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**Evaluating Impacts of Institutional Reforms
on Port Efficiency Changes: Malmquist
Productivity Index for World Container Ports**

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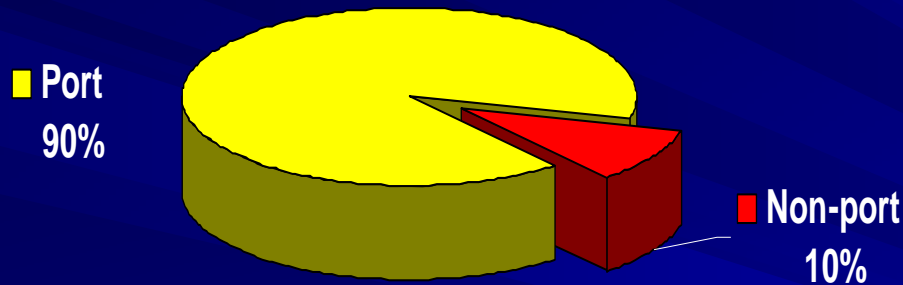
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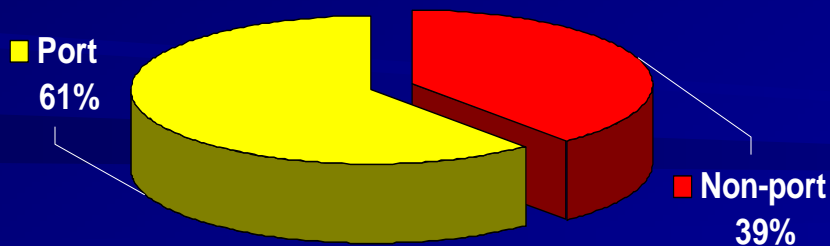
Ports, the backbone of trade, requiring huge capital investment

Modal Split for International Trade by Weight



- Global Investment, '01-'07:
 - \$ 14 billion for
 - 5000 ha of yard
 - 930 cranes
 - 144 km quayline
 - \$ 3 billion for yard equipment

Modal Split for US Trade by Value



- Rapidly increasing global container capacity:
 - 350 million TEU in '01
 - 450 million TEU in '07

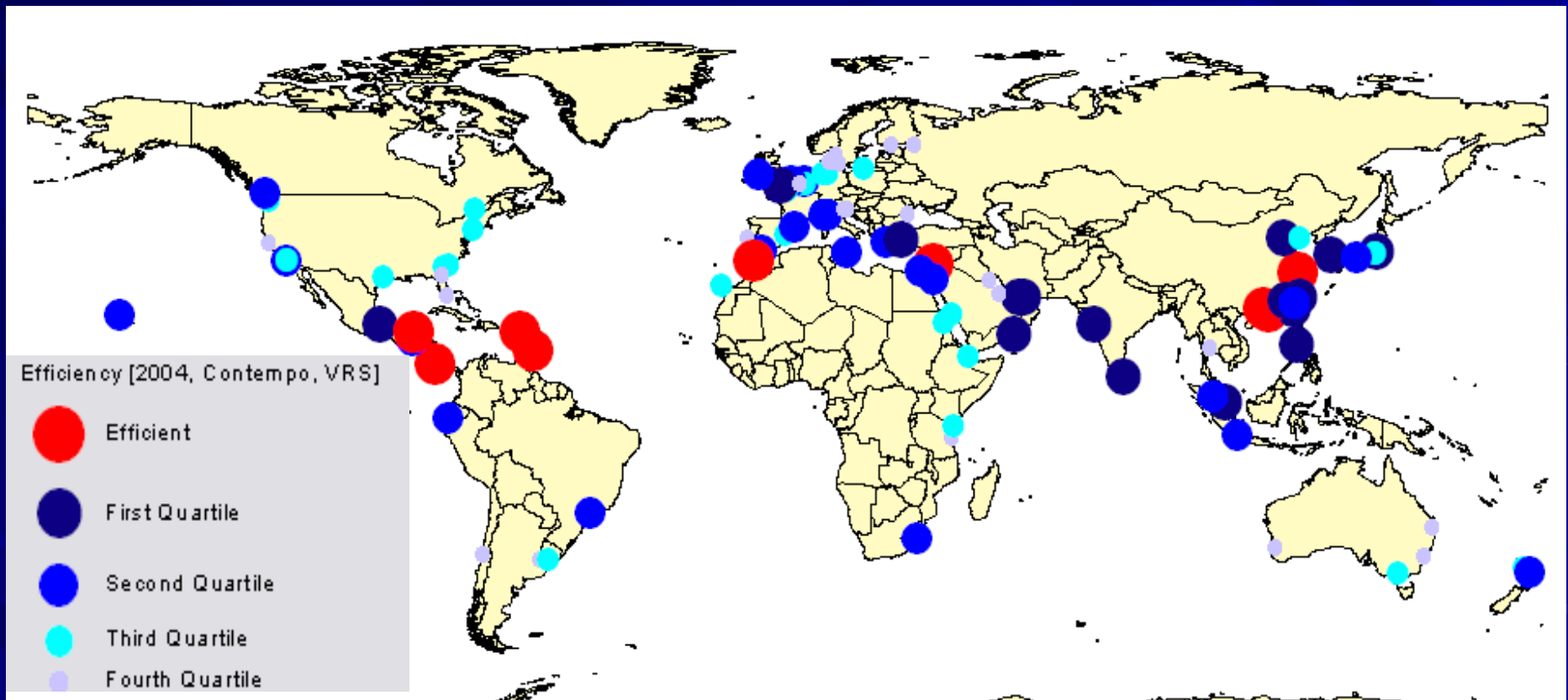
Port infrastructure for freight handling: pier, yard, berth, crane...



- Post-panamax ship: 8000 TEU (350 m)
- Super post-panamax ship: 12000 TEU by 2012
- 12000 TEU X 5 meter trucks = *60 km traffic*
- *US \$ 7 ~10 Million / post-panamax crane*

“Whatever the cause, capacity constraints are pushing logistics to the top of management agendas around the world (Financial Times, Nov. 16th, 2004)”

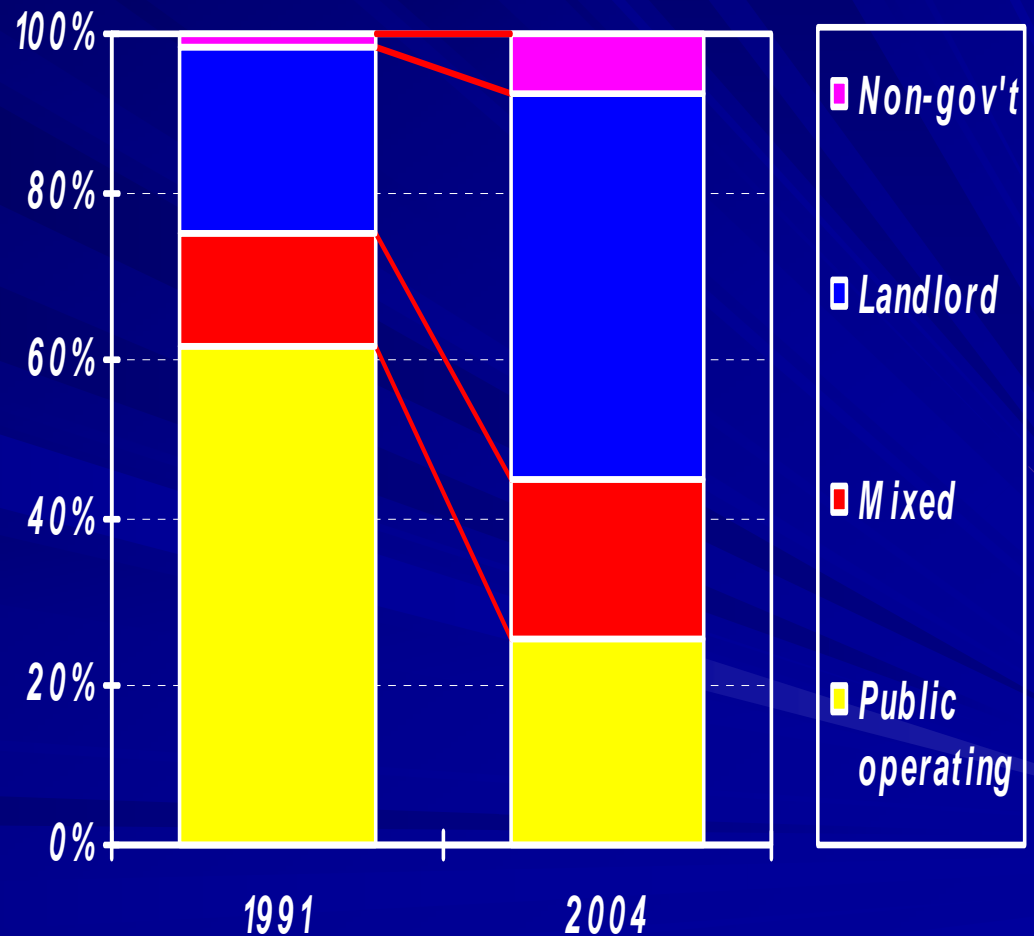
■ Inter-regional, intra-regional efficiency gaps



- Efficiency index created based on Data Envelopment Analysis (DEA), 100 ports
- Output-oriented, Variable returns-to-scale, Contemporaneous (Year =2004)

Transition of port institution model

- Institutional reforms: decentralization of port management and privatization of seaport assets
- Increasing numbers of hybrid models
- Internationalization of ports and port competition



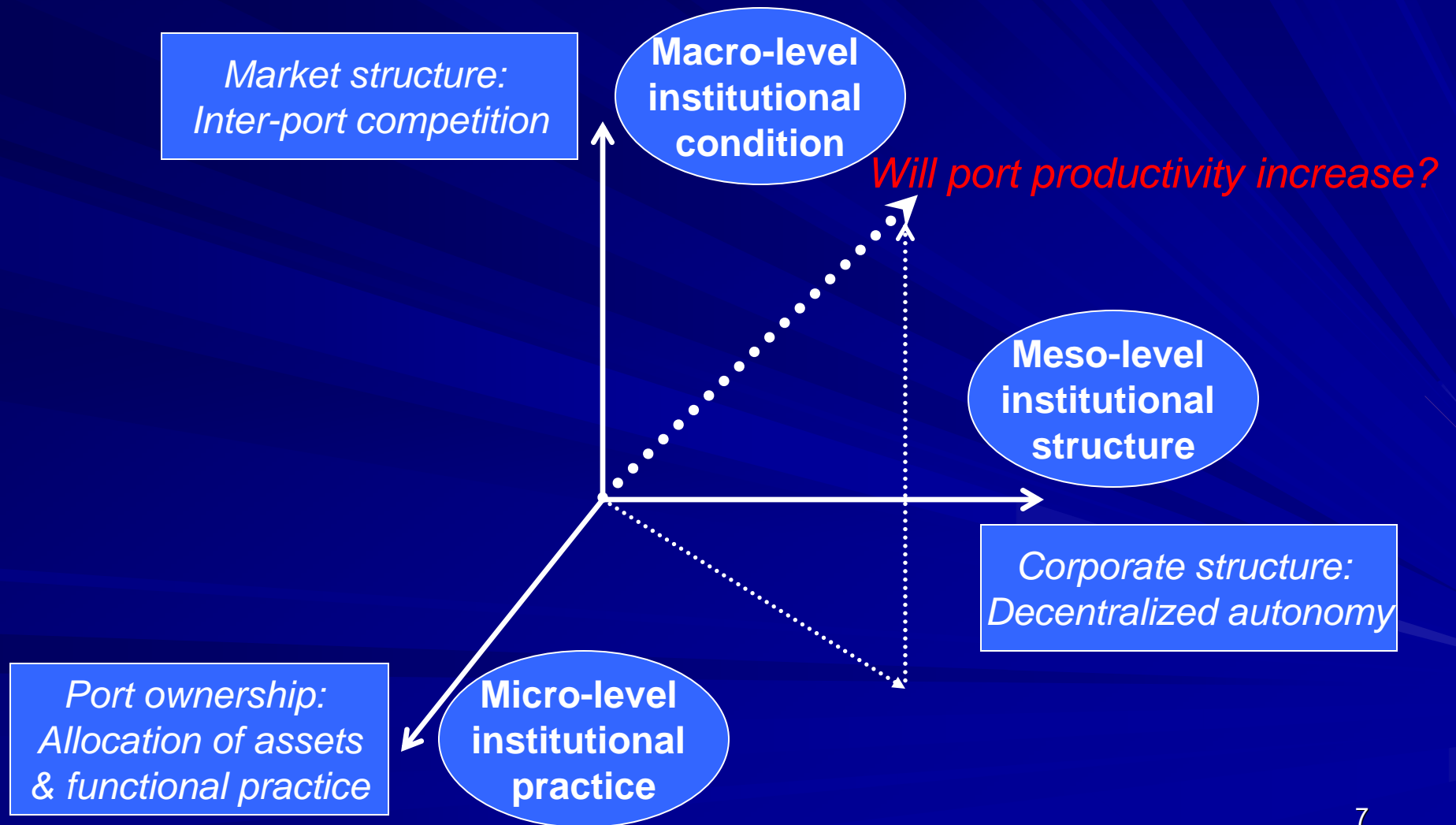
Strategic & academic issues

- What makes ports outperform others?
 - Exogenous (geography) vs. Endogenous (strategy)
- What institutional models are more effective to create better port infrastructure efficiency and management?
 - Kevin Cullinane, Antonio Estache

Research questions:

- Whether have institutional reform efforts over the last decade improved seaport infrastructure efficiency?
 - Examine efficiency changes of top global container ports between 1991 and 2004
 - Identify sources of efficiency changes

By seaport institutions, I mean...



Methods

Port Institutions:

- *Corporate structure*
- *Ownership practice*

Qualitative:

- Institutional survey for original data collection
- Document review
 - Interview

Port Productivity:

- *Efficiency*
- *Efficiency change*

Quantitative:

- *Data Envelopment Analysis (DEA)*
- *Malmquist Productivity Index (1991-2004)*

Triangulation

Evaluation:

100
global hub,
national
gateway
container
ports
between
91 & 04

Typology: Port corporate *structure*

Criteria: major manage't body	Specific Proxy
Authority to plan and design ports strategically and in the long term	Financial, strategic, and master plans for physical infrastructure
Authority to give lease or concessions for port property	Container terminals
Authority to decide port tariffs or transfer the authority to terminal operators	Handling fee

Boundaries between Gov'ts, P.A., and terminal operators

1. National Gov't / P.A.

2. State/Provincial Gov't

3. Local Gov't / P.A.

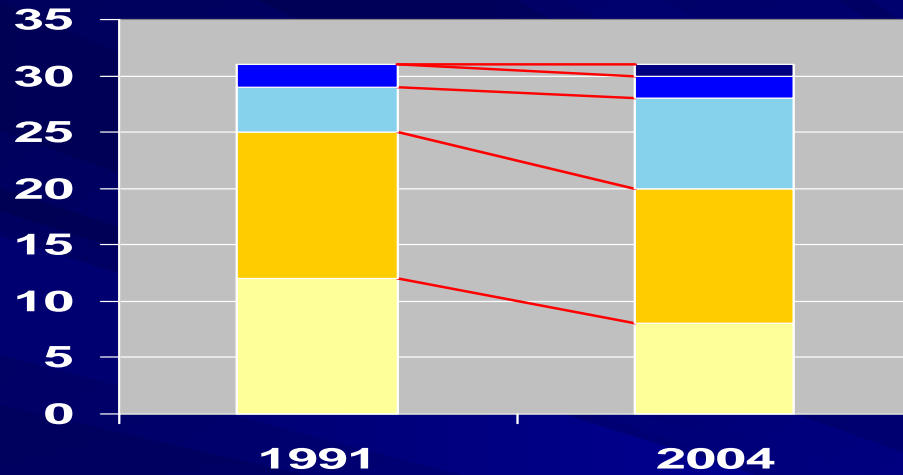
4. Statutory Port Corp.

5. Gov't Owned Corp.
(under corporate law)

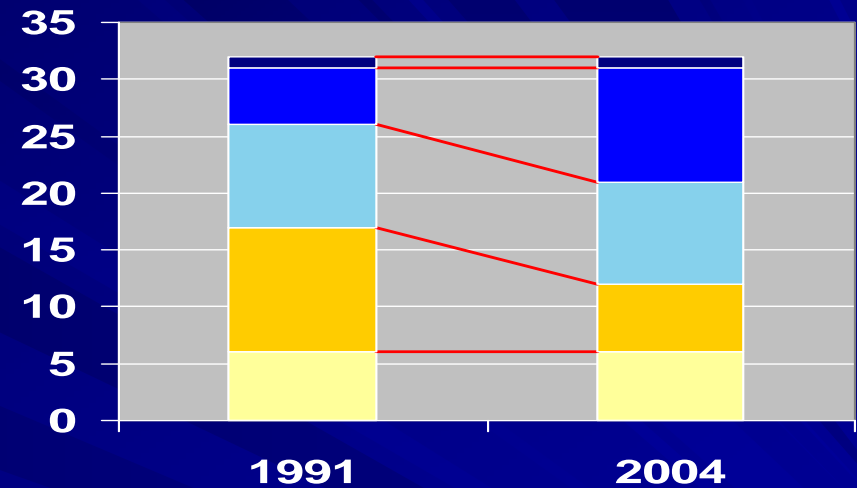
6. Private Enterprise

Transition of corporate structure, 1991-2004

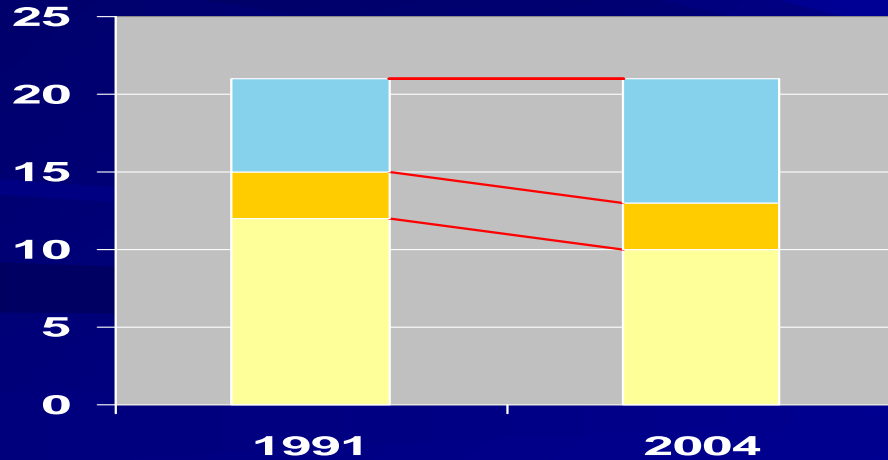
Asia (25) & Oceania (6)



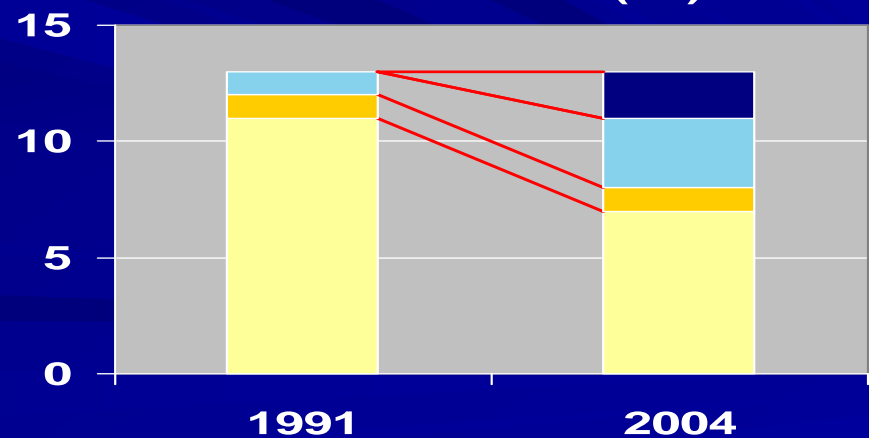
Europe (25) & Middle East (7)



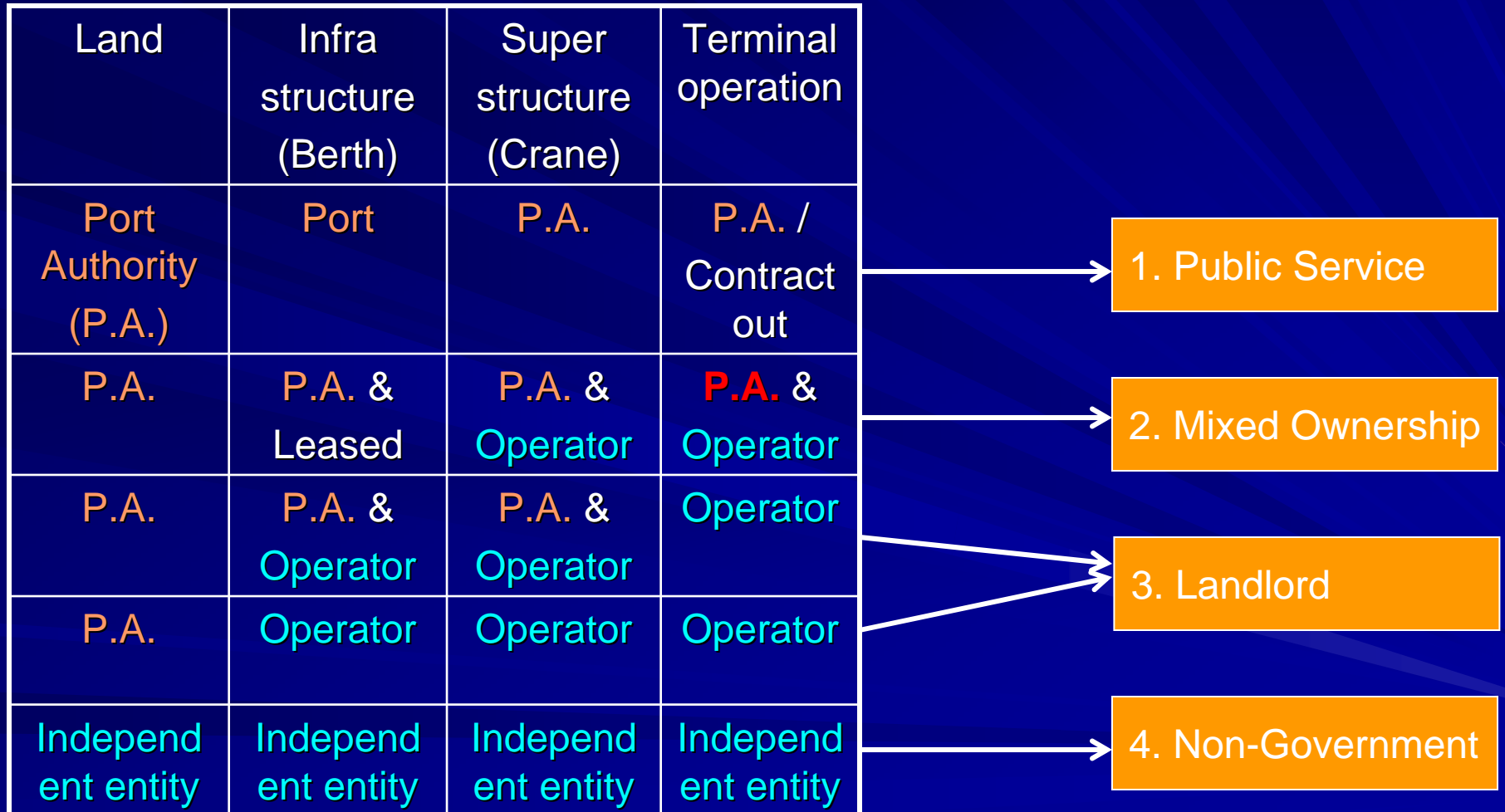
North America (15) & Africa (6)



Latin America (13)

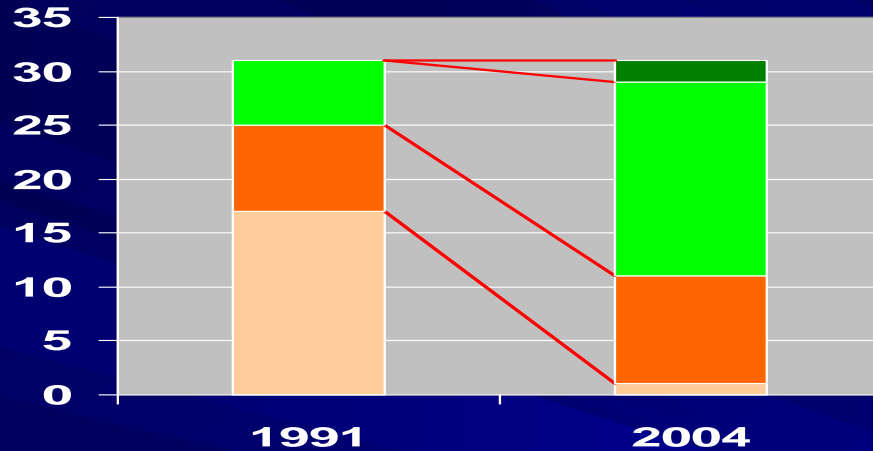


Typology: Port ownership *practice*

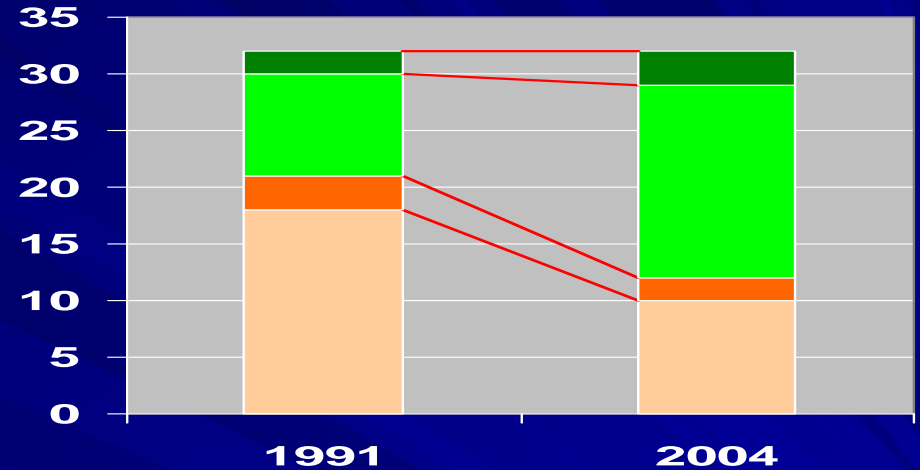


Transition of port ownership, 1991-2004

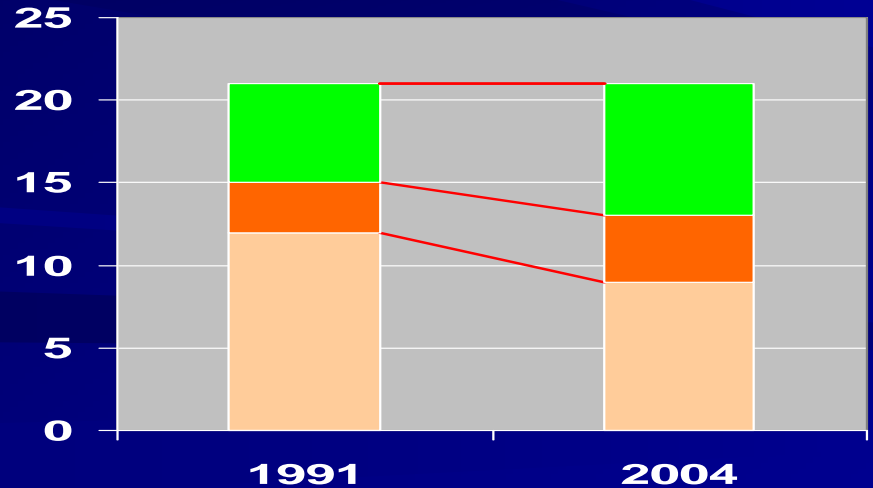
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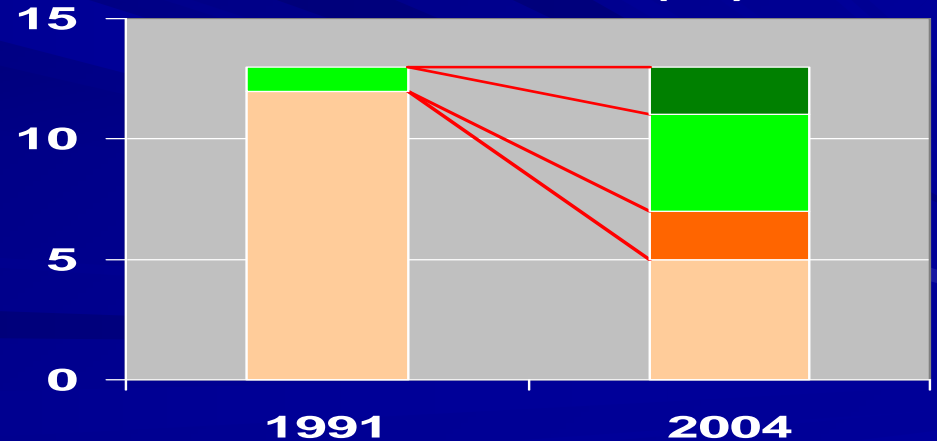
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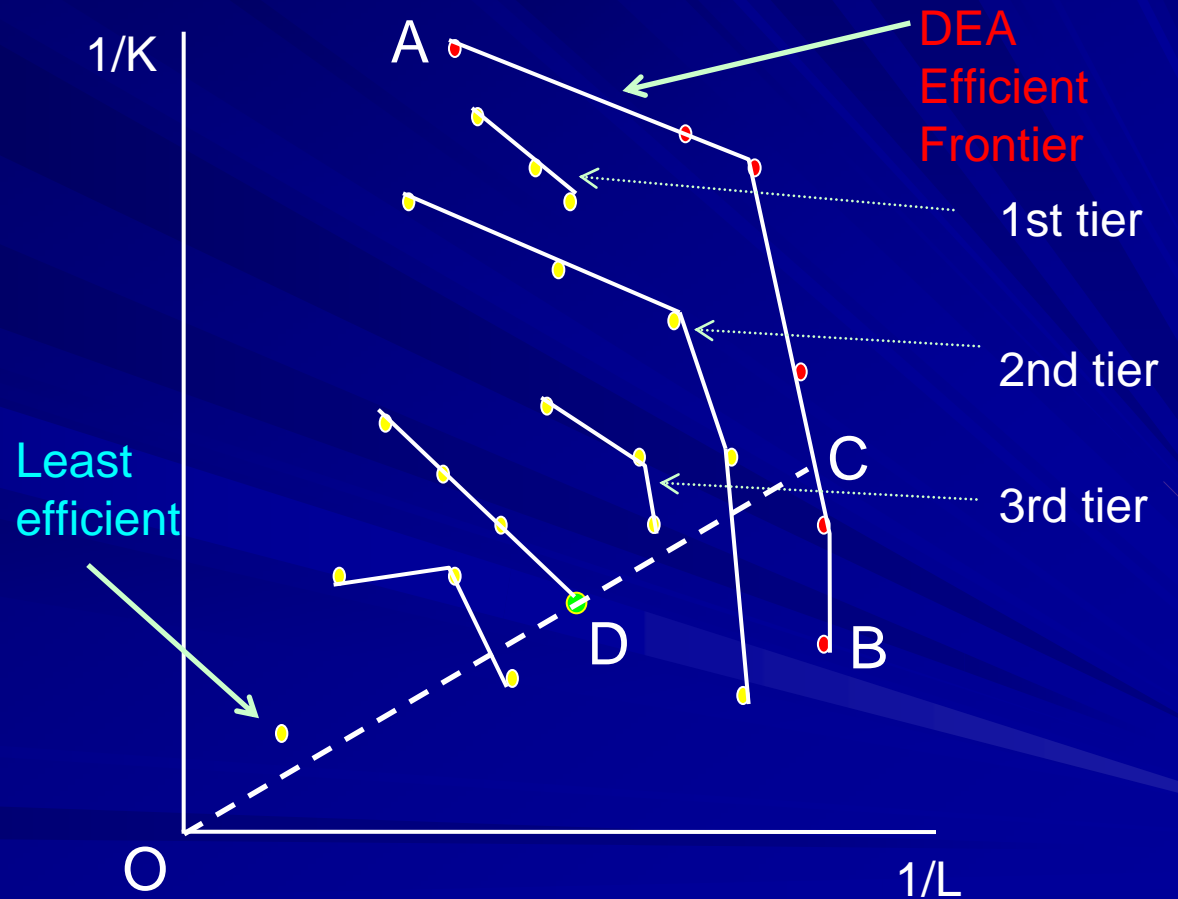


Latin America (13)



Data Envelopment Analysis

- Malmquist Productivity Index (MPI) based on Data Envelopment Analysis (DEA)
- DEA: Compare organizations' capability to convert inputs into outputs
- Radial contraction
- Efficiency scores: Ratio of OD to OC



Formal Concept of MPI

$$\begin{array}{ccccccc}
 \text{A} & \times & \text{B} & \times & \text{C} & = & \\
 \frac{\Phi_{t_0}(v)(x_{t_0}, y_{t_0})}{\Phi_{t_1}(v)(x_{t_1}, y_{t_1})} & \times & \frac{\Phi_{t_1}(v)(x_{t_1}, y_{t_1}) * \Phi_{t_0}(c)(x_{t_0}, y_{t_0})}{\Phi_{t_0}(v)(x_{t_0}, y_{t_0}) * \Phi_{t_1}(c)(x_{t_1}, y_{t_1})} & \times & \left[\frac{\Phi_{t_1}(c)(x_{t_0}, y_{t_0}) * \Phi_{t_1}(v)(x_{t_1}, y_{t_1})}{\Phi_{t_0}(c)(x_{t_0}, y_{t_0}) * \Phi_{t_0}(v)(x_{t_1}, y_{t_1})} \right]^{1/2} & = & \\
 & & & & & &
 \end{array}$$

Where

$\Phi_{t\alpha}(v)(x_{t\beta}, y_{t\beta})$: efficiency scores (under VRS) produced by the benchmarking of a port in the year of β in comparison to the year of α

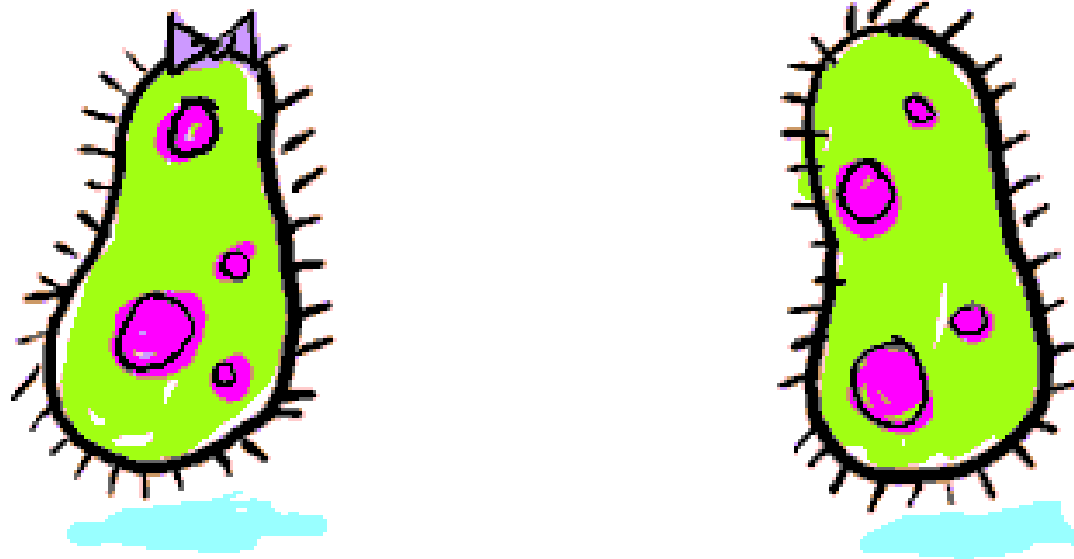
$\Phi_{t\alpha}(c)(x_{t\beta}, y_{t\beta})$: efficiency scores (under CRS) produced by a benchmarking of a port in the year of β in comparison to the year of α

- **A: Catch-up effects ('Pure' technical efficiency change)**
- **B: Catch-up effects (Scale efficiency change)**
- **C: Frontier Shift effects (Production frontier change)**

Sources of Improvement in Efficiency

explained by Malmquist Productivity Index

The Evolution Of Man And Woman

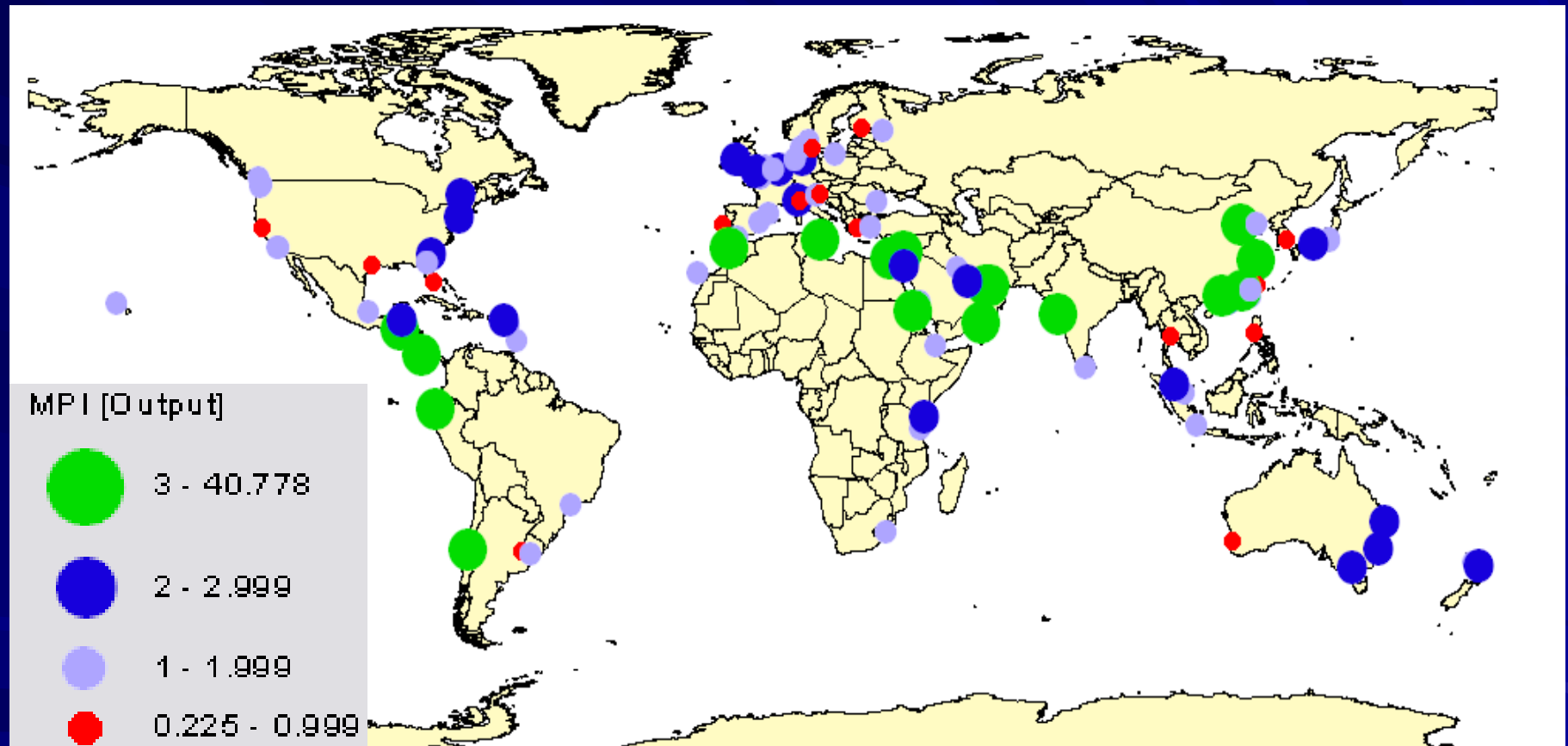


- Dynamically measure efficiency changes and disintegrate sources :
 - **Frontier shift effects**: technological progress
 - **Catch-up effects**:
 - **Scale efficiency change**: adjust production scales
 - **'Pure' technical efficiency change**: timely adjust input factors

Variables and data

- Input variable: capital, land, and labor
 - Total container berth length (meter)
 - Container terminal area (sq. meters)
 - Capacity of container cranes (tonnage)
- Output variable: throughput
 - Container volumes handled (total TEU)
- Data: *Containerisation International Yearbook 1991, 2004*

Result: Efficiency improved overtime
Sources of Change: $TEC > SEC \approx FSE$

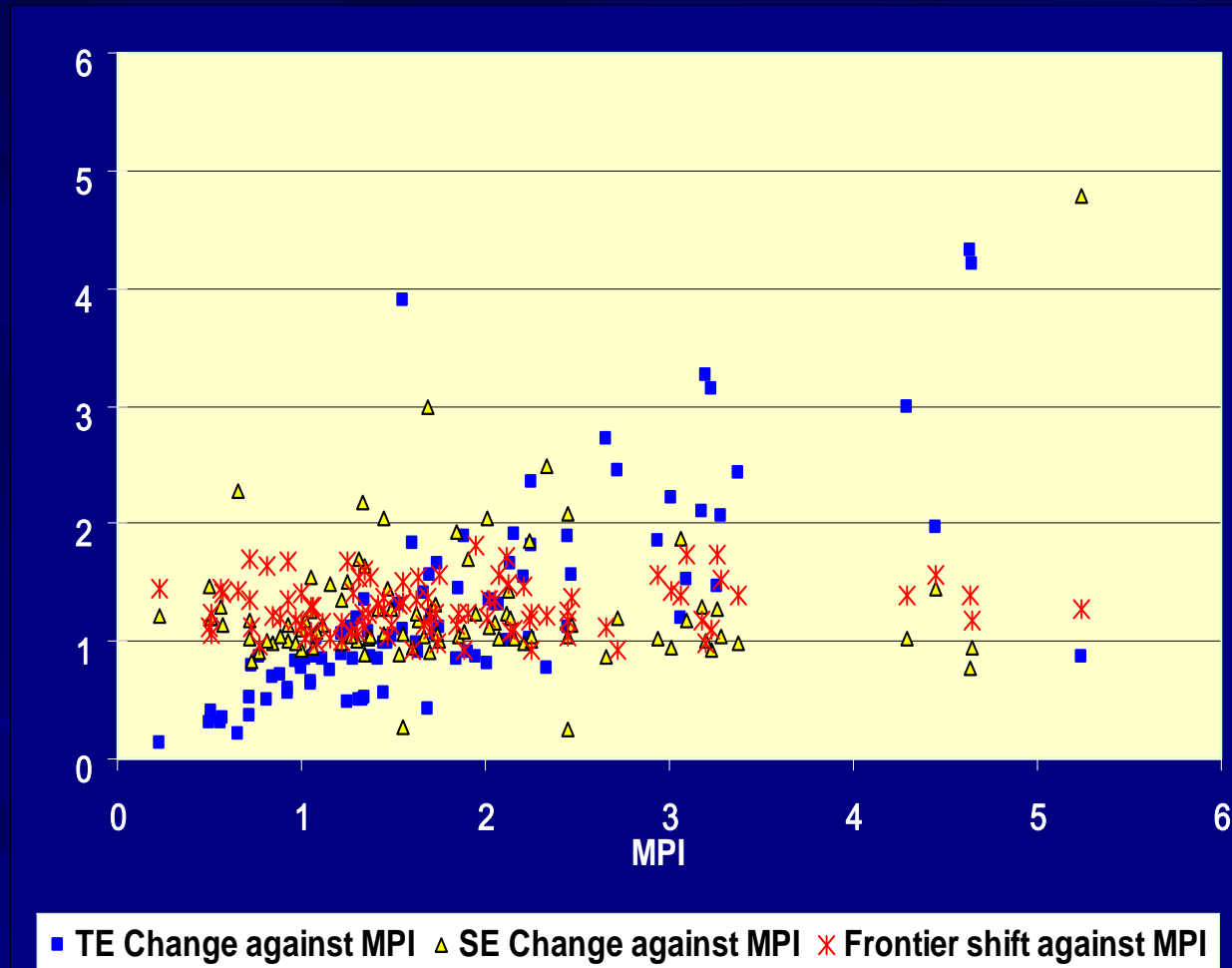


■ Averages for the industry:

$$MPI (1.823) = TEC (1.333) \times SEC (1.262) \times FSE (1.286)$$

Result: Sources of efficiency change (con't)

■ Correlations

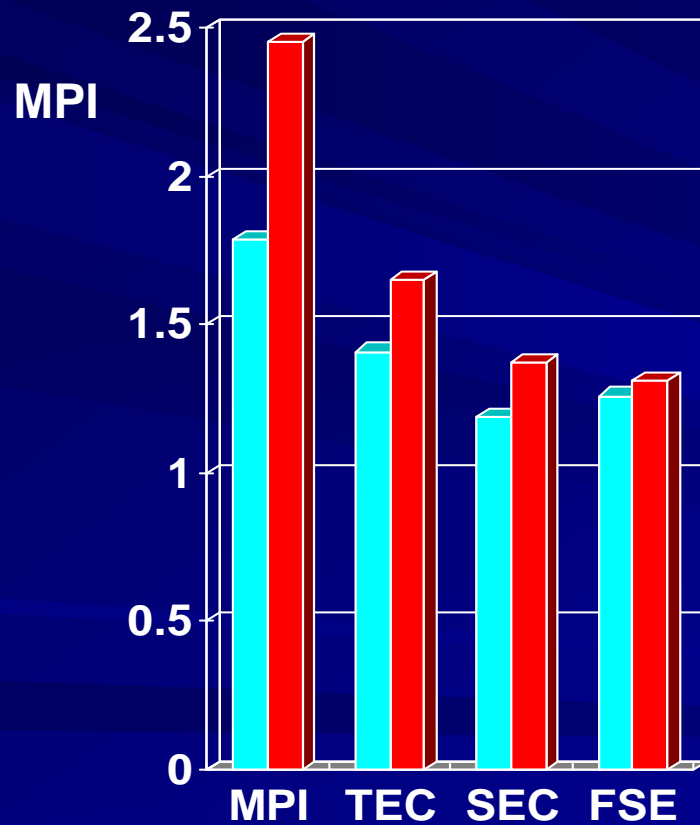


	MPI	TEC	SEC	FSE
MPI	1.00	.59*	.19*	.09*
TEC	.59*	1.00	-.39	-.15
SEC	.19*	-.39	1.00	.01
FSE	.09*	-.15	.01	1.00

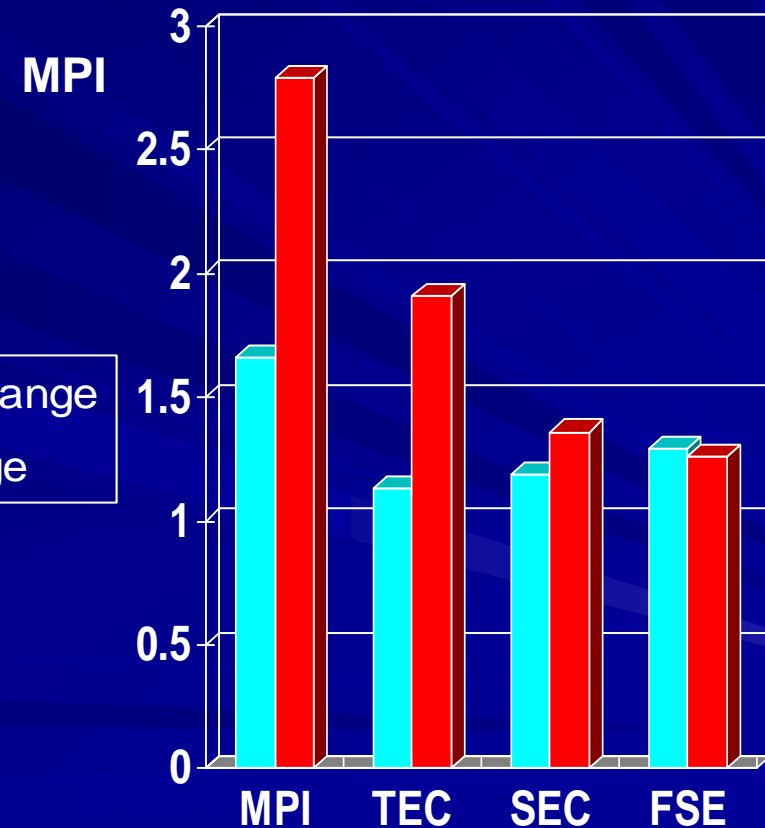
*: Significant at 5%

Ownership disintegration & MPI

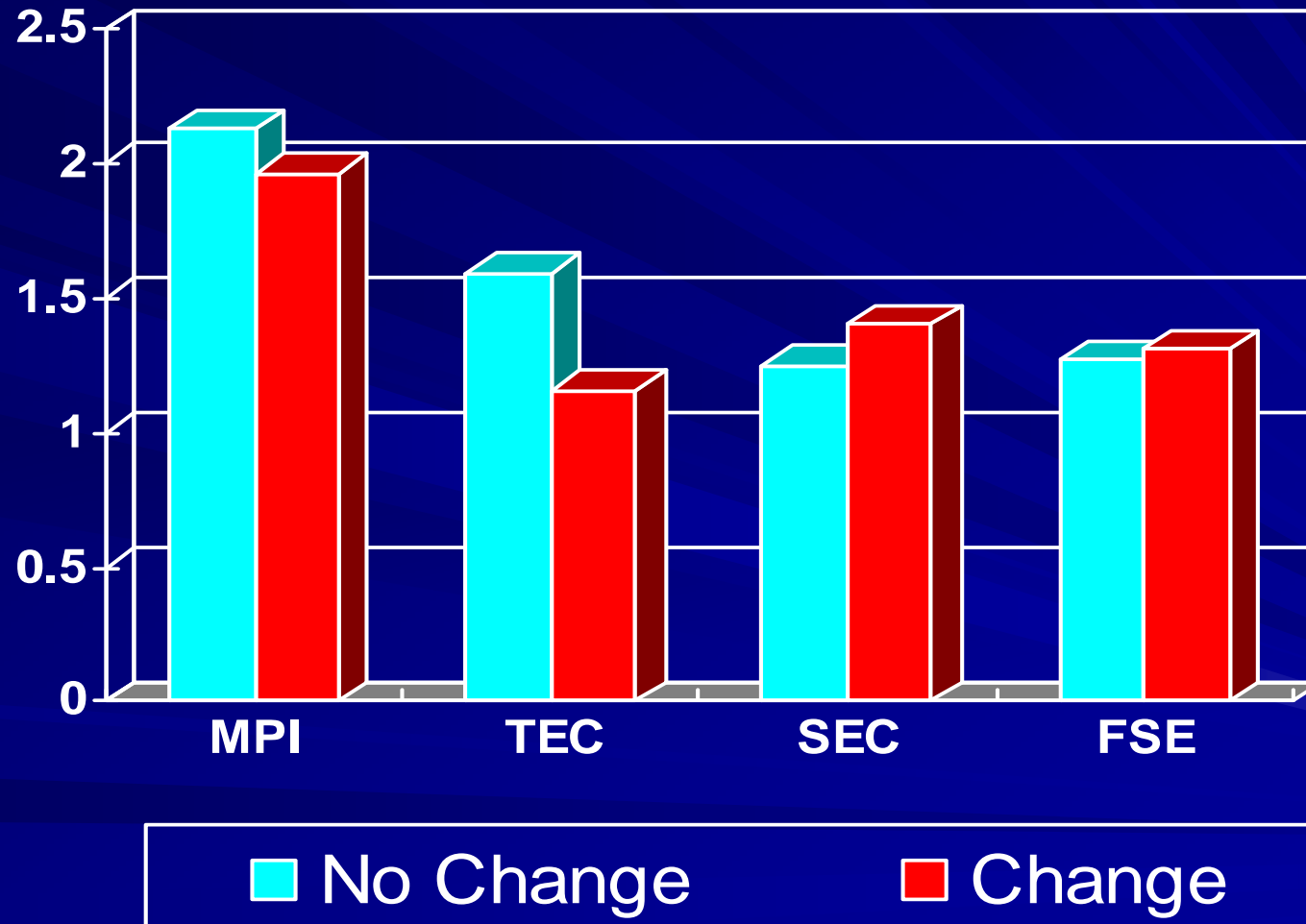
All Ports
(N=98)



Larger ports
(N=63)



Corporate structure devolution & MPI



Conclusions

- How have global seaport institutions evolved over time?
 - Port institutions mirror the historical development of national and regional political structure and economic systems
 - Since new ages of globalization have risen, port policy in different countries has interacted with each other, and therefore ports have assimilated their port managing institutions.
 - While ports in South Asia, Oceania, Northern Europe drive institutional changes, ports in US, Japan and Africa show very little change in port institutional models.

Conclusions (con't)

- Whether have mechanisms of institutional reform efforts changed port efficiency over the last decade?
 - Yes. port policy and management did something to “compensate” limitations due to scale efficiency.
 - But, what really matters are institutional **practice** rather than institutional **structure**.
 - Technical efficiency is important: port reform efforts improved managerial practice
 - Scale efficiency, representing influences from hinterland environments and demand, is still influential, but, not predominant.
 - Capital investment in technology may not be a sufficient but a minimum strategy.

Policy implications

- Diverse public-private partnerships / outsourcing in institutional relationship building
- Strategic asset management
 - Linking to ports' strategic planning
 - Capable of real-time monitoring of port assets
 - Operational efficiency
 - Strategic/Proactive capital investment based on demand projection / SWOT analysis