What Impacts the Productivity of Indian Seaports?

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Motivation

- Seaport reform vital for developing contries in trade integration
- Value added in seaport clusters (de Langen; 2004; p.201):
  - Logistics
  - Manufacturing
  - Trade Activities
- Seaports that perform well add higher value to the surrounding regions
- Seaport performance could be impacted by external factors

Agenda

- Measuring relative performance of Indian central seaports for the time period 1995-96 to 2015-16 (21 years, 11 seaports) with DEA
- Impacts of external factors on performance with a seaports fixed effects regression
  - An economic measure of specialization (Keeble and Hauser HHI) (Keeble and Hauser, 1971)
  - External stakeholder participation
  - Competition between state and central ports at the level of the state, along the coast and from the opposite coast
  - Tariff regulation from a partly independent regulator (Tariff Authority for Major Ports (TAMP))

Previous Research – Impacts of External Factors on Seaport Performance

- Specialization
  - Spanish port authority efficiency positively corrrelated with complexity of port operations (Martinez-Budria et al., 1999)

- Ownership
  - No significant impact of public or private ownership on technical efficiency of container ports (Cullinane et al., 2005a)
  - Ownership restructuring contributes to total factor productivity gains of container ports (Cheon et al., 2010)
  - Public-private partnerships enhance technical efficiency of Brazilian seaports (Wanke and Barros, 2015) and Chinese container ports (Yuen et al., 2013)

Previous Research – Impacts of External Factors on Seaport Performance

- Competition
  - Intra- and inter-port competition has positive technical efficiency impacts on Chinese container ports (Yuen et al., 2013)
  - Inter-port competition has negative impacts on the efficiency growth of Chinese container ports (ibid.)
  - Increasing regional inter-port competition has negative impacts on technical efficiency of container ports (Oliviera and Cariou, 2015)
  - Increasing regional inter-port competition has positive impacts on technical efficiency of European container ports (Merkel, 2018)
- Regulation
  - Proposal of DEA as an incentive regulatory tool in Mexico (Estache et al., 2002), Portugal (Barros, 2003a) and Italy (Ferrari and Basta, 2009)

Technical Efficiency Model – Slacks Based Measure of Efficiency (SBM) (Tone, 2001)

$$Min_{\lambda,s^-,s^+}\ \rho = \frac{\left(1-\frac{1}{\mathrm{m}}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}\right)}{\left(1+\frac{1}{\mathrm{s}}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}\right)}$$

$$s.t.$$

$$x_o = X\lambda + s^-$$
$$y_o = Y\lambda - s^+$$
$$e\lambda = 1$$
$$\lambda \geq 0,\ s^- \geq 0,\ s^+ \geq 0$$

$\rho \rightarrow Technical\ efficieny\ score, (0 < \rho \leq 1)$
$X \rightarrow Input\ matrix$
$Y \rightarrow Output\ matrix$
$e \rightarrow A\ vector\ with\ all\ elements\ equal\ to\ 1$
$\lambda \rightarrow A\ non-negative\ vector\ of\ weights$
$x_o \rightarrow Input\ vector\ of\ DMU\ o$
$y_o \rightarrow Output\ vector\ of\ DMU\ o$
$s^- \rightarrow Input\ excess$
$s^+ \rightarrow Output\ shortfall$
$\mathrm{m} \rightarrow$ Number of inputs
$\mathrm{s} \rightarrow$ Number of outputs
$x_{io} \rightarrow Input\ i\ of\ DMU\ o$
$y_{ro} \rightarrow Output\ r\ of\ DMU\ o$
$s_i^- \rightarrow Excess\ in\ input\ i$
$s_r^+ \rightarrow Shortfall\ in\ output\ r$

Data for SBM of Technical Efficiency

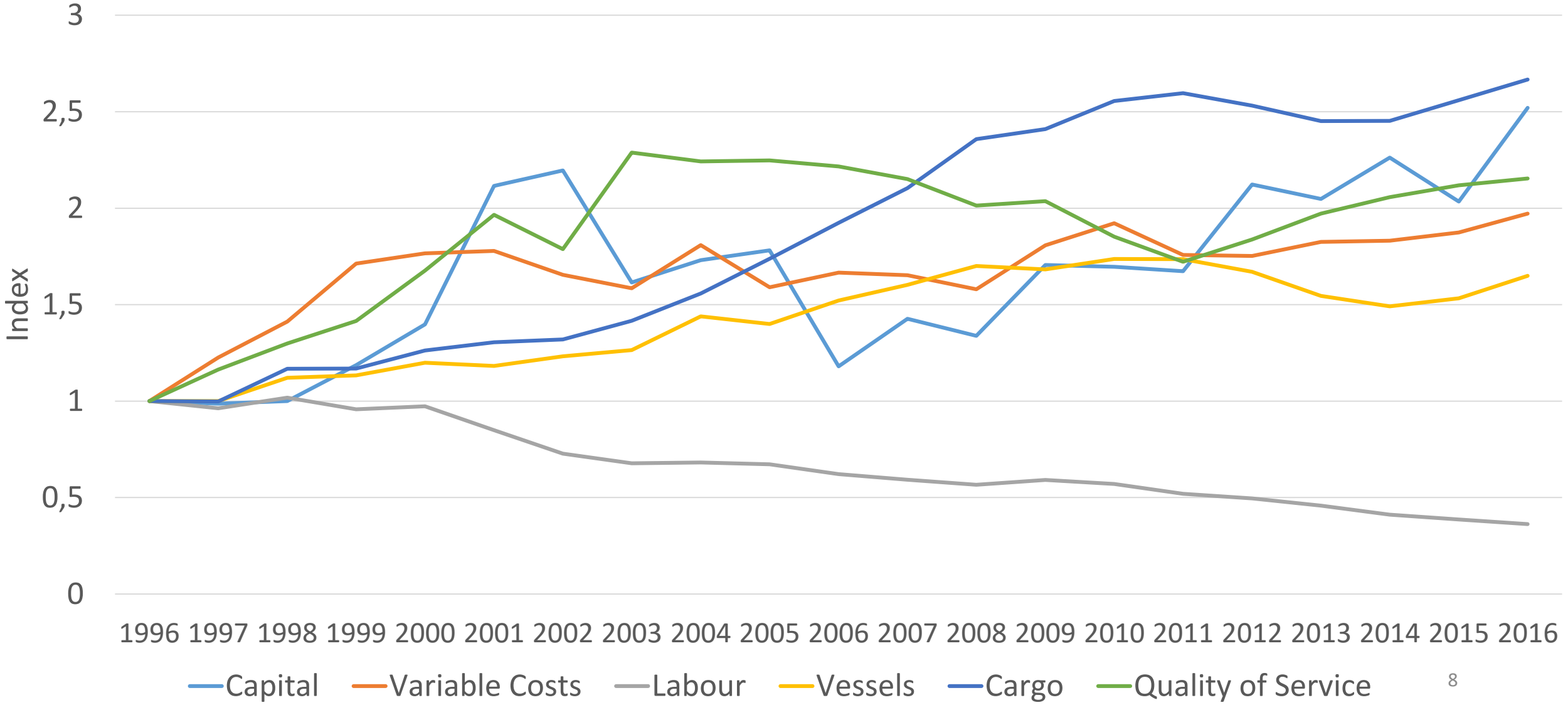
	Factor	Description	Unit	Mean	Std. Dev.	Min.	Max.
Inputs	Capital	Depreciation of the port authority's assets plus the finance and miscellaneous expenditure	Rs. Crore*	95	84	9	398
	Variable Costs	Operating expenditure minus the depreciation of the port authority's assets minus the expenses on salaries and wages	Rs. Crore*	91	76	5.4	405
	Labour	Number of non-cargo handling officers and workers	Count	4,039	3,783	686	20,019
Outputs	Vessels	Total number of vessels handled	Count	1,668	748	414	3,681
	Cargo	Total volume of cargo handled	Million Tonnes	36	19	6.9	100
	Quality of Service	Reciprocal of the average turnaround time	$Days^{-1}$	0.27	0.11	0.067	0.63

Observations: 230

* All monetary measures are in crores of Rupees, which have been adjusted with the wholesale price index (WPI) with FY96 as the base year in order to account for inflation

All data gathered from the annual publication of the Indian Ports Association

General Trends



Inputs and Outputs

Model	Inputs	Outputs
A	Capital	Vessels
	Variable Costs	Cargo
	Labour	Quality of Service
B	Capital	Vessels
	Variable Costs	Cargo
	Labour	

Seaport Fixed Effects Regression

- $Eff_{it} = \alpha_i + \beta_1 Spec_{it} + \beta_2 O_{it} + \beta_3 CompState_{it} + \beta_4 CompCoa_{it} + \beta_5 CompOppCoa_{it} + \beta_6 Reg_t + \beta_7 Time_t + \mu_i + \epsilon_{it}$
- $Eff_{it} \rightarrow Technical\ efficiency\ of\ seaport\ i\ at\ time\ t$
- $\beta_1\ to\ \beta_7 \rightarrow Coefficients\ of\ the\ independent\ variables\ that\ are\ estimated\ in\ the\ model$
- $Spec_{it} \rightarrow Keeble\ Hauser\ HHI\ of\ seaport\ i\ at\ time\ t$
- $O_{it} \rightarrow External\ stakeholder\ participation\ in\ seaport\ i\ at\ time\ t$
- $CompState_{it} \rightarrow Competition\ within\ state\ for\ seaport\ i\ at\ time\ t$
- $CompCoa_{it} \rightarrow Competition\ along\ coast\ for\ seaport\ i\ at\ time\ t$
- $CompOppCoa_{it} \rightarrow Competition\ from\ opposite\ coast\ for\ seaport\ i\ at\ time\ t$
- $Reg_t \rightarrow TAMP\ regulatory\ guidelines\ introduced\ at\ time\ t$
- $Time_t \rightarrow Annual\ time\ period\ dummy\ for\ time\ t$
- $\alpha_i \rightarrow Time\ invariant\ intercept\ for\ seaport\ i$
- $\mu_i \rightarrow Time\ invariant\ error\ component\ of\ seaport\ i$
- $\epsilon_{it} \rightarrow Idiosyncratic\ error\ term\ of\ seaport\ i\ in\ time\ period\ t$

Variables for Second Stage Regression Models

- Eff_{it}- Derived from the first stage VRS SBM of TE
- $Spec_{it}$
  - $Spec_{it} = \sqrt{\sum_{k=1}^{4}(s_i^k)^2}$
  - $s_i^k = \frac{x_i^k}{\sum_{k=1}^{4} x_i^k}$
  - x represents the cargo handled in a port within each of four types k and k is divided into dry bulk, liquid bulk, break-bulk and container cargo
- O_{it}- Three levels of external stakeholder participation at the level of the berth
  - Between 0 and 33%
  - Between 33 and 66%
  - Above 66%
- $Comp_{it}$
  - $Comp_i = \sum_{j=1}^{n-i-c} \frac{CarHan_j}{d_{ij}}$
  - $Comp_{it}$ calculated within state, along coast and from opposite coast
  - Measures normalized by the standard deviation of the sample
- Reg_t- Seven levels with the date of publishing of a certain set of TAMP guidelines
  - Internal regulation
  - 1998
  - 2003
  - 2005
  - 2008
  - 2013
  - 2015

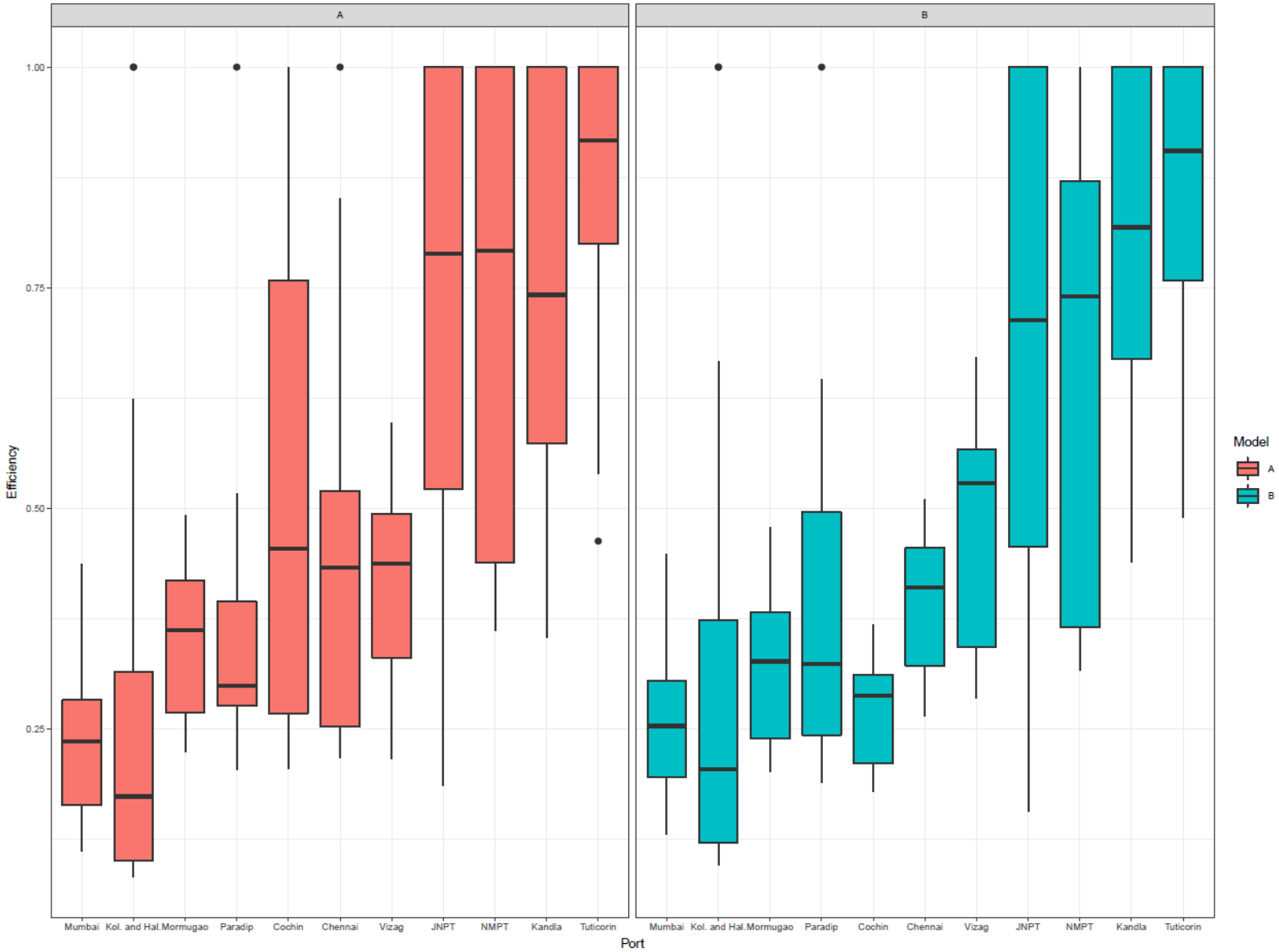
Data for Second Stage Regression Models

Variable	Mean	Std. Dev.	Min.	Max.
Specialization	0.74	0.11	0.54	0.96
Competition within State	0.46	1	0	5.51
Competition Along Coast	0.75	1	0	4.47
Competition from Opposite Coast	0.69	1	0	3.77

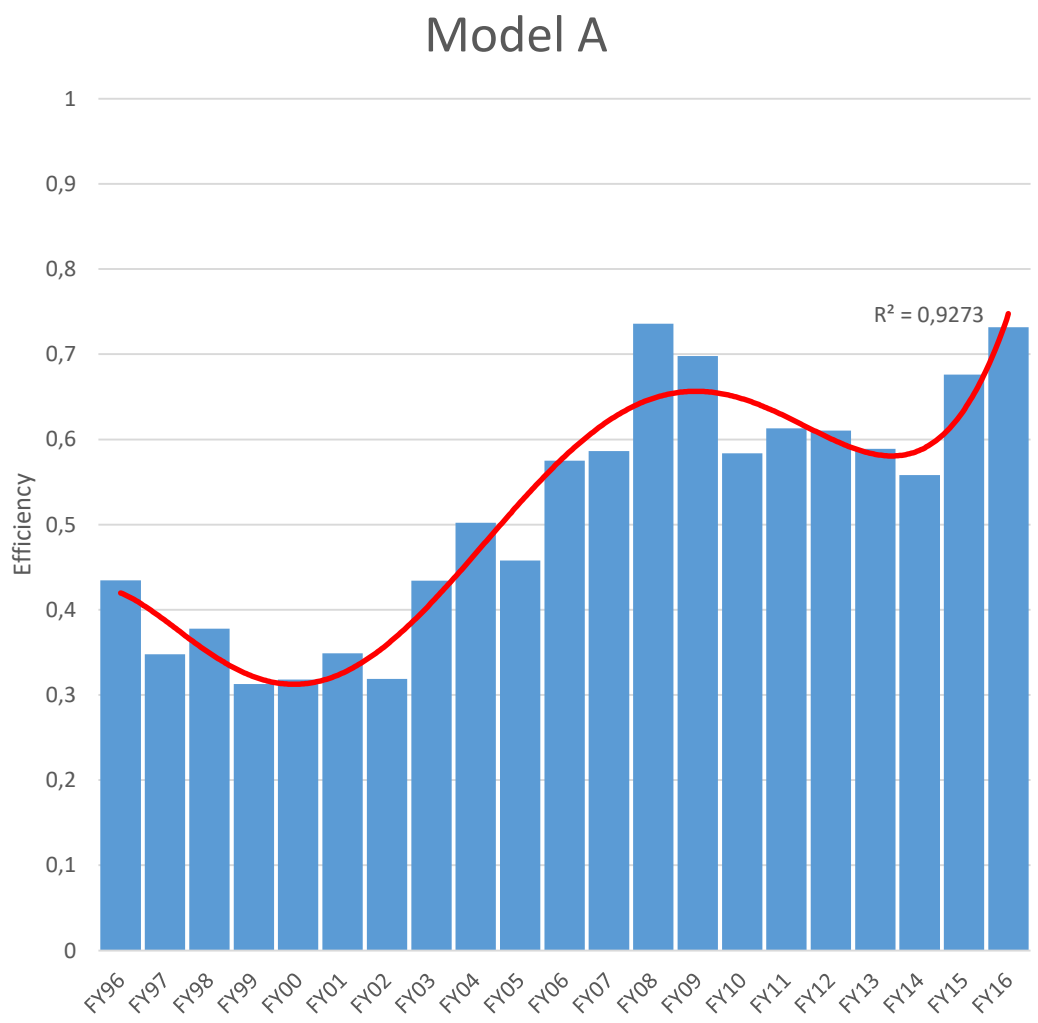
Regulation	Number of Observations
Internal Regulation	30
TAMP 1998	48
Modified TAMP 1998	22
TAMP 2005	32
TAMP 2008	54
TAMP 2013	22
TAMP 2015	10

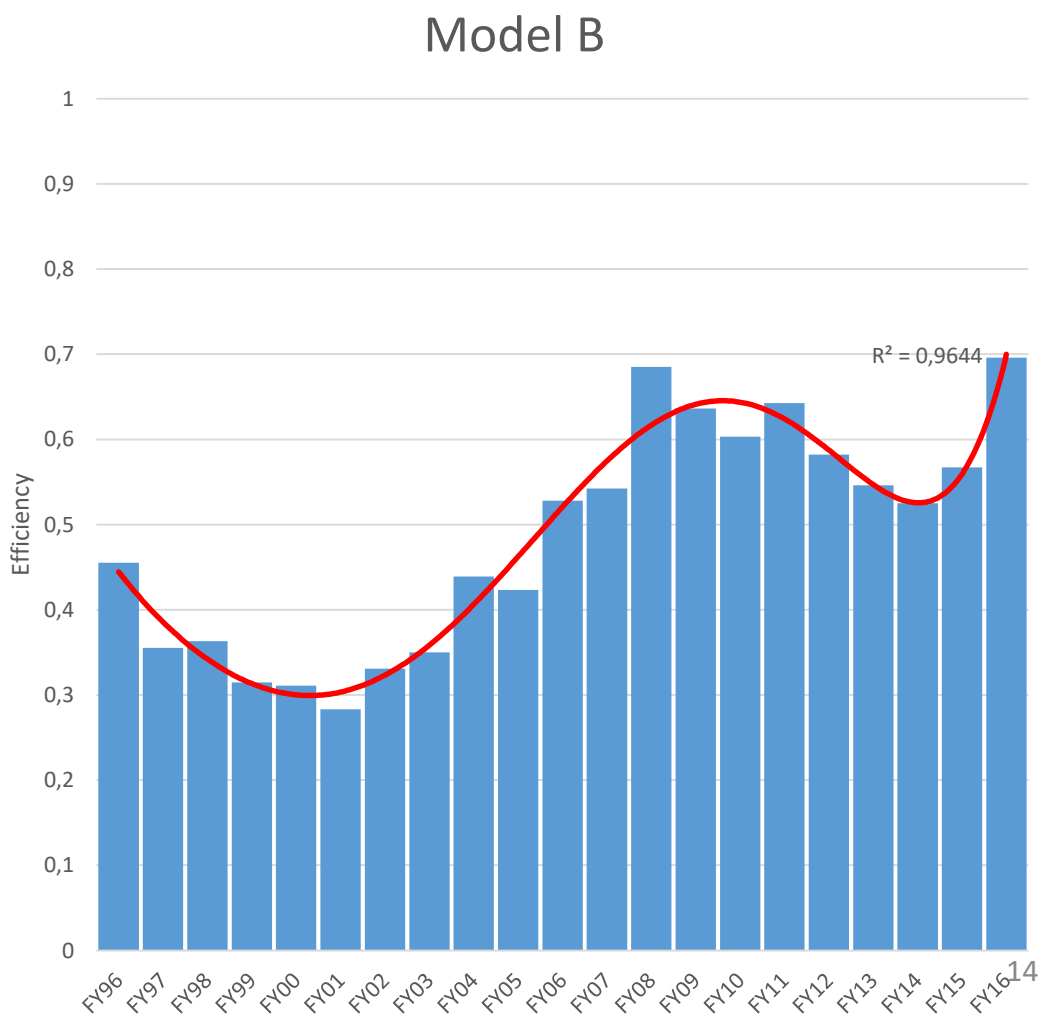
Ownership	Number of Observations
0 to 33%	161
33 to 66%	53
Above 66%	4

SBM of Technical Efficiency



Average Yearly SBM of Technical Efficiency





Seaports Fixed Effects Regression Results

	Dependent Variable	
	Efficiency Model A	Efficiency Model B
Specialization	**0.731****	**0.934*****
	(0.305)	(0.250)
Ext. Ownership 0 to 33%	**Base Case**	
Ext. Ownership 33 to 66%	**0.228*****	0.081
	(0.073)	(0.059)
Ext. Ownership Above 66%	**0.334*****	0.171*
	(0.114)	(0.093)
Competition State	**-0.052*****	**-0.048*****
	(0.020)	(0.016)
Competition Coast	**-0.101****	**-0.081****
	(0.041)	(0.033)
Competition Opposite Coast	-0.050	-0.012
	(0.031)	(0.025)

	Dependent Variable	
	Efficiency Model A	Efficiency Model B
Internal Regulation	**-0.145****	-0.100*
	(0.073)	(0.060)
TAMP 1998	**-0.189*****	**-0.141****
	(0.071)	(0.058)
Modified TAMP 1998	**Base Case**	
TAMP 2005	**0.222*****	**0.228*****
	(0.071)	(0.058)
TAMP 2008	**0.270*****	**0.242*****
	(0.090)	(0.073)
TAMP 2013	**0.449*****	**0.351*****
	(0.110)	(0.090)
TAMP 2015	**0.495*****	**0.433*****
	(0.112)	(0.091)
Observations	217	218
R^2	0.506	0.555
Adjusted R^2	0.407	0.466
F Statistic	7.082*** (df = 26; 180)	8.683*** (df = 26; 181)
Note	* p<0.1; ** p<0.05; *** p<0.01	

Conclusion

- Gradual increase in efficiency of the seaports from around 40 % to around 70% over the time duration considered
- Specialization has a significant positive impact on performance
- External stakeholder participation have significant positive performance impacts only when the quality of service is included as an output in the DEA
- Competition from state ports have significant negative performance impacts within the state and along the coast
- Cost based regulation by a partly independent regulator is more performance inducing than when the ports are internally regulated
- Regulation of competition for the market has had positive performance impacts
- The upfront tariff fixation policy has had positive impacts on performance
- Wholesale price indexing of tariffs and the inclusion of performance compliance terms for tariff escalations have significant positive impacts on performance

Vielen Dank!

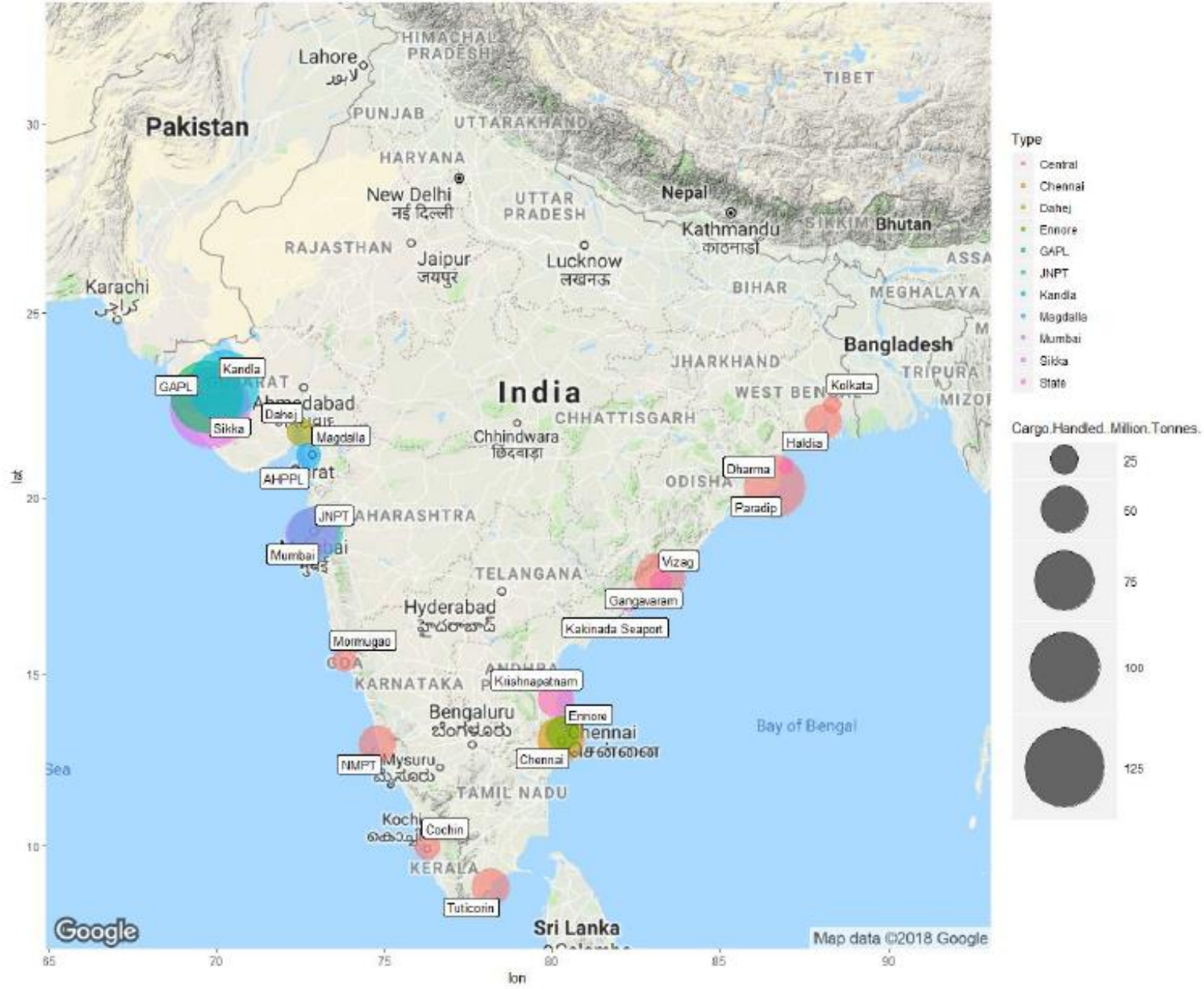
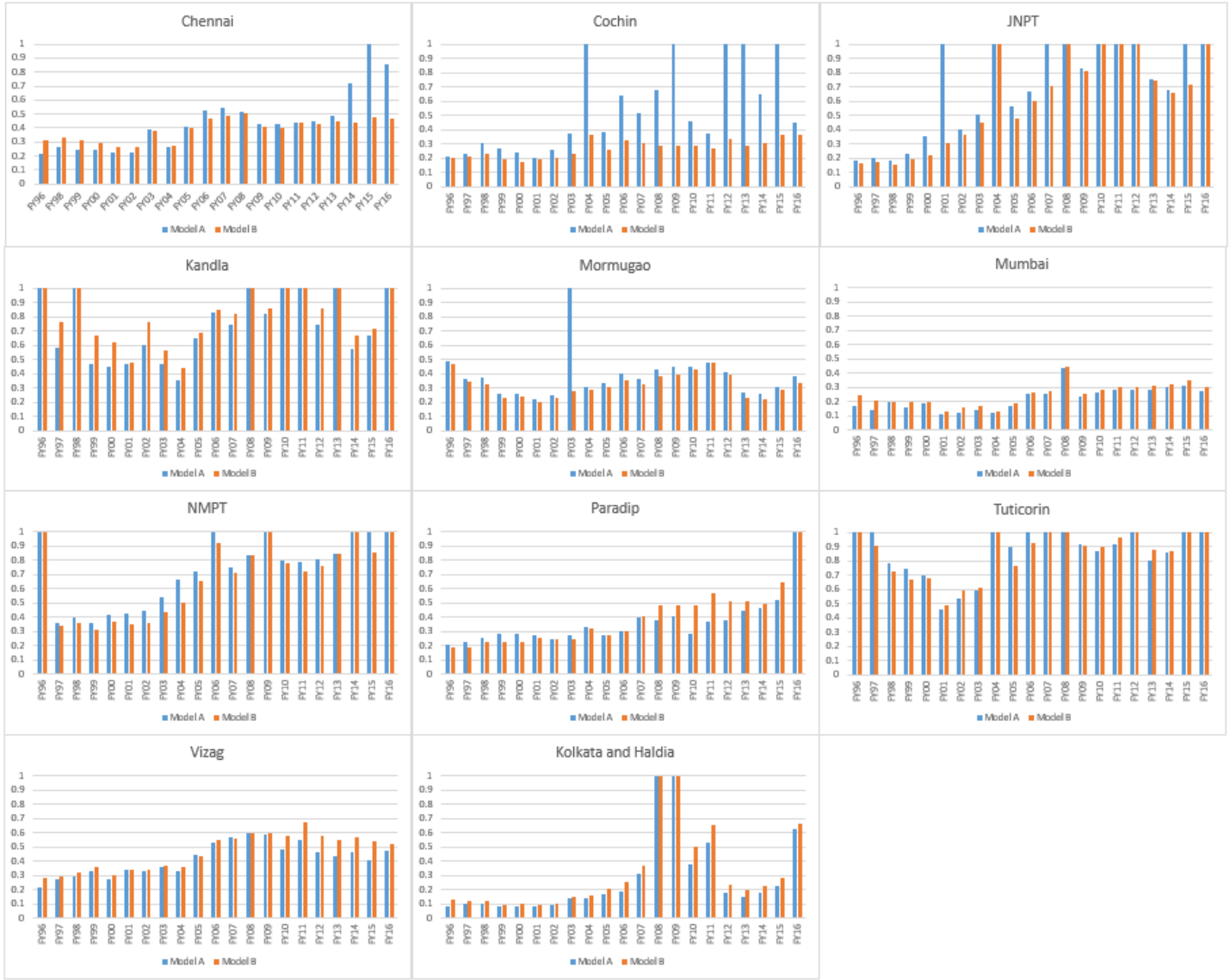


Figure 1: Prominent Ports in India (A Snapshot for financial year 2015-2016)
Data Source: Major Ports of India. A Profile: 2015-2016; Indian Ports Association (2017)
Map made using ggmap and ggplot2 packages in R (Kahle and Wickham; 2013)

Annual Seaport Efficiency Scores



Time Effects

	Dependent Variable	
	Efficiency Model A	Efficiency Model B
FY96	0.076 (0.070)	0.114** (0.057)
FY97	-0.027 (0.072)	0.004 (0.059)
FY99	-0.010 (0.069)	0.003 (0.056)
FY01	-0.022 (0.070)	-0.022 (0.057)
FY02	0.018 (0.068)	0.029 (0.056)
FY03	0.070 (0.088)	0.025 (0.072)
FY04	0.026 (0.068)	0.001 (0.056)
FY06	-0.106 (0.071)	-0.124** (0.058)
FY07	-0.091 (0.070)	-0.100* (0.057)
FY09	-0.066 (0.083)	-0.066 (0.068)
FY10	-0.066 (0.073)	0.017 (0.060)
FY11	0.033 (0.069)	0.103* (0.057)
FY12	0.011 (0.068)	0.029 (0.056)
FY14	-0.165** (0.071)	-0.105* (0.057)

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