel('RASP_Yearbook_2023.xlsx', sheet_name='Containers')
teu = teu[['Year','Haifa_ports_TEU','Ashdod_ports_TEU']]
# combining new + old in regions
```

If labor per port company is available (e.g., Haifa Port workforce from reports), compute rough **TEU per employee** as a proxy LP for each port.

8. Include **ship wait time** or **berth productivity** data: e.g., average hours per ship or moves per crane-hour from the Comptroller report. These can serve as alternative LP measures (the **higher the moves/hour, the higher the productivity**).

9. **Visualize Pre/Post Trends:** Plot the time series to identify any structural breaks:

10. **Figure: LP and K/L over time.** We expect a noticeable uptick in K/L starting ~2021 (new ports = more capital, not yet proportionally more labor) and potentially an uptick in LP by 2022–2023 if operations improved.
11. **Figure: TEU per employee (Haifa vs Ashdod).** We anticipate Haifa (with Bay Port) shows rising output per worker post-2021 relative to Ashdod (which faced competition later and had labor constraints).
12. *Code stub (visualization):*

```
import matplotlib.pyplot as plt
fig, ax = plt.subplots()
ax.plot(prod['Year'], prod['LaborProd'], label='Labor Productivity (VA/
```

```
worker)')
ax.plot(prod['Year'], prod['K_per_L'], label='Capital per Worker')
plt.axvline(2021, color='grey', linestyle='--', label='Bay Port opens')
plt.axvline(2023, color='grey', linestyle=':', label='Haifa privatization')
plt.legend(); plt.title('Transport Sector: Productivity and K/L');
plt.show()
```

13. We will also run quick **difference-in-differences checks**: e.g., compare average LP growth 2015–2020 vs 2021–2024 for Transport sector **minus** the average in other sectors (to see if a divergence occurs post-reform).

14. **Validity Checks for Controls/Donors:** We outline and test a few strategies in parallel:

15. **Within-country industry control:** Use a similar industry as a control for macro trends. For instance, **"Communications"** or **"Land transport"** might share economic trends but not affected by port reform. We gather their productivity series (from CBS/OECD) and check **parallel trends** pre-2021. If parallel, implement a DiD: Transport vs Control, pre vs post.
    - *Validity sketch:* Ensure no other major reform hit the control industry during this period (communications had some reforms, but less dramatic; manufacturing could be another control if not shock-driven).
16. **Synthetic control (cross-country):** Construct a synthetic Israel for port productivity using OECD countries. Use, say, a weighted average of countries that had no significant port shake-up in 2021–2023 (e.g., use pre-2021 trends in their transport/storage LP to fit Israel's, then compare post-2021). We will use variables like GDP growth, trade volume as covariates to improve the fit.
    - *Validity:* Check Israel's pre-reform trend vs synthetic – small RMSPE indicates a reliable counterfactual. We'll be cautious of global COVID effects (which hit all, but differently).

17. **Downstream exposure approach:** We can attempt a *sector-by-sector* analysis: compute productivity in manufacturing industries that rely heavily on seaports (e.g., chemicals, minerals exports) vs those that don't (e.g., software or diamonds which go by air). If port reforms significantly lowered logistics frictions, heavily-exposed sectors might see productivity gains (through smoother supply chains). Data needed: each sector's share of output that is seaborne trade (from trade data). We can then do a **DiD across industries** (high vs low seaport reliance, pre vs post 2021).

    - *Validity:* Need to ensure no other policy disproportionately affected the high-exposure industries in that timeframe (we will control for any known shocks per industry).

18. **Initial Results in 48h:** Within two days, we aim to produce:

19. A chart of **K/L and LP for the port/logistics sector**, highlighting the 2021 and 2023 reforms. This will visually indicate if LP rose alongside K/L.
20. Summary stats: e.g., "Labor productivity in transport grew X% in 2022–24 vs Y% in prior years; capital per worker grew faster, suggesting capital deepening contributed."
21. A rudimentary DiD estimate: e.g., "relative to control industry, transport sector LP post-2021 increased by β% (with citation or standard error)." This would be purely exploratory.
22. Diagnostics for our control strategies (parallel trend plots, synthetic fit metrics).

Throughout this quick exploration, we maintain a **clear chronology**: account for COVID in 2020 (which depressed productivity) and the post-COVID rebound in 2021, to avoid mis-attributing those effects to the reform. We will also separate the **Bay Port opening (2021)** effect from the **Haifa privatization (2023)** effect if possible – e.g., looking at immediate changes in Haifa Port Company performance in 2023 (throughput per worker) after privatization, compared to Ashdod.

This preliminary analysis will guide a more detailed econometric approach and highlight any data issues early (e.g., if specific series are missing, we'll know to find proxies or adjust strategy).

(By the end of 48 hours, we expect to have basic figures and tables to inform whether labor productivity indeed rose post-reform and whether capital deepening is visibly correlated, setting the stage for rigorous causal analysis.)

4. Causality Viability Module

Treated Units Definition: We identify two levels of "treated" units: - *Firm/Port-level:* **Haifa Port** (the incumbent port in Haifa) experienced treatment via **entry of Bay Port in 2021** and **privatization in 2023**. Similarly, **Ashdod Port** got a partial treatment (entry of South Port in 2022, though Ashdod Port Co. remains state-run). We can treat **Haifa Port Co.** as the primary treated entity, with Ashdod Port Co. as a comparison (control) unit not fully privatized and with later competition. - *Sector-level:* The broader **"Port/logistics industry"** – roughly captured by ISIC H or a sub-sector of it – is treated economy-wide starting in 2021. This could include port operating companies and possibly related cargo handling and storage activities. The counterfactual would be the same sector without the reforms (which we approximate via control industries or synthetic countries).

We propose **two main identification strategies**:

1. **Difference-in-Differences using Ashdod as Control:** Leverage the staggered reform:
2. Haifa's environment changed markedly in 2021 (new competitor) and 2023 (ownership change), whereas Ashdod had a smaller competitive jolt in 2022 and no ownership change. We can compare **Haifa vs Ashdod port performance over time**. *Outcomes:* e.g., annual containers per employee, crane moves/hour, ship turnaround time at Haifa Port Co. vs Ashdod Port Co.
3. **Validity:** Both ports were previously government-run with powerful unions and had similar technology (Haifa slightly smaller throughput historically [34]). The assumption is that absent reform, their productivity trends would be similar (supported by evidence that both suffered increasing delays pre-2021 [31]).
4. **Threats:**
    - *Spillovers:* Bay Port's opening may have indirectly affected Ashdod (some cargo might divert, or Ashdod pre-emptively improved knowing competition coming). This violates the strict DiD no-interference assumption. Indeed, Ashdod's management likely responded (though South Port's opening in Ashdod was later and smaller scale).
    - *Concurrent shocks:* Supply-chain crisis in 2021 affected both ports (massive influx of cargo, COVID labor shortages) [37] [38]. If Haifa's new port helped alleviate the crisis, the treatment effect could partly be interacting with that shock, whereas Ashdod saw severe congestion in 2021 [31]. We must control for COVID period effects (e.g., include year 2021 dummies or exclude 2020–21 for a cleaner pre-period).

5. **Diagnostics:** We will check pre-2019 trends: e.g., was Haifa's productivity growing or declining similarly to Ashdod's? The State Comptroller noted both had declining service levels pre-2021 [39] [31], supporting common trends. We'll also examine Ashdod as "untreated" in 2021 vs Haifa treated – Ashdod's big spike in wait times in 2021 while Haifa's was mitigated by Bay Port could itself be evidence of treatment effect.

6. **Synthetic Control or Donor Pool (International or Domestic):** Construct a counterfactual for the **Israeli port/logistics sector**:

7. **Synthetic International:** Use other countries' transportation sectors as donors. For example, combine OECD countries that did not undergo port reforms in 2021–2023 to match Israel's pre-2021 productivity trend in Transport & Storage. This synthetic will capture global trends (post-COVID recovery, etc.) and isolate the extra boost in Israel after reform.
    - *Feasibility:* Israel's port reform timing is fairly unique, which helps – many peer countries' port performance in 2021–23 was only affected by global factors (and not major domestic reforms).
    - *Threat:* Israel's economy had a strong tech sector boom and unique COVID recovery path, which could confound the sectoral productivity. We will include broad economic predictors in the synthetic control fit (GDP growth, manufacturing output, etc.) to improve similarity.
8. **Domestic Donor (Sector-level DiD):** Compare the transport/logistics sector (treated) with other sectors in Israel. For instance, **manufacturing** or **construction** as controls (no direct benefit from port reform, but affected by general economy similarly). We control for sector-specific shocks (e.g., construction has its own dynamics).
    - *Threat:* Port reform might indirectly benefit many sectors through cheaper imports, meaning the "control" sectors might also see some effect (albeit smaller). This biases against finding a difference, making our DiD conservative.
    - *Solution:* The downstream exposure design (mentioned earlier) refines this by differentiating sectors by how much they rely on seaports. That gives a continuum of treatment intensity rather than assuming one sector fully unaffected.
9. **Diagnostics:** Check if transport/storage sector was behaving like chosen control sectors pre-2021 in terms of productivity growth. If not, synthetic control (which is essentially an optimized donor combination) is preferred.

Key Threats & Proposed Remedies:

- *Spillovers:* The reform may affect non-treated units:
- Geographic spillover: Firms in other cities might benefit if port efficiency improves nationwide (reducing this as a control). We address this by focusing on **port company level** for direct treatment, or using very low-exposure industries as controls.

- Behavioral spillover: Anticipation of reform can lead to pre-trend deviation (e.g., Haifa Port might have ramped up efforts in 2020 anticipating Bay Port). We will check data for any trend breaks **before** Sep 2021. If found, we might use an *event-study* model to see the timing of changes and exclude the anticipatory period.

- *Concurrent events:*

- **COVID-19 (2020–21):** Caused abnormal fluctuations in productivity (initial lockdowns reduced output, then pent-up demand overwhelmed ports). We will include controls for COVID (e.g., an indicator or use 2019 as baseline, skipping 2020). We may difference out the global effect by using international data (since all ports faced COVID to some extent).
- **Ukraine War (2022):** Minor direct impact on Israeli ports, but global shipping rerouting might have modest effects.

- **Domestic: 2023 security situation:** The October 2023 war drastically reduced port activity in late 2023 [40] – but our main evaluation window (through mid-2023) is mostly prior. We will truncate analysis to Q2 2023 for causal inference, to avoid war noise (or treat war as an interruption to be analyzed separately for robustness).

- *Sample size & statistical power:* At port-company level, N is very small (essentially 2 ports, pre/post). This means estimates will be qualitative or need external data to bolster them (e.g., benchmarking Haifa's change against distribution of changes in a panel of world ports). Using a panel of industries or countries will improve N for statistical inference.

Viability Score (0–5): We assign a **score of 3/5**. This reform is **moderately viable causally**. On one hand, the timing (2021, 2023) and nature (new competitor, ownership change) are clear, external interventions, and there are plausible comparisons (Ashdod port, other sectors, other countries) [41] [31]. The expected effects are relatively large (making signal discernible) – e.g., Haifa port's throughput jumped and wait times dropped when Bay Port opened [21]. On the other hand, **confounding factors** (especially the pandemic logistics surge) and the small number of treated units complicate identification. Spillovers are a concern since the whole sector was meant to improve, leaving fewer truly untreated observations. Nonetheless, with careful design (staggered analysis, synthetic controls, controlling for global trends), a credible causal story can be told. Diagnostics like parallel trend tests and placebo checks (e.g., falsely assigning treatment to Ashdod pre-2021 to see if a "phantom" effect appears) will be used to support validity.

Diagnostics summary: We will produce: - Event-study plots (e.g., port productivity relative to 2021) to ensure changes align with reform dates and not earlier. - Check that no unusual divergence existed pre-2019 between treated and controls. - Use **Placebo tests**: e.g., assume treatment happened two years earlier and verify no significant effect then, or randomly assign fake "reforms" to other sectors to ensure we don't find spurious effects.

In conclusion, while challenging, the case is **doable** with a combination of approaches, and the large magnitude of inefficiency reduction expected provides a fighting chance to isolate the reform's impact.

5. Scoring Table (Reform Evaluation Criteria)

We evaluate the ports competition reform on key dimensions (scale 1=poor, 5=excellent):

Criterion	Score	Assessment & Evidence
Data Feasibility	**5/5**	**Excellent** – Plentiful data from official sources. High-frequency port performance stats (throughput, wait times) are public [24] [21]. Sectoral capital and labor data are available via CBS/OECD. No special access needed, enabling quick analysis.

Criterion	Score	Assessment & Evidence
Identification Strength	**3/5**	**Moderate** – Clear **treatment events** (Bay Port open, privatization) provide temporal demarcations. However, few comparison units and concurrent shocks weaken a simple DiD. We do have a plausible control (Ashdod port) and can use synthetic methods to strengthen identification [42] [31]. Parallel trends will need careful verification.
Causality Viability	**3/5**	**Moderate** – We can make a case that observed productivity changes are caused by the reform, but must address confounders. The reform was exogenous to port firms (driven by government policy), satisfying a key causality criterion. Yet, spillover to the control and global supply-chain noise complicate causality. Diagnostics and alternative specifications will be critical. Overall viable, with some caution [21] [31].
Capital Deepening Plausibility	**5/5**	**High** – The reform explicitly brought **new capital investment**: Bay Port introduced state-of-the-art cranes and deeper berths [43]; Haifa's new owners pledged capital upgrades. Historical evidence shows tech investments drive port productivity (e.g., containerization's large impact [15]). It's very plausible that a significant share of any LP gains will be mediated by higher K/L (more cranes, automation per worker).
Magnitude & Significance	**4/5**	**High** – Israel's ports were notoriously inefficient (world ranking ~300s) [34], contributing to high costs [44]. The reforms yielded immediate large effects: Haifa's port complex jumped into the top 60 globally by 2022 [35], and Bay Port handled more containers than the old port by 2023 [45]. Such a leap suggests a sizable productivity shock. The economic stakes (trade facilitation, consumer prices) are significant, strengthening the case for studying this reform [46] [2].
External Validity	**4/5**	**Good** – Findings will be relevant to other countries considering port privatization or competition. Many emerging economies struggle with port inefficiency; our study could provide a blueprint. However, Israel's context (security concerns, single-operator new ports) has unique elements. Still, the core mechanism – competition + investment improving productivity – aligns with international evidence [8] [10].

Sources: The above scores cite evidence of data availability [24], initial outcomes [42] [21], and literature support [15] [8] to justify each rating.

6. IV-Mediation Readiness (Capital Deepening Path)

To formally test how much of the productivity boost is mediated by capital deepening (K/L increases), we consider potential **instruments for capital intensity**:

- **Instrument 1: Pre-existing Physical Constraints (Berth Depth).**
  Variation in harbor depth or ability to handle large ships can serve as an instrument for capital investment. Ports with insufficient draft had to invest in dredging and new berths to stay competitive once the reform allowed larger entrants. For instance, Bay Port's deep-water berth forced Haifa's old

port to dredge its basin to accommodate similar ships. **Exclusion assumption:** Natural depth impacts productivity mainly by enabling capital upgrades (bigger cranes, deeper berths) – not by itself (depth alone doesn't increase throughput unless used with new equipment). However, caution: deeper ports might attract more traffic **directly** (a violation if traffic volume (demand) changes independently of capital per worker). We argue that in the short run, depth mattered because it dictated capital responses (e.g., purchasing post-Panamax cranes), rather than acting alone. We will control for demand factors (like trade volume) to mitigate exclusion violations. **Lag:** Investments due to depth limits happen on a lead time – e.g., dredging projects initiated in 2018–2020 in anticipation of Bay Port. So, instrumenting K/L by depth might show effect with a ~1–2 year lag (capital projects complete by 2021, affecting productivity by 2022). We will test different lag structures (e.g., using an interaction of depth with a post-2021 dummy as an instrument for K/L jump in 2022).

- **Instrument 2: Timing of Crane Procurement/Installation.**
  The rollout of new ship-to-shore cranes at ports can be treated as an exogenous shock to capital per worker, especially if delivery was scheduled before knowing exact demand. For example, Haifa Port Company ordered cranes in 2019 (as part of modernization), which arrived in 2021. Similarly, Bay Port's cranes came online in phases. We can use **"number of new cranes operational"** as an instrument for capital stock. This assumes crane deliveries are predetermined and not a reaction to a sudden productivity shock. **Exclusion risk:** New cranes can directly improve throughput (more moves/hour) even without affecting labor count – but that *is* the capital deepening mechanism. The worry is if management only deploys cranes when expecting traffic surges (endogeneity). However, many port crane purchases are long-term decisions based on infrastructure plans, so they have an exogenous component. We will bolster this by using global supply factors – e.g., a global crane manufacturer backlog might delay or bunch deliveries independent of local demand. **Lag:** Minimal – once cranes are installed and operators trained (few months), output per worker should rise. We might instrument **K/L in year t** with **number of cranes installed by t-1**.

- **Instrument 3: Privatization Investment Mandates.**
  The Haifa Port privatization deal reportedly required the new owner to invest a certain sum in capital improvements (yards, equipment). This essentially created a quasi-random jump in K independent of short-term performance. We can exploit this by using a **dummy for "post-privatization mandatory investment period"** or the **expected investment amount (in NIS) as an instrument for K/L**. The logic: Adani-Gadot's commitment to spend (say) ₪1 billion in 2023–2025 on port capital is exogenous to immediate productivity (it was a contract condition). **Exclusion:** Privatization also has managerial effects (work practices, incentives) that directly impact productivity aside from capital – violating exclusion if not controlled. To isolate capital's role, we would control for ownership change via fixed effects or include variables capturing new management practices (if measurable, like changes in overtime rules). The instrument then isolates the portion of productivity change attributable solely to the injection of new capital. **Lag:** Some lag since spending and installation take time; we'd expect mediation effect gradually over 1–3 years as new equipment comes online. We will examine first-stage (K/L rising in 2023–24 due to mandated investment) and then second-stage (productivity rising as a result in 2024+).

- **Instrument 4: Global Shipping Shock – Vessel Upsizing.**
  Leverage the external trend of container vessels getting larger (especially 2018–2022). Ports globally had to respond by buying larger cranes and expanding capacity. We can create an instrument such as **"global average vessel size in year t"** or **an indicator for introduction of 15k+ TEU vessels on**

Asia-Med routes. This affects Israel's ports' capital needs exogenously – e.g., when **very large ships started arriving (after the Panama Canal expansion)**, ports had no choice but to invest in bigger infrastructure or lose those calls [47] [48] . **Exclusion:** Larger global ships could also directly affect port productivity if they carry more cargo per call (increasing throughput per call independent of capital). But that effect still requires the port to be able to handle them – which circles back to needing capital. We will be cautious: if using this, we control for total trade volume so that the instrument mainly captures the technological pressure to invest, not demand. **Lag:** The effect is somewhat immediate – e.g., 2016 Panama Canal expansion led to new ship deployments by 2017–2018; Israel's new ports were built by 2021 to handle them. So by 2021, this instrument kicked in.

For each instrument, we'll run a **first-stage regression** (K/L on instruments) to ensure it's strong (e.g., ports with deeper berths or mandated investments indeed show higher capital per worker). We expect: - At Haifa, deep berth + new cranes + privatization mandate all coincide, yielding a strong jump in K/L. At Ashdod, shallower and no privatization => smaller K/L growth. - First-stage F-stats should be high given the magnitude of changes.

Exclusion Risks Summary: As noted, each instrument has potential pathways to affect productivity beyond just K: - *Depth:* deeper port might directly reduce ship waiting (since big ships don't need to offload partially elsewhere), an efficiency gain not entirely via capital. We mitigate by controlling for ship size composition or focusing on labor productivity metrics that inherently involve output per worker (which should still improve mainly once capital is in place to handle bigger ships). - *Cranes:* essentially part of K, so not a separate violation – just need to ensure the timing isn't chosen based on unobserved productivity shocks. - *Privatization:* entails managerial change. We may combine this instrument with others to isolate pure capital (e.g., use mandated investment *amount* rather than a binary privatization dummy). - *Global vessel trend:* could affect trade flows (big ships might lower freight cost, boosting trade volume). We would control for overall trade to focus on productivity (output per worker, controlling for output level if needed).

We will perform **over-identification tests** since we have multiple instruments (depth, cranes, etc.) for K/L. If the instruments are valid, results from different instruments should concur. If they differ, that indicates an exclusion violation (e.g., one instrument might be pushing productivity through another channel).

Expected Lags: We anticipate the **capital deepening effect on productivity may not be instantaneous**: - New port infrastructure takes months to ramp up (workers training on new cranes, operational kinks). For example, Bay Port in late 2021 had a learning curve – we might see bigger productivity jump in 2022 [35] [21] . - Thus, we will allow lags in the mediation analysis: e.g., instrument 2021–2022 K/L changes and look at 2022–2023 productivity changes. - Also consider dynamics: a burst of capital might initially even lower productivity (disruptions, or if capacity outstrips utilization in early phase) then increase it. We'll check yearly patterns to set appropriate lag structure in the IV.

Mediation Approach: Once we have a valid instrument for K/L, we will implement a mediation analysis: estimate how much of the total effect of the reform on productivity is channeled via K/L. This involves: - Step 1: Regress K/L on reform dummy (or use IV for K/L to get exogenous variation). - Step 2: Regress productivity on predicted K/L (from step 1) and on reform dummy. - The coefficient on predicted K/L shows the mediated effect. A Sobel-Goodman mediation test can quantify the share of total effect mediated by K/L.

We expect a **significant mediated share**, given qualitative evidence that new equipment and infrastructure are driving faster container handling (e.g., Bay Port's semi-automation allows ~50% more moves per hour than legacy ports – a pure capital-driven productivity boost) [48] [21].

In sum, we have a plan to leverage **exogenous variation in capital deepening** due to technical and policy factors. While careful checks are needed, the multiple instruments and clear timeline strengthen our ability to isolate capital's role in improving labor productivity.

7. Mini Pre-Analysis Plan (1-Page)

Research Question: Did the 2021 entry of a new private port and the 2023 privatization of Haifa Port increase labor productivity in Israel's port/logistics sector, and how much of any productivity gain is attributable to capital deepening (higher K/L)?

Hypotheses: 1. **H1 (Productivity impact):** The reforms led to a significant increase in labor productivity in port operations (output per worker/hour rose, or service times fell). 2. **H2 (Capital mediation):** A substantial portion of the productivity improvement is mediated through capital deepening – i.e., through new infrastructure and equipment per worker (rather than purely through TFP or labor effort changes).

Treatment Units & Timing: - *Primary treated unit:* **Haifa Port operations** (inclusive of the Haifa Port Company and the new Bay Port) from **September 2021** onward (competition shock), with an additional treatment in **January 2023** (ownership change to private). - *Secondary:* The entire **Israeli port sector** from 2021 onward (since a new competitor affects market-wide practices and expectations). - *Controls:* **Ashdod Port** operations (state-run, faced new competition only from Feb 2022, no privatization). Also, other transport industries or global ports as needed for control comparisons. - *Pre-treatment period:* 2015–2020 (enough years to establish baseline trends, excluding the abnormal COVID spike in late 2020–early 2021 or treating it carefully). - *Post-treatment period:* 2021–2024 (excluding late-2023 war disruptions in primary analysis; we may censor at mid-2023).

Outcomes: - **Labor Productivity Metrics:** - *Firm-level:* TEUs handled per employee per year at Haifa vs Ashdod; Tons per gang-hour; Ship turnaround time (hours) per ship (inversely, fewer hours = higher productivity) [37] [31]. - *Sector-level:* Real value-added per worker in Transportation & Storage (with focus on the port sub-sector if isolatable). - *Service Performance:* Average vessel waiting time (a system-level productivity indicator). This captures efficiency gains visible to port users [44]. - **Capital Deepening Metric:** Capital-Labor ratio (K/L) in port operations. Proxy by net capital stock per employee (from national accounts) or, if only firm-level data: number of cranes & yard equipment per 100 workers. - **Auxiliary outcomes:** Total throughput (to check if productivity gains come with volume growth or just doing same work with less labor), and unit labor costs (wages relative to output, if data allows, to see if savings occurred).

Identification & Estimation Strategy: - **Difference-in-Differences (DiD):** Compare Haifa vs Ashdod port outcomes over time. We'll use a two-period DiD initially: pre (avg of 2017–2019) vs post (2022–2023), treated = Haifa. Then refine with annual panel data DiD with year fixed effects and port fixed effects. This estimates the *average treatment effect on Haifa* post-competition and post-privatization [21]. - We will also exploit the staggered nature: use 2021–2022 as "competition treatment" (Haifa got Bay Port, Ashdod not yet fully treated) and 2023 as "privatization treatment" (Haifa treated, Ashdod not). - Check parallel trends using 2015–2020 data – both ports had similar trends in, e.g., container moves/shift (we expect yes, as both were constrained by similar labor practices). - **Event Study:** Within the DiD, include leads/lags to separate the

2021 and 2023 impacts. Expect to see a sharp drop in wait times or jump in throughput at Haifa in late 2021, and possibly another improvement after privatization in 2023 (unless war intervened). - **Synthetic Control:** Construct a synthetic for the transport/storage sector's productivity using other OECD countries (predictors: pre-2021 productivity, GDP, etc.). This will corroborate the magnitude of change beyond general trends. - **Instrumental Variables (IV) for Mediation:** As outlined, use instruments (berth depth, crane count, etc.) to isolate changes in K/L. Then perform 2SLS: 1. First stage: predict K/L using instruments (and port/company fixed effects for panel). 2. Second stage: regress productivity on predicted K/L and other controls (year effects, etc.). This yields the portion of productivity change due to capital deepening. A high *Mediation Ratio* (e.g. >50%) would confirm capital deepening is a dominant channel. - **Downstream sector DiD:** As a robustness/extended analysis, regress manufacturing sector outcomes (like TFP or inventory costs) on their reliance on seaports * post-reform interaction [49] [50]. Hypothesis: sectors that import heavy inputs (e.g. metals, as hinted by delays in 2021 affecting construction steel) benefit more after ports improved, evidenced by higher output or productivity relative to low-reliance sectors.

Controls and Covariates: We include: - **Macro controls:** GDP growth or industrial production index (to account for general economic conditions). - **COVID controls:** Dummies or stringency index for 2020–21 to net out pandemic effects. - **Labor unrest dummy:** If strikes occurred (e.g., there were threats of strikes when new ports opened, or slowdowns), include an indicator to avoid attributing those disruptions to lack of reform effect. - **Trend adjustments:** If Ashdod had a pre-existing trend difference, include a port-specific linear trend up to 2020.

Inference: Use robust clustered standard errors (cluster by port for port-level regressions, or by country for synthetic control placebo tests). Given only 2 ports, inference in DiD will rely on longer time series (treating year as the unit for cluster can help, or use permutation tests in synthetic control).

Mediation Effect: After IV estimation, use Sobel test (if sample size permits) to test significance of indirect effect (Reform -> K/L -> Productivity).

Validity and Sensitivity: - Test no-effect on placebo outcomes (e.g., *truck productivity* at the ports – should not be directly affected by port management changes). - Remove 2020–2021 data to see if results still hold (because those years are volatile). - Use Ashdod as treated in a falsification test in a period it wasn't (pre-2021) to ensure our method doesn't find false positives. - Check if **labor hours or workforce composition** changed: if the only change was fewer workers (labor shedding) vs same output, that's still productivity but via reduction in L. We'll differentiate productivity gains from pure downsizing. For instance, if Haifa Port Co. offered retirement packages post-privatization, output may have stayed similar with fewer workers (productivity rises). That's a valid efficiency gain but qualitatively different from output increasing. We'll document such mechanisms (e.g., we know ~200 workers took buyouts at Haifa pre-sale – we'll confirm if true and incorporate).

Expected Findings: - We expect to find a **significant productivity jump in Haifa relative to Ashdod starting 2022** – e.g., Haifa's containers per worker might rise by ~20-30% [21], whereas Ashdod's remains flat or only slight increase until later. - Part of this jump is due to Bay Port's high productivity (with ~170 workers handling what 1,000 workers did before, it lifts the average) [51] [21]. - We anticipate the IV mediation will show **at least half** of the productivity gain is explained by higher K/L (new cranes, automation, etc.). The rest might be due to improved work practices (e.g., longer operating hours, reduced downtime due to competition, which is more a TFP gain). - The evidence of mediation: e.g., an additional crane per 100 workers might lead to X more TEUs per hour, which aligns with engineering benchmarks.

If selected as top pick, this analysis will yield actionable insights on how introducing competition and private capital can dramatically improve efficiency in essential infrastructure. We will produce clear charts (before-after comparisons, difference plots) and regression tables isolating the reform effect, as well as a mediation breakdown (e.g., “of the 25% increase in output per worker, 15 percentage points are due to capital deepening”). These will inform policymakers about the mechanisms – whether simply injecting capital suffices or if complementary labor reforms are needed (e.g., if a portion of productivity remained unachieved due to restrictive work rules, as Kohelet suggests [52]).

Overall, the pre-analysis plan ensures we **separate correlation from causation** and pin down *how* the ports reform delivered productivity gains – critical for generalizing this success to other sectors or countries.

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