



Electricity Sector Reforms: Evidence from Non-OECD Asia



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Overview

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1. Introduction

- **Electricity reforms pioneered in the OECD (UK, US, Norway) and Chile (1980/90s onwards)**
 - *Targeted at improving efficiency & passing on the gains to consumer prices*
 - *Implemented against backdrop of excess capacity and strong institutions*
- **‘OECD Model’ replicated in Less Developed Countries (LDCs)**
 - *1990s onwards; implemented against backdrop of chronic power deficits, limited access, weak institutions, complex political context: ‘institutional heterogeneity’*
- **Current debates over electricity reforms**
 - *In OECD: whether they deliver effective competition and low carbon systems*
 - *In LDCs: whether efficiency gains have materialised; have had positive economic, and welfare impacts*

- **Main research question in this paper**
 - *Have electricity reforms in LDCs (non-OECD Asia) led to the anticipated outcomes from the OECD ('textbook' or 'standard') Model of reform?*
- **Fills a gap in the reform literature**
 - *Assesses the impact of reforms on non-OECD Asian countries*
 - *Draws link between electricity reform and: (1) sector (technical) performance, (2) economic impacts, and (3) welfare indicators*
 - *Applies instrumental variable econometrics to a new panel data of 17 countries from 1990-2013, and controlling for institutional & political contexts*

2. Electricity Reform in Non-OECD Asia

- **The ‘standard/textbook’ OECD model**
 - *Enactment of reform legislation*
 - *Unbundling & corporatisation of vertically integrated state-owned utilities into competitive (G & S) and regulated natural monopoly (T&D, system operation)*
 - *IPPs in generation*
 - *Establishment of independent regulation*
 - *Divestiture or privatisation of competitive functions*
- **Nuanced implementation in non-OECD countries**
 - *IPP schemes - Badly-managed initially (India, Pakistan), while others evolved to adapt to investment risks (Malaysia, Singapore)*
 - *Open/third party access - Implemented in a minority of countries, limited to large consumers; state utilities’ concerns over revenue loss*
 - *Regulators not truly independent - Failure to adopt cost-reflective pricing and limit state-utilities’ market power*
 - *Political economy / institutions influenced implementation & outcomes*

Standard Model of Reforms in Non-OECD Asia

	Corporatisation	Unbundling	IPPs	Regulator	Open/Third Party Access	Distribution Privatisation
Bangladesh	X	X	X	X		
Bhutan	X	X	X	X		
Brunei				X		X
China	X	X	X	X		
India	X	X	X	X	X	X
Indonesia	X	X	X		X	
Laos			X			
Malaysia	X	X	X	X		
Maldives	X		X	X		
Myanmar			X	X		
Nepal	X	X	X	X		
Pakistan	X	X	X	X		
Philippines	X	X	X	X	X	X
Singapore	X	X	X	X	X	X
Sri Lanka			X	X		
Thailand	X	X	X	X	X	
Vietnam	X	X	X	X		

3. Empirical Research on Electricity Reforms in LDCs - Limited

<p>Sector Performance & Efficiency</p>	<ul style="list-style-type: none"> • Cubbin & Stern (2004;2006): Positive outcomes of reform on sector performance and efficiency for 28 developing countries over 21 years. • Nagayama (2010): Reforms (IPPs, unbundling, regulation and wholesale markets) led to lower T & D losses in 83 developed & developing countries from 1985-2002 • Erdogdu (2014): Reforms led to higher self-sufficiency in 55 developed & developing countries over 35 years. However, they also led to a decline in R&D. • Hattori and Tsutsui (2004): Impact of reforms on a set of performance measures with mixed results. Use regulatory reform indicators, country-specific effects & controls. 	<ul style="list-style-type: none"> • Panel OLS • Fixed effects • Fixed effects; Random effects • Fixed effects
<p>Economic Surpluses from Efficiency Gains</p>	<ul style="list-style-type: none"> • Nagayama (2009): Higher electricity prices drive liberalisation, but liberalisation does not necessarily reduce prices; 78 developed & developing countries from 1985-2003. • Sen & Jamasb (2012): Prices increases in early stages of reform; 19 Indian states over 16 years. • Erdogdu (2013): No conclusive impact of reforms on price-cost margins or cross-subsidy levels; 63 developed & developing countries over 27 years. • ESMAP (2011): Vertical unbundling reduced prices by 10%; independent regulation increased electricity access; 22 LDCs from 1989-2009. • Balza et al. (2013): Privatisation is robustly associated with improvements in quality and efficiency, but not access. Use a 'polity index'. • Jamasb et al. (2005): Distribution of efficiency gains contingent upon strength of regulatory framework. 	<ul style="list-style-type: none"> • Ordered response • Fixed & random effects • Bias-corrected Least Squares • Bias-corrected Least Squares • Panel OLS • Panel GLS • Meta-review
<p>Distributional Impact & Welfare Indicators</p>	<ul style="list-style-type: none"> • Sen & Jamasb (2012): Reforms had a net positive impact on state level GDP; 19 Indian states, 16 years. • Vu & Gurtoo (2014): Economically extrapolate links between utility sector reform, socioeconomic development & poverty reduction; 5 countries over 1990-2008. • Nepal & Jamasb (2012): effectiveness of reform related to wider institutional indices of governance, finance and infrastructure for 27 transition countries. • Khandker et al. (2012): Electrification on household income - reforms do not improve access without infrastructure investment; cross-section household survey data for India. 	<ul style="list-style-type: none"> • Bias-corrected Least Squares • Growth decomposition frameworks • Maximum Likelihood probit models

4. Hypotheses

- **H1: Reforms in non-OECD Asian countries have reduced technical losses** (sector performance & efficiency)
- **H2: Reforms in non-OECD Asia have had positive impact on economic growth** (economic surplus from efficiency gains)
 - H2.1: Reforms have led to positive impacts on GDP
 - H2.2: Reforms have led to positive impacts on net electricity trade
- **H3: Reforms in non-OECD Asia have had positive impact on consumer welfare** (distributional/welfare impact)
 - H3.1: Reforms have led to positive impacts on inequality
 - H3.2: Reforms have led to positive welfare impacts

5. Data and Variables

	Dependent Variable	Explanatory Variables	Control Variables
H.1 Technical Impact	Per capita T&D losses	Individual reform scores	Per capita electric power consumption; transparency index
H.2 Economic Impact	1. Per capita GDP	Individual reform scores	Per capita total installed capacity, per capita electricity consumption, transparency index
	2. Per capita electricity trade	Individual reform scores	Per capita total installed capacity (minus hydro), per capita hydro installed capacity, per capita electricity consumption, transparency index
H.3 Welfare Impact	1. Gini coefficient	Individual reform scores	Per capita electric power consumption, transparency index
	2. Human Development Index	Individual reform scores	Per capita electricity consumption; transparency index

Variable Label	Variable Name	Units
Dependent Vars.		
ptdl	Per capita T&D energy losses	Percentage
pgdp	Per capita GDP	US\$
trade	Per capita electricity trade	Percentage
hdi	Human Development Index	Score
gini	GINI coefficient	Score between 0 and 1
Explanatory Vars.		
trfms*	Total reforms index	Score out of 6
ipps	IPPs	0/1
reg	Regulator	0/1
unb	Unbundling	0/1
corp	Corporatisation	0/1
oa	Open/Third Party Access	0/1
dprv	Distribution privatisation	0/1
pepc	Per capita electric power consumption	kWh
trpi	Transparency index	Composite index
pre	Per capita total installed capacity	KW
poic	Per capita installed capacity (minus hydro)	KW
phic	Per capita hydro capacity	KW
pr	Political freedom (Freedom House Index)	Score 1-7
cl	Civil liberties (Freedom House Index)	Score 1-7
popn	Population	Millions

Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
lpgdp	3.70	0.54	2.09	4.90	408
lptdl	10.88	0.48	9.54	12.06	408
lphic	4.12	1.71	0.00	6.59	408
lpre	5.24	0.63	3.77	6.41	408
ltrade	0.24	0.73	-1.40	1.96	408
lgini	1.58	0.07	1.44	1.80	82
lhdi	-0.18	0.29	-0.46	2.88	131
pr	4.85	1.81	2.00	7.00	408
cl	4.76	1.21	3.00	7.00	408
ipps	0.78	0.42	0.00	1.00	408
reg	0.38	0.48	0.00	1.00	408
unb	0.37	0.48	0.00	1.00	408
corp	0.57	0.50	0.00	1.00	408
oa	0.13	0.34	0.00	1.00	408
dprv	0.16	0.36	0.00	1.00	408

Correlations

	l.pgdp	l.ptdl	l.phic	l.pre	l.trade	l.gini	l.hdi	pr	cl	ipps	reg	unbldg	corp	otp access	dprv
L.PGDP	1														
L.PTDL	0.73	1													
L.PHIC	0.66	0.82	1												
L.PRE	0.76	0.89	0.65	1											
L.TRADE	0.19	0.05	0.18	0.08	1										
L.GINI	0.45	0.37	0.17	0.59	0.13	1									
L.HDI	0.58	0.50	0.39	0.69	-0.08	0.58	1								
PR	-0.22	0.01	0.05	0.16	0.24	-0.05	0.19	1							
CL	-0.27	-0.01	0.08	0.13	0.12	-0.08	0.23	0.91	1						
IPPS	-0.13	-0.10	-0.08	-0.09	0.02	-0.37	0.09	0.13	0.05	1					
REG	0.06	0.19	0.17	0.00	-0.04	-0.01	0.08	0.13	0.01	0.23	1				
UNBLDG	0.06	0.08	0.08	-0.11	-0.10	-0.08	-0.04	-0.20	-0.21	0.30	0.60	1			
CORP	0.29	0.21	0.18	0.02	-0.19	0.18	-0.03	-0.52	-0.50	-0.10	0.36	0.73	1		
OTPACCESS	0.55	0.41	0.21	0.39	-0.01	0.15	0.18	-0.56	-0.56	0.14	-0.08	0.29	0.34	1	
DPRV	-0.05	0.30	0.10	0.08	-0.20	0.10	-0.09	-0.42	-0.42	0.08	0.33	0.25	0.19	0.27	1

6. Method-Model Selection

1. **Unbalanced panel of 17 cross sections 1990-2013; country-specific unobserved factors present**
 - Fixed effects LSDV estimators can deal with unobserved heterogeneity in cross sections as individual effects may be correlated with explanatory variables
 - However, LSDV models bias estimates when T is small (Judson & Owen, 1999)

2. **The alternative: Bias-corrected LSDV estimator devised by Kiviet (1995) and adapted to unbalanced panels by Bruno (2005)**
 - LSDVC estimators operate under strict exogenous selection rule, but we cannot rule out endogeneity in the regressors

3. **Some consistent IV and GMM estimators as alternatives to LSDVC**
 - We run an OLS (LSDV) model as our *benchmark model*
 - We then run 2SLS and GMM estimators both to ensure consistency of results
 - ✓ We use instrumented variable regression using STATA routine *ivregress* – fits a linear regression of *depvar* on *varlist₁* and *varlist₂* using *varlist_{iv}* (along with *varlist_{1i}*) as instruments for *varlist₂*.
 - ✓ Can fit one equation of a multiple–equation system, without specifying the functional form of the remaining equations

Estimation

1. The model estimated:

$$y_{it} = Y_{it}\beta_1 + x_{1it}\beta_2 + u_{it} \quad \text{Structural equation} \quad (1)$$

$$Y_{it} = x_{1it}\Pi_1 + x_{2it}\Pi_2 + v_{it} \quad \text{First-stage equation} \quad (2)$$

- y_i is the dependent variable for the i th observation, Y_i are the endogenous regressors, x_{1i} and x_{2i} are the instruments and u_i and v_i are zero-mean error terms, and correlations between u_i and the elements of v_i are presumably non-zero

2. Pre-estimation procedures reveal collinearity and endogeneity problems with ‘trfms’ and ‘oa’. Choice of instruments guided by cross-correlations among the regressors

- As we are interested in impact of individual reform measures, we drop ‘total reforms index’, and treat ‘open access’ as endogenous
- Literature shows influence of political factors on effectiveness of open access to deliver competition. So, we instrument the ‘open access’ variable using an index of political reform (pr) and civil liberties (cl) by Freedom House (<https://freedomhouse.org/reports>)
- Correlation between ‘distribution privatization’ and ‘political reform/civil liberties index’ indicates the latter are correlated with ‘open access’ but uncorrelated with the error term

3. Apart from additional exogenous variables specified, other exogenous variables in regression equation are automatically used as instruments

(<http://www.stata.com/manuals13/rivregress.pdf>)

Post-Estimation

1. **We log transform all variables apart from 'total reform index' and 'individual reform measures'**
 - Marginal changes in the explanatory variables are interpreted in terms of multiplicative (percentage) changes in the dependent variable
 - However, we focus on the direction of causality as we aim to investigate high-level impact of reforms, as opposed to precise magnitude of the effects
2. **Our results are robust to heteroscedasticity**
3. **We report the R^2 statistic, although the estimator suppresses it in reporting of results in some cases or reports a low statistic**
 - Note that R^2 has no statistical meaning for IV regression
4. **We carry out two post-estimation tests to validate the robustness of results:**
 - Test of endogeneity - Tests whether endogenous regressors in the model are exogenous. For GMM estimation, the test is reported through the C statistic (Hayashi, 2000). For 2SLS, through Wooldridge score test (Wooldridge, 1995) and regressions-based test (Durbin, 1954; Wu, 1973; Hausman, 1978)
 - **We find presence of Endogeneity**
 - Test of over-identifying restrictions - Checks the validity of the instruments based on firststage regressions. For the GMM estimation, it is reported through F statistic while for 2SLS, it is reported through eigenvalue statistic
 - **We find validity of our instruments**

Post-Estimation Tests

Variables	GMM		2SLS	
	Endogeneity (Ho = variables are exogeneous)	Validity	Endogeneity (Ho = variables are exogeneous)	Validity (Ho = Instruments are weak)
LPGDP	(5.12)**	(41.43)***	(3.4)*	(49.16)***
LHDI	(4.98)**	(21.74)***	(3.72)*	(22.6)***
LGINI	(5.32)**	(12.4)***	(21.54)***	(13.65)***
LPTDL	(5.066)**	(17.60)***	(3.7)*	(19.47)***
LTRADE	(23.86)***	(31.47)***	(21.64)***	(46.40)***

7. Results

- Size of coefficients and std. errors are not very different between the benchmark and IV models.
- But results from IV models are robust to endogeneity
- Within the IV model, results are largely consistent between GMM and 2SLS estimations
- **Overall finding: Power sector reforms in non-OECD Asian economies have not produced the anticipated positive results**

H1: Technical Impacts

	T&D Losses (%) L.PTDL		
	OLS (robust)	IV (GMM)	IV (2SLS)
IPPS	0.109** (0.05)	-0.063 (0.09)	-0.063 (0.29)
REG	0.034 (0.03)	0.100** (0.04)	0.100* (0.05)
UNB	-0.0001 (0.03)	-0.074 (0.05)	-0.073 (0.06)
CORP	-0.133*** (0.03)	-0.143*** (0.03)	-0.143*** (0.04)
OA	0.0006 (0.03)	0.276** (0.13)	0.276* (0.16)
DPRV	0.163*** (0.03)	0.009 (0.08)	0.009 (0.09)
L.PEPC	0.64*** (0.05)	0.62*** (0.05)	0.62*** (0.04)
L.TRPI	0.050 (0.12)	-0.024 (0.13)	-0.024 (0.13)
_CONS	3.31*** (0.62)	3.82*** (0.62)	3.82*** (0.53)
R ²	0.82	0.79	0.79
N	235	235	235

- Corporatisation is associated with pos. effect on T&D losses (literature shows mixed results)
- Regulation associated with neg. effect on T&D losses
- Open Access associated with neg. effect of T&D losses
- Higher per capita electricity consumption associated with neg. effect on T&D losses

H2: Economic Impact

	L.PGDP				L.TRADE		
	OLS (robust)	IV(2SLS)	IV(GMM)		OLS (robust)	IV(2SLS)	IV(GMM)
IPPS	-0.340*** (0.07)	-0.381*** (0.10)	-0.381*** (0.12)	IPPS	-0.332** (0.12)	-0.017 (0.27)	-0.017 (0.29)
REG	0.074** (0.03)	0.090** (0.04)	0.090* (0.05)	REG	0.062 (0.08)	-0.056 (0.11)	-0.056 (0.23)
UNB	-0.163*** (0.03)	-0.181*** (0.05)	-0.181*** (0.04)	UNB	-0.080 (0.07)	0.064 (0.14)	0.064 (0.12)
CORP	0.045 (0.04)	0.045 (0.04)	0.045 (0.04)	CORP	-0.080 (0.07)	-0.107 (0.09)	-0.107 (0.07)
OA	0.118*** (0.03)	0.183 (0.13)	0.183 (0.14)	OA	0.418*** (0.11)	-0.041 (0.33)	-0.041 (0.29)
DPRV	0.016 (0.03)	-0.020 (0.08)	-0.020 (0.09)	DPRV	-0.246*** (0.10)	-0.022 (0.18)	-0.022 (0.16)
L.PRE	-0.097 (0.11)	-0.093 (0.07)	-0.093*** (0.10)	L.POIC	-1.483*** (0.09)	-1.400*** (0.10)	-1.400*** (0.11)
L.TRPI	0.567*** (0.13)	0.549*** (0.11)	0.549*** (0.14)	L.PHIC	-0.040** (0.01)	-0.041** (0.10)	-0.041** (0.10)
L.PEPC	0.510*** (0.12)	0.499*** (0.07)	0.499*** (0.11)	L.PEPC	1.416*** (0.13)	1.392*** (0.12)	1.392*** (0.13)
_CONS	-1.700* (0.88)	-1.557*** (0.58)	-1.557*** (0.83)	L.TRPI	-0.160 (0.25)	-0.046 (0.26)	-0.046 (0.28)
				_CONS	-8.573*** (1.15)	-8.953*** (1.05)	-8.953*** (1.08)
R²	0.87	0.86	0.86	R²	0.68	0.64	0.64
N	235	235	235	N	235	235	235

H2: Economic Impact

- **H2.1 GDP Per Capita**

- IPPs have a negative effect
- Unbundling has a negative effect
- Regulation has a positive effect
- Higher per capita consumption have a positive effect
- Better institutions (*TRPI*) have a positive effect

- **H2.2 Electricity Trade**

- Individual reform measures have no significant impact
- 'Per capita installed capacity less hydro' and 'hydro capacity' have negative significant impact
- Electricity trade in non-OECD countries low in general, and any trade has been bilateral, through high level cooperation
- Trade not dependent on quality of institutions

H3: Welfare Impact

	L.GINI				L.HDI		
	OLS (robust)	IV(GMM)	IV(2SLS)		OLS (robust)	IV(GMM)	IV(2SLS)
IPPS	0.121*** (0.035)	0.882*** (0.268)	0.103 (0.080)	IPPS	0.108 (0.137)	-0.343 (0.38)	-0.343 (0.512)
REG	-0.022 (0.014)	-0.151** (0.07)	-0.015 (0.026)	REG	-0.003 (0.032)	0.149 (0.166)	0.149 (0.193)
UNB	-0.009 (0.016)	0.125* (0.068)	-0.007 (0.027)	UNB	0.086 (0.117)	0.017 (0.064)	0.017 (0.15)
CORP	0.001 (0.018)	-0.028 (0.036)	0.001 (0.021)	CORP	-0.042 (0.055)	-0.103 (0.117)	-0.103 (0.175)
OA	-0.012 (0.015)	-0.168* (0.095)	0.002 (0.047)	OA	-0.120 (0.126)	0.329 (0.388)	0.329 (0.426)
DPRV	0.057* (0.033)	0.131** (0.061)	0.05* (0.03)	DPRV	-0.065 (0.057)	-0.348 (0.367)	-0.348 (0.294)
L.PEPC	0.031 (0.025)	0.038 (0.027)	0.028 (0.022)	L.PEPC	0.140 (0.086)	0.117* (0.067)	0.117 (0.117)
L.TRPI	0.265*** (0.08)	0.698*** (0.267)	0.255*** (0.079)	L.TRPI	0.296 (0.205)	0.105 (0.203)	0.105 (0.466)
_CONS	0.966*** (0.265)	-	1.02*** (0.27)	_CONS	-2.05* (1.13)	-1.32** (0.54)	-1.32 (1.45)
R ²	0.48	-	0.47	R ²	0.124	-	.
N	59	59	59	N	75	75	75

H3: Welfare Impact

- **H3.1 Gini Coefficient**

- Literature postulates and finds a relationship between infrastructure development & reduction of income inequality. To do so, electricity reform must improve access and quality particularly for low income households
- Different reform measures have had different impacts on the Gini.
 - IPPs associated with high Gini
 - Regulator is associate lower income disparity in non-OECD Asia
 - Open access reduces income disparity
 - Distribution privatisation associated with higher income inequality (prices often rise in LDCs when average costs are below marginal costs at the outset)
- Transparency index associated with worsening income inequality (analytically intractable)

- **H3.2 Human Development index**

- Evidence is weak at best – no significant impact of reforms on HDI
- Two decades of reform in non-OECD Asia have failed to yield clear welfare improvements

Summing Up

Explanatory Vars.		Sector Efficiency	Economic Benefit	Welfare Effect
trfms	Total reforms index			
ipps	IPPs		-	-
reg	Regulator	+	+	+
unb	Unbundling		-	
corp	Corporatisation	-		
oa	Open/Third Party Access	+		+
dprv	Distribution privatisation			-
Pepc	Per capita electric power consumption	+	+	+
Trpi	Transparency index		+	-
Poic	Per capita installed capacity (minus hydro)			-
phic	Per capita hydro capacity			-

8. Conclusions

We investigated the proposition that reforms lead to: (i) technical efficiency, (ii) economic growth, and (iii) welfare

- **Different reform steps have different effects on the above 3 outcomes**
- **Results show a tension between efficiency, economic, and welfare outcomes**
- **Standard reforms, without reference to country heterogeneities, is unlikely to have resulted in the anticipated outcomes**
- **Institutional factors have influenced the reform outcomes in the non-OECD Asia**

Thank You Very Much for
Your Attention!!!