Have Model, Will Reform: Assessing the Outcomes of Electricity Reforms in Non-OECD Asia

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ABSTRACT

Non-OECD Asian economies comprise about 34% of world primary energy demand, 60% of population and 65% of the world's poor, and will account for more than 60% of the total increase in energy consumption between 2015 and 2040. Energy sector reforms in non-OECD Asia are thus significant for global energy use, sustainability and socio-economic welfare. The region has experienced a slow and difficult reform path and after more than two decades of reform efforts it is time to take stock of their outcomes. Using a novel dataset assembled for this purpose for the period 1990–2013 for 17 non-OECD Asian countries, we apply instrumental variables regression techniques to several electricity sector reform outcome models. We find that the standard reform model has had limited benefits, largely due to sectoral heterogeneity and institutional endowments. We also show empirical evidence of the theoretical trade-offs between technical efficiency, economic and welfare objectives of reforms. The results call for rethinking of the effectiveness of reforms and awareness of the effects of key reform steps on different outcomes. This is useful for balancing the trade-offs among competing reform objectives.

Keywords: market liberalisation, electricity restructuring, development, welfare

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1. INTRODUCTION

The energy sector is currently undergoing worldwide introspection, following more than two decades of a trend towards liberalised markets in electricity provision. While partly related to the growing adoption of renewables, this is also concerned with the effectiveness of the original or 'standard model' of electricity reforms, which was pioneered in the 1980s and 1990s by OECD economies—the UK, Norway, Chile and the US. These reforms were aimed at improving the efficiency of the sector, implementation of cost-reflective pricing based on competitive wholesale and retail markets and incentive regulation of distribution and transmission networks (Pollitt, 2004; Joskow 1998; Newbery, 2005).

The standard model, designed to move away from electricity provision by vertically integrated state-owned monopolies, typically comprised a set of measures, including (Sen, 2014; Gratwick and Eberhard, 2008; Joskow, 2008; Victor and Heller, 2007): (i) enactment of electricity reform legislation; (ii) opening the sector to private generation companies or Independent Power Producers (IPPs); (iii) corporatisation and unbundling of vertically integrated state-owned utilities into competitive (generation and retail supply) and regulated natural monopoly (distribution,

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transmission and system operation) functions and commercialisation of these; (iv) establishment of independent regulatory authorities; and (v) divestiture or privatisation of the sector.[1]

The standard model spread to non-OECD Asian developing countries through a demonstration effect, largely predicated on multilateral lending programmes, but was intended to serve rather different goals from the developed economies. In the latter, it was targeted at market-oriented restructuring to improve technical and economic efficiency, and pass on welfare gains (e.g., through lower prices) to consumers. In non-OECD countries, the standard model was adopted to resolve distributional issues[2], with governments assuming that market-oriented reforms would pass efficiency gains to consumers (Jamasb et al., 2017). Further, reforms were implemented against the backdrop of electricity shortages, weak institutions, and complex political factors. In contrast, the OECD countries enjoyed relatively stable economic and institutional conditions.[3]

Consequently, the viability of the standard model for the heterogeneous institutional contexts of developing countries is debatable (Sen, 2014; Nepal and Jamasb, 2012a, 2012b; Gratwick and Eberhard, 2008; Williams and Ghanadan, 2006; World Bank, 1993). Whilst in the OECD, the scrutiny over reforms relates to their suitability in delivering low-carbon systems (Keay, 2009; Keay et al., 2013), in non-OECD Asia it pertains to whether reforms have delivered the expected technical and efficiency gains, and whether these have translated into welfare gains for consumers. These issues merit a comprehensive empirical analysis of electricity reforms in developing Asia, focusing on the gap between anticipated and actual outcomes. The data set assembled is suitable for a focused study of the region and reduces the effect of omitted variables relative to a global study of reforms.

This paper seeks to address the following questions: to what extent has the standard model of electricity reforms in non-OECD Asia delivered the expected technical, economic and welfare gains? And, to what extent have the heterogeneous country-contexts in these countries influenced the reform outcomes? The answers to these questions have implications for electricity reforms in developing economies, and the literature: first, this is the first paper to empirically assess the multi-dimensional impacts of key electricity reform steps in non-OECD Asia—a region central to future world energy use. Second, it applies econometric techniques to a new and original panel dataset of 17 non-OECD Asian countries from 1990 to 2013, allowing for cross-country comparisons whilst controlling for institutional and political contexts. Third, it contributes to the reform literature by extending the literature, which has hitherto largely focused on partial analysis of technical impacts, and to some extent on economic impacts, to the welfare and distributional impacts of reform.

The next section summarises the electricity reform experience in non-OECD Asia. Section 3 discusses the reform literature and presents the hypotheses. Section 4 describes the methodology and data, followed by the results in Section 5. Section 6 concludes.

2. ELECTRICITY REFORMS IN NON-OECD ASIA

This paper focuses on non-OECD Asian countries, for four key reasons. First, electricity reforms in the majority of these countries were initiated in the late 1990s (Jamasb et al., 2017), providing a clear starting timeframe for analysis. In contrast, the first wave of electricity reforms in other non-OECD regions such as Latin America was initiated in the 1980s.[4] In many non-OECD

1. With some exceptions—e.g., Norway (Bye and Hope, 2005).
2. E.g., expanding electricity (capacity) provision and extending basic access.
3. Corruption and patronage were prevalent in energy sectors of non-OECD countries (Victor and Heller, 2007).
4. Non-OECD Latin America has achieved 97% electrification, whereas in South Asia this is at 80%, indicating that energy related welfare issues have a different relevance in either region (WDI, 2017).

Table 1: Status of Electricity Reforms in Non-OECD Asia

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

*Open access has been implemented to varying degrees; mainly confined to large consumers (>1 GW).
Source: Authors

Asian countries (e.g., Bangladesh, Pakistan, India, Indonesia, Thailand, Philippines), reforms were undertaken as part of Structural Adjustment Programmes linked to multilateral financial lending, providing a common starting context. Second, although the pace of reforms has differed, the electricity sector in non-OECD Asia has been characterised by the same underlying problems of inefficiency, below-cost pricing, high technical and commercial losses, and weak institutions. Third, the 17 non-OECD countries in our analysis[5] account for 34% of world primary energy demand, 60% of population and around 65% of the world's poor (IEA, 2014). Non-OECD Asia alone will account for more than 60% of the total increase in energy consumption between 2015 and 2040, with power generation needing to grow by 115% over 2015 levels to reach 17,835 Terawatt-hours (TWhs),driven by India and China which will collectively constitute 3.2 billion consumers by 2040 (EIA, 2017; IEA, 2016). Electricity reforms in non-OECD Asia thus have significant implications for global energy use, sustainability and socioeconomic welfare. Finally, our regional focus is supported by evidence that reform measures are influenced by region-specific institutional contexts. For instance, Eberhard et al. (2016) argue that while IPP projects in Asia have faced significant hurdles, in Sub-Saharan Africa they have been relatively successful in bringing investment into the power sector.

Table 1 depicts electricity reforms in the 17 countries in our dataset against the main milestones of the standard reform model (Gratwick and Eberhard, 2008; Joskow, 2008). The IPPs were regarded in the early 1990s as a quick way to introduce competition into electricity generation. They transferred some risks to utilities and in some cases to consumers (through higher tariffs) through 'take-or-pay' clauses in contracts. While some countries (e.g., Malaysia and Singapore) evolved to adapt to this risk, many struggled to harness IPPs to fit with their fiscal and institutional contexts. In India and Pakistan, the inability of utilities to recoup higher IPP tariffs from consumers who paid

5. The 17 countries are: Bangladesh, Bhutan, Brunei Darussalam, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. Our sample was constrained by the availability of data.

prices below cost led to renegotiations and cancellations in the 1990s (Mukherjee, 2014; Kessides, 2013). Regulations enabling third party access to networks in the 2000s meant that IPPs offered an alternative to inadequate public-sector investments through the auctioning of low-cost supplies.[6]

Contextual events have frequently affected IPP projects in Asia. For example, the Philippines in the 1990s contracted IPPs for about 40% of generation capacity, as did Indonesia (Wu and Sulistiyanto, 2013). However, following the Asian financial crisis a spate of renegotiations uncovered allegations of patronage in the awarding of IPPs in both countries (Henisz and Zelner, 2002; Wu and Sulistiyanto, 2013). Similarly, political upheaval stalled IPPs in Thailand (Wu, 2005a). In smaller countries, Laos, Bhutan and Nepal have significant hydropower potential, some of which has been developed through IPPs. However, property rights and sovereignty issues have prevented progress (Strahorn, 2011).[7] In China, the lack of grid integration meant that despite early entry of IPPs, capacity surpluses could not reach the deficit regions, making investments susceptible to regional supply and demand fluctuations (Wu, 2005b). The reorientation of multilateral financing towards clean energy has stalled IPPs in newly hydrocarbon-rich countries such as Bangladesh and Myanmar. Singapore is among the few non-OECD Asian countries to have liberalised its market, incorporating IPPs. However, oversupply and high gas take-or-pay clauses drove market prices down to short-run marginal cost, deterring new investments (Somani and Lim, 2014). Improvements in market design, such as setting up a futures market, were undertaken to resolve this issue.

The establishment of electricity sector regulators occurred around the early to mid-2000s, with 15 out of 17 countries (Indonesia and Laos being exceptions) having some type of regulator. However, in most cases these agencies are not truly independent from government. In countries where reform is lagging, the main issue faced by regulators relates to reforming tariffs to reflect costs (e.g., India and Pakistan). China has aimed at consolidating electricity regulation with other energy-related sectors to 'protect other objectives such as health and safety, and environmental and consumer protection' (Ngan, 2010).

Where markets have developed, issues include market power, in many cases exercised by state-owned companies; e.g., in Thailand the regulator is tasked with 'promoting competition' while contradictorily 'supporting' the position of previously dominant state-owned enterprises (Wisuttisak, 2012). In the Philippines, the regulator has struggled with politicised tariffs and market power exercised by government utilities (Santiago and Roxas, 2010). However, the literature on market power is mostly with reference to markets in developed economies with limited relevance to the markets of non-OECD countries (see, e.g., Wolak, 2003; Borenstein, 2003; Bigerna et al., 2016). Developing countries have tended to aim for competition for the market arrangements than competition in the market and very few can claim the existence of effective competition in their markets.

In smaller import-dependent countries such as Maldives, the regulator plays a critical role in the country's trade balance.[8] In Singapore, the regulator has successfully limited market power through regulating 'vesting contracts'—bilateral agreements between generators and market support services licensees[9] which require generation companies to sell a set amount of electricity at a specified price (Chang and Li, 2013). This limits the incentive for large generators to exercise market power via capacity withholding during scarcity periods to push up wholesale spot prices (Chang and Li, 2013).

6. In many countries this was from coal, which ensured lower tariffs but had adverse environmental impacts.
7. Indian investment in Nepal's hydro infrastructure faced public protests over the acquiescing of sovereignty.
8. Maldives aims to achieve carbon neutrality in energy by 2020 (MMEE, 2010).
9. Which provide metering and billing services to consumers (Chang and Li, 2013).

Unbundling involves the structural and functional separation of the sector into potentially competitive (generation and retail) and regulated (distribution and transmission) functions. While unbundling implies 'accounting or legal separation', corporatisation implies the commercialisation of unbundled entities or their incorporation as businesses under Company Law—mandating economically motivated (as opposed to politically motivated) decisions. Although most countries have implemented unbundling and corporatisation, the public sector still dominates and in many cases, the finances of distribution companies have not improved. Although the logic of reforms implies that unbundling follows corporatisation, actual experience has varied. Brunei, Laos, Myanmar and Sri Lanka retained vertically integrated public-sector monopolies. They have relatively small power systems and Nepal and Jamasb (2012b) argue that in small systems, the creation of an independent regulator may be more effective than unbundling, particularly for politically less-stable countries and where hydropower is dominant. Several countries corporatized prior to unbundling, often several years after corporatization (China, Philippines, Vietnam) (Dupuy et al., 2015).

Open/third party access to the grid is a critical enabling factor of reform, as it facilitates competition. First, consumers of public sector utilities are permitted to opt out of receiving supply from those utilities. Second, consumers as well as private sector generation and distribution are able to access network infrastructure. Open access has been implemented in just 5 countries, with obstacles. In India, the main impediment has been the imposition of 'surcharges' by public utility companies on large industrial users to compensate for the loss of revenue.[10] In Indonesia, the state company PLN remains the sole owner of transmission and distribution assets with priority rights under the law to conduct its business. In Thailand, despite open access, public companies operate geographically segregated oligopolies and have majority shares in private generation companies (Wisuttisak, 2012). In Singapore, however, retail market liberalisation was carried out in two phases beginning in 2003, and roughly 80% of (contestable) demand is exposed to retail choice.

Brunei, India, Philippines and Singapore have privatised distribution networks. Singapore is the most advanced, with seven electricity retailers and the Market Support Services Licensee (MSSL) competing for (contestable) retail consumers. Privatisation in the Philippines' distribution sector resembles a switch from public to private monopoly, as the National Power Corporation controls the majority of electricity production through direct ownership shares in generation companies or long-term contracts with IPPs (Blank et al., 2012). In Brunei, the Berakas Power Management Company is a private limited company that owns and operates distribution substations and networks. In India, distribution has been privatised in two states: Orissa's 1996 World Bank reform was carried out without restructuring or financial reform, and did not lead to the anticipated efficiency gains; Delhi's 2002 reform was deemed relatively successful as the bids were awarded based on promised reductions in commercial and technical losses, and sharing the gains with consumers.[11]

3. LITERATURE AND HYPOTHESES

3.1 Theoretical Underpinnings

The economic rationale for electricity reform has its foundations in microeconomic theory and industrial organisation, in which a key objective is the maximisation of economic welfare. Standard theory suggests that welfare is maximised under perfect competition, as it drives prices (P) down to marginal cost (MC); in contrast, monopoly leads to a deadweight loss. This rationale has

10. Industrial consumers cross subsidise agricultural consumers; hence in the absence of a tariff reform, open access has serious financial consequences for public utilities (Jamasb and Sen, 2013).

11. Delhi is a special case as it is a predominantly urban state with no agricultural consumers.

evolved with technological advancements in the sector. Prior to OECD reforms in the 1980s/90s, the industry was seen as best organised around increasing returns to scale and cost efficiencies to be realised by a monopoly market structure.[12] Under private ownership, a profit-maximising monopolist charges $P>MC$, resulting in a deadweight losses, and hence governments instituted public ownership assuming state-owned companies would not maximise profits, improving consumer welfare (Steiner, 2000).

The regulated public monopoly model also enabled pursuit of welfare policies, such as income distribution and universal service goals.[13] However, the risk of regulatory capture by interest groups (e.g., political constituents), led governments to direct public monopolies to set prices close to variable costs of production, constraining their return, and preventing them from making investments. This adversely affected quality and access to services, increasing the fiscal burden on the government[14] and defeating the original purpose of state-owned provision (Armstrong and Sappington, 2006). The lack of strong institutions compounded these effects and has indeed been the experience in most non-OECD Asian countries.

Technological advancements reduced the minimum efficient scale of operation, enabling the functional decomposition of the industry (Steiner, 2000), which provided the momentum towards reform and building blocks of the standard model. Replacing regulation with competition could increase operational efficiency[15] (Newbery, 1996; Steiner, 2000) with positive effects on output and economic activity (Mohanty, 2015), and market liberalisation was seen as facilitating competition. Armstrong and Sappington (2006) argue that the greatest gains from competition tend to arise when industry scale economies are limited relative to consumer demand; the industry regulator has limited information, limited resources and limited instruments with which to craft policy; the regulator's commitment powers are limited; and, subsidisation of some of the dominant supplier's services is not critical or can be achieved by means other than through the price structure—e.g., through replacing universal subsidies with targeted direct cash transfers.[16]

Privatisation was not necessary to engendering competition, as some countries (e.g., Norway) implemented competitive reform under public ownership (Newbery, 2006); however, relative to monopoly, private companies' focus on lowering costs could generate a higher surplus within a competitive market structure (where $P=MC$), and thus be welfare-enhancing for consumers. The removal of entry barriers was seen as crucial to enhancing competition. But as the industry proceeds towards greater competition, market power may shift from being exercised through pricing to being exercised through capacity, and it was argued that regulation should be replaced with anti-trust oversight authorities (Armstrong and Sappington, 2006). Theory postulates that there are instruments that could engender greater competitiveness in the transition towards 'full' competition (e.g., a system of auctioning (or bidding) franchises may capture much of the surplus for consumers).

Three arguments emerge from the theoretical rationale underpinning electricity reforms:

- Reforms are expected to lead to gains in operational efficiency in the sector,

12. As the number of consumers supplied by a utility increased, reserve margin requirements decreased because the grouping of heterogeneous consumers pooled the risk faced by the supplier, avoiding duplicative fixed costs (Steiner, 2000; Armstrong and Sappington, 2006).

13. A private profit-maximising monopolist would have a preference for serving low-cost areas which exclude more expensive to serve, unconnected consumers in rural areas (Armstrong and Sappington, 2006).

14. If, e.g., the government compensates the company through the national budget.

15. A wealth of literature exists on this, covering aspects such as the Averch-Johnson effect (Steiner, 2000).

16. E.g., financial support might be provided directly to the poorer groups of consumers; replacing implicit subsidies with explicit subsidies to those with the greatest need (Armstrong and Sappington, 2006).

- Gains from reform have a positive effect on output and economic activity, and
- Reforms are expected to have a positive impact on consumer welfare.

Theory also explains, to an extent, why the anticipated outcomes may *not* materialise in certain contexts. Under vertically integrated public ownership in countries with weaker overseeing institutions, prices are often set below costs at the outset (i.e. average costs (*AC)* < *MC*), to subsidise poorer consumers through the pricing system—or for reasons of political patronage (Victor and Heller, 2007). Kahn (1979) argues that liberalisation can be welfare-enhancing only when *AC* > *MC*, as competition can drive down system *AC* and potentially final prices. When *AC* < *MC* at the outset, *rising* prices and hence worsening consumer welfare are a more likely early outcome as pricing distortions are corrected. Nevertheless, competition can be welfare-enhancing when combined with payments to worse-off consumers (Armstrong and Sappington, 2006). However, a cash transfer to the worse-off consumers was not a standard element of the early reform programs. This reasoning explains why: (a) the actual outcomes may have differed from anticipated outcomes in the developing countries of non-OECD Asia; and (b) the experience may have varied even between countries in non-OECD Asia, due to vastly differing institutional and economic contexts.

3.2 The Gap in Empirical Literature

The sections above highlight some contextual differences between OECD countries, and non-OECD countries implementing the standard reform model, outlining the need for assessments of outcomes that explicitly take this distinction into account. Jamasb et al. (2017) provide a qualitative review of electricity reforms in developing countries, underscoring this difference. Yet, empirical assessments of reforms have tended to focus on OECD countries, or use mixed panels of developed and developing countries, which obscure the differing contexts against which they have been implemented and limit the interpretation of outcomes.

'Reforms' in the empirical literature are measured against the individual milestones or measures (Table 1) that form the standard model, or against an index combining these measures. The majority of studies have focused on assessing the impact of reforms on operational or technical efficiency, most of which find positive outcomes. The main variable used to model efficiency has been transmission and distribution (T&D) losses, partially due to the consistency of measurement across countries and partially to data availability. Seminal studies include Cubbin and Stern (2004; 2006) which applied OLS regression to panel data for 28 developing countries, concluding that regulation improved per capita generation and installed capacity; Nagayama (2010) which applied fixed effects models to 86 developed and developing countries, concluding that reforms (IPPs, unbundling, regulation and wholesale markets) reduced T&D losses; and Erdogdu (2014) which used panel data on 55 developed and developing countries with fixed and random effects models, concluding that reforms led to higher electricity 'self-sufficiency' (e.g., through better utilisation). A sub-literature on productivity and efficiency analysis of utilities concludes that the distribution of efficiency gains relies on the strength of the regulatory framework (Jamasb et al., 2005; Malik et al., 2015).

A limited number of studies have focused on extending the impact of improved operational efficiency to output and economic activity. Cubbin and Stern (2004; 2006) used panel data for 28 developing countries and 21 years using fixed effects OLS to conclude that regulatory law and higher quality regulatory governance had positive impacts on per capita electricity generation and installed capacity. Sen and Jamasb (2012) used bias corrected least squares regressions on a panel dataset of 19 Indian states spanning 16 years to show that reforms had a net positive impact on state-level GDP. Nepal and Jamasb (2012a) measured the impact of reform indices on economic outcomes

(including installed capacity and per capita GDP) to conclude that positive outcomes were observed only alongside the implementation of wider economic and institutional reforms. Vu and Gurtoo (2014) explore the contributions of the South Asian utility sector to GDP and employment (growth and average labour productivity) using econometric methods.

Very few studies have investigated the impact of reforms upon welfare, in two ways, direct and indirect. Direct studies have focused upon the effects of reforms on electricity prices on the premise that a reduction in prices (e.g., through greater competition) yields higher consumer surplus. Evidence has been mixed. Amongst studies that use a composite index of reform, Sen and Jamasb (2012) in an econometric study on 19 Indian states, find that electricity prices increased in the early stages of reform. Erdogdu (2013) used fixed and random effects models on 63 developed and developing countries over 27 years with no conclusive impact on price-cost margins or cross-subsidy levels. Nagayama (2009) uses ordered response, fixed and random effects models for 78 developed and developing countries from 1985–2003 and concludes that high prices tend to drive liberalisation, but liberalisation does not necessarily reduce prices. Studies that decompose the impact of individual reform steps yield more conclusive results—ESMAP (2011) used panel data for 20 countries, concluding that unbundling and independent regulation reduced prices by 10%. As argued earlier, electricity prices in developing countries may rise, rather than fall, following reforms, due to the *ex-ante* existence of pricing distortions—therefore it is difficult to draw clear observations on welfare from this measure.

The second (indirect) channel pertains to the *wider welfare improvements* through electricity provision—such as access and knock-on effects on income and socioeconomic development, which is relevant to Asian developing country contexts, and has been under-explored. ESMAP (2011) uses panel data for 20 developing countries to show that independent regulation increased electricity access substantially. Khandker et al. (2012a; 2012b) use maximum likelihood probit models to examine the impact of electrification on household income. Vu and Gurtoo (2014) extend to socioeconomic development and poverty reduction. Jamasb et al. (2017) argue that most welfare studies consist of qualitative case studies combined with social cost-benefit analysis at the utility level, or micro level single-country cross-sectional household survey data.

Lopez (2003), Estache (2003) and Calderon and Severn (2004) establish links between infrastructure and welfare improvements, which have been applied to electricity and questions around access by Brenneman and Kerf (2002), Leipziger et al. (2003) and Khandker et al. (2012a). In order for infrastructure expansion to reduce income inequality, it must improve access and/or enhanced quality particularly for low-income households. Lee et al. (2016) find evidence from Africa that social welfare consequences of rural electrification are closely tied to organisational performance and economic and political institutions. Household electrification in their study is seen to reduce social welfare, due to leakages, bureaucratic red tape, low grid reliability and household credit constraints.

A final area of empirical work pertinent to this paper is the effect of country characteristics—resource endowments and institutional heterogeneity—on reform outcomes, which should be a critical consideration of any reform programme. Weinmann and Bunn (2004) show how industry structure and resource endowment of a country affect the feasibility of reform; Nepal and Jamasb (2012a) relate the effectiveness of reforms to wider institutional indices of governance, finance, and infrastructure for a panel of 27 transition economies; Erdogdu (2013) investigates the impact of political economy on the electricity reform process for 55 developed and developing economies; and Balza et al. (2013) utilise a 'polity' index capturing relative autocracy or democracy for 18 Latin American countries and use Generalised Least Squares (GLS) estimations to conclude that

privatisation is robustly associated with improvements in quality and efficiency, but not with access, whereas regulatory quality is strongly associated with better quality and access.

This paper contributes to the literature in three ways: it is the first study to assess the impacts of electricity reforms in non-OECD Asian countries, recognising their common underlying contexts and region-specific issues as described in Section 2. Second, it extends the literature which has hitherto largely focused on the analysis of technical impacts, and to some extent on economic impacts, to consider the welfare and distributional impacts of reform which relate directly to the policy challenges faced in non-OECD Asia. Third, it applies econometric techniques to a new dataset of non-OECD Asian countries allowing for cross-country comparisons in this important region of the world whilst controlling for institutional and political contexts.

3.3 Hypotheses

We develop our empirical method through three hypotheses exploring the technical, economic and welfare impacts of reforms for non-OECD Asia. We assemble a set of indicators which reflect the impacts of electricity reform, and regress reform measures (with relevant controls) on these indicators, whilst controlling for institutional differences and differing resource endowments, using panel data on 17 non-OECD Asian economies for 1990–2013. The choice of variables is informed by the literature, and by data availability.[17] Tables A1 and A2 in the Appendices contain descriptive statistics and correlations for our dataset.

H1. Electricity reforms in non-OECD Asian countries have resulted in improved technical efficiency.

We use transmission and distribution (T&D) losses per capita as the dependent variable. There are two factors underpinning this. First, as stated in Section 1, a key objective of non-OECD countries in adopting the standard reform model was to resolve distributional issues, as governments assumed that productivity improvements and efficiency gains would be passed through to consumers (Jamasb et al., 2017). Reforms were therefore targeted at improving efficiency across the entire supply chain. In non-OECD countries where vertical integration was the immediate precursor to reform, T&D losses concealed not just technical but also commercial inefficiencies—the latter included commercial losses from unmetered consumption. Unbundling of the main constituent functions of the sector can help in making the inefficiencies of the different functions, including the T&D losses, visible and thus easier to address, even in the absence of incentive regulation of networks, which is uncommon in non-OECD Asia.

Tongia (2007) shows how in India utilities concealed these losses by categorising them as ‘agricultural consumption’, as well as losses from power theft (Victor and Heller, 2007). Second, many OECD country studies tend to use measures of generator performance at the plant level—including capacity factors, vintage and unit configurations. However, such data, disaggregated to plant level, is not publicly available for most of the non-OECD Asian countries in our sample. Further, a cross-country study such as ours raises data issues related to variable definition and standardisation of measurement. It is for this reason that even existing cross-country empirical literature on reforms

17. See Table 3.

in developing countries utilises T&D losses (measured by the World Bank) as an indicator for technical impacts.[18]

The main explanatory variables include a 'reform index', drawing from Balza et al. (2013), Nepal and Jamasb (2012a), Sen and Jamasb (2012), Nagayama (2007), Cubbin and Stern (2005), and Hattori and Tsutsui (2004), made up of six measures: (a) IPPs in generation, (b) an electricity regulator as a separate, distinctive body,[19] (c) unbundling of the state utility, (d) corporatisation of the utility, (e) open / third party access to networks, and (f) distribution privatisation. The reform index and individual measures are informed by the reform characteristics of the non-OECD Asian countries. While unbundling and corporatisation are synonymous in the standard reform model, corporatisation (incorporation of a utility under the 'Companies Act') by itself implies commercialised operations. Most non-OECD Asian countries do not have regulators that are truly independent from government. Dummies (0/1) are assigned to each measure.

We control for institutional differences between countries using an internationally recognised composite transparency index—the Corruption Perceptions Index (CPI)—which is based on a combination of institutional surveys, and is a widely used indicator of institutional effectiveness.[20] Stronger institutions and governance enable transparency of operations, less rent-seeking and more effective outcomes. Per capita power consumption is included as a control variable—as higher power consumption in absolute terms could lead to higher T&D losses, and consumption is the residual of generation after losses.[21]

H2. Electricity reforms in non-OECD Asia have led to positive impacts on output and economic activity.

The second hypothesis draws from earlier studies such as Nepal and Jamasb (2012a) and Sen and Jamasb (2012) which utilise per capita GDP as the dependent variable. The reform impacts on per capita GDP has also been the subject of several studies based on computable general equilibrium models (Chisari et al., 1999; Benitez et al., 2001; Boccanfuso et al. 2009a, 2009b). Explanatory variables used are the reform index and individual reform measures. We control for institutional differences using the transparency index, and differences in initial resource endowments using per capita total installed capacity.[22] We extend the scope of this hypothesis by including a secondary indicator of economic activity which measures an economy's openness to electricity trade[23] by estimating a second equation that uses per capita electricity trade (as electricity exports plus electricity imports as a percentage of total electricity generation)[24] as a dependent variable. As several

18. A limitation of using a per capita measure of T&D losses is incomplete electrification rates in some countries in our dataset. We use per capita measures to address this.

19. Whether independent or not.

20. The CPI is a country-specific composite index measuring perceptions of corruption in the public sector. It is the only internationally recognised, cross-country dataset measuring governance and institutional capacity. The detailed methodology and dataset are freely downloadable from http://www.transparency.org/cpi2014/in_detail.

21. About 90% of the losses (commercial, non-commercial and outages) occur at the distribution level (Hammond and Waldron, 2008; Nepal and Jamasb, 2013). The T&D losses data mostly captures the 'D' network energy losses since the 'T' losses are minimal across all systems. For this reason, we do not include the length of transmission lines as a control variable, as per capita consumption serves as a better proxy.

22. While an alternative would be to use some indicator of primary energy reserves, installed capacity is more suitable as it represents the existing infrastructural capacity to deliver resource endowments to the population. Further, this captures the cumulative effects of resource endowments in a dynamic rather than static form.

23. Following Frankel and Romer (1999) that examines the links between trade and economic growth by region.

24. This is consistent with the World Bank World Development Indicators' definition of trade.

countries in developing non-OECD Asia are generously endowed with hydroelectric resources, we subtract hydroelectric capacity from total installed capacity and include it separately as a regressor in order to account for its effect.

H3. Electricity reforms in non-OECD Asia have led to positive welfare impacts.

The third hypothesis extends the impact of reforms to socio-economic welfare. As seen above, the literature on this is extremely limited, as is the availability of consistent data on indicators such as price, which would be representative of direct impacts on consumer surplus. We therefore focus on indicators that reflect welfare in a broader sense, through the impact on access and income, following the literature discussed above.

We carry out two estimations, each of which uses a dependent variable that is consistently measured across the countries in our dataset. The first is the Gini coefficient, which captures the welfare impact through changes in income distribution. There are two factors underpinning this. First, existing evidence shows that inequality in income mirrors inequality in final electricity consumption—in other words, there is a marked correlation between the Lorenz curves of income inequality, energy inequality and inequality of electricity use (Grubler et al., 2012).[25] And second, in OECD countries, power sector reforms were expected to lower the cost of producing electricity through productivity gains and change the relative prices charged to households and businesses, improving the distribution of income.[26] We therefore test for this impact in non-OECD Asia.

Our second indicator is the Human Development Index (HDI), which covers social wellbeing in a wider sense through its representation of standard of living, educational attainment and life expectancy in a society.[27] Our econometric estimation takes into account the effects of other unobserved variables upon the welfare indicators. The transparency index and per capita electric power consumption are included as controls; the former in order to contextualise the implementation of reform, and the latter to control for the efficiency of energy usage.

4. METHODOLOGY AND DATA

4.1 Method

Our dataset constitutes an unbalanced panel with 17 cross-sections from 1990–2013. Each cross section represents a non-OECD Asian country, with country-specific unobserved factors influencing the behaviour of each. The starting point for this analysis is to run an Ordinary Least Squares (OLS) model with robust standard errors as a benchmark model, which we then test and refine. An obvious option is to use a fixed effects panel estimation in order to control for country-specific observable and unobservable heterogeneity. The basic specification for a fixed effects model is: $Y_{it} = \alpha_i + \beta X_{it} + \eta_i + \varepsilon_{it}$.

25. Grubler et al. (2012) plot the Lorenz curves of energy inequality, measuring cumulative global population (in percent) disposing of corresponding fraction of cumulative income (in percent of PPP$), final energy, and electricity use (in percent of Joules energy used) for the year 2000 to clearly show this relationship.

26. For example, in Australia, electricity reforms are estimated by the Australian government to have led to capital, labour and fuel productivity improvements and subsequent price reductions (of up to 29%) for some consumers in the mid-1990s (Productivity Commission, 1996).

27. Measured through per capita income, mean years of schooling and expected years of schooling, and life expectancy at birth.

However, our dataset has a finite and relatively small time dimension, '*T*' and it is established in the literature that a LSDV model biases estimates when *T* is small; thus, LSDV performs well when *T* is large (Judson and Owen, 1999). Kiviet (1995) devised a bias-corrected LSDV estimator (LSDVC), later refined by Bun and Kiviet (2003), which is generally seen to have the lowest Root Mean Square Error for panels of all sizes; its applicability was, however, limited to balanced panels. A version of the bias-corrected LSDV estimator (LSDVC) for unbalanced panels was developed by Bruno (2005), which operates under two assumptions; first, it has a strictly exogenous selection rule, and second, it classifies the error term ε_{it} as an 'unobserved white noise disturbance'. However, we cannot rule out endogeneity amongst our regressors, which violates the exogenous selection rule of LSDVC. A number of consistent Instrumental Variable (IV)[28] and Generalised Method of Moments (GMM)[29] estimators are proposed in the literature to overcome endogeneity (see Baum et al., 2003), and we therefore run our estimations using an instrumented variable regression (using the STATA routine *ivregress)*.[30,31] This fits a linear regression of *depvar* on $varlist_1$ and $varlist_2$, using $varlist_{iv}$ (along with $varlist_1$) as instruments for $varlist_2$.[32] It supports estimation using two-stage least squares (2SLS) and GMM estimators.

The model estimated under this routine is as follows:

$$Y_i = \beta_0 + \beta_1 X_i + u_i, \;\; i = 1, \ldots\ldots..., n \qquad (\textit{Structural equation}) \qquad (1)$$

$$X_i = \Pi_0 + Z_i \Pi_1 + v_i \qquad (\textit{First-stage equation}) \qquad (2)$$

where Y_i is the dependent variable, X_i represents the endogenous regressors, u_i is the error term representing omitted factors that determine Y_i, Z_i is the instrumental variable used to isolate that part of X_i that is uncorrelated with u_i, Π_0 is the intercept, Π_1 is the slope, v_i is the error term.

The literature on the OECD countries has tended to argue that reform is a largely endogenous decision. Kwoka (2008) in a study of US states that restructured their electricity sectors versus those that did not restructure, in relation to the impact on retail electricity prices (the dependent variable) argues high prices in some US states at the outset may have caused them to restructure their power sectors in the first place. However, in non-OECD Asia, the decision to adopt the 'standard model' was arguably not endogenous; instead, the standard reform model was part of wider Structural Adjustment Programmes (SAPs) externally imposed on countries by multilateral agencies over a period spanning the 1990s/early 2000s. It was also a result of 'demonstration effect' in the adoption of standard model in non-OECD Asia following on from non-OECD Latin America (Nepal and Jamasb 2012a). As the impacts of individual reform measures yield greater insights than the composite reform index, we drop the latter (*Trfms*) from our estimations.

28. Baum (2006); Wooldridge (2010; 2013).

29. Hall (2005).

30. The syntax for *ivregress* assumes that you want to fit one equation from a system of equations or an equation for which you do not want to specify the functional form for the remaining equations of the system. An advantage of *ivregress* is that we can fit one equation of a multiple-equation system without specifying the functional form of the remaining equations.

31. A concern was raised by an anonymous reviewer stating that the analysis covers a period of time during which countries in the sample may have experienced volatile GDP growth. We therefore ran a fixed effects instrumental variable regression on GDP per capita with time dummies to capture the effects of time-varying shocks. We did not obtained significant results (including for 1997—the year of the Asian financial crisis), and the R^2 of our model is <0.5, indicating possible misspecification and/or small sample bias, which led us to use *ivregress* as a more robust estimation. Additionally, Indonesia and Thailand were the only countries in our dataset affected by the Asian financial crisis.

32. $varlist_1$ and $varlist_{iv}$ are the exogenous variables, and $varlist_2$ the endogenous variables.

Kwoka (2008) states that "while not all models assessing policy effects necessarily encounter selection bias … good methodology requires recognition of and attention to the issue." While reforms in non-OECD Asian countries were initiated through SAPs, the political economy literature shows that their continued implementation can be endogenous when the impact of rising prices risks creating public opposition and unrest to incumbent governments (Victor and Heller, 2007). Intuitively, the implementation of open access acts as a trigger for increasing electricity prices. This is because open access leads to a flight of 'paying' consumers (i.e. large industries which typically cross subsidise residential and agricultural electricity users in developing countries) from state-owned utilities to non-state firms or captive generation, thus putting pressure on the state-owned utilities to raise their prices to compensate for the loss in revenue. Joseph (2010) and Tongia (2007) show that this has been the case for India; Wisuttisak (2012) discusses the case of Thailand). This intuitive reasoning leads us to identify open access (*OAccess*) as an endogenous variable and to instrument for it, but we also supplement this intuition with observations from the descriptive statistics and appropriate post-estimation tests described later in this Section. In choosing an instrument for *OAccess*, we need a variable that is correlated with open access, but is uncorrelated with the error term. As argued above, open access often requires an increase in electricity prices, and it is less likely that this increase will be implemented in non-OECD Asian countries where the public can vote out governments and likely to mount protests against price increases. Open access has limited direct measurability, but we instrument for it using an index of Political Rights (*PRights*)[33] which essentially conveys the extent to which citizens have the right to participate in and to elect their government, and are hence more likely to influence endogenous government decisions on reforms.

A further requirement of our instrument for open access is that it should not impact the outcome variables (i.e. per capita GDP, HDI and Gini Coefficient) directly, other than through the endogenous variable (*OAccess*). Here again, there is no clear intuitive evidence of direct causality. For instance, in the case of GDP: China, which many argue has been the engine of global GDP growth over the past decade, scores at the lowest end of the scale (7—or the smallest degree of political rights) on the PR index. The same applies for other non-OECD Asian countries with strong GDP growth but low scores on PR (e.g., Thailand with a score of 6). Next, if we take HDI and the Gini Coefficient, again we do not find definitive evidence of direct causality between the PR index and either of these variables: Singapore, a non-OECD Asian country which scores low on the PR index (at 4), has high levels of HDI and income equality.

Finally, Table A.1 reports very low correlations between the PR index, GDP, HDI and Gini allowing us to infer that PR does not affect the outcome variables directly—these low correlations are indicative of the instruments satisfying the exclusion restrictions. *PRindex* is therefore intuitively and statistically a suitable instrument, not only satisfying the exogeneity assumption but also reflecting the complex political contexts of this region. In our estimation method, apart from additional exogenous variables specified, other exogenous variables that appear in the equation are automatically included as instruments, thus further accounting for the presence of endogeneity that

33. *PRindex* is published annually in the 'Freedom in the World' report which began publishing in the 1950s, deriving its methodology from the UN Universal Declaration of Human Rights. The Index covers 195 countries. A country is awarded 0–4 points for each of 10 political rights indicators, which take the form of questions; a score of 0 represents the smallest degree of freedom and 4 the greatest degree of freedom. The political rights questions are grouped into three subcategories: Electoral Process, Political Pluralism and Participation, and Functioning of Government. A country or territory is then assigned a composite rating (between 1 and 7) for political rights, with 1 representing the greatest degree of freedom and 7 the smallest degree of freedom, corresponding to a specific range of total scores. Description of the report's methodology, including data sources and the questionnaire used to score the index, is available online at: https://freedomhouse.org/report/methodology-freedom-world-2017

is not statistically explicit. The results are robust to heteroscedasticity and serial correlation,[34] and we run GMM and 2SLS estimations to test for consistency. We report the R-squared (goodness of fit) statistic along the results, although the estimator suppresses it in some cases, or reports a low statistic; but R-squared has no statistical meaning for instrumental variables regression.[35] Instead, we carry out two post-estimation tests to validate the robustness of our results. The first is a test of endogeneity, which tests whether endogenous regressors in the model are in fact exogenous.

The second is a test of instrument validity where an excluded exogenous variable must be sufficiently correlated with the included endogenous regressions but uncorrelated with the error term to be a valid instrument. The GMM and 2SLS estimators perform better when instruments are strongly correlated with the endogenous regressors (Hahn and Hausman, 2003). A test of over-identifying restrictions can be further performed if there are more instruments than the endogenous variables. For the GMM estimations, the test for endogeneity is reported through the 'C' statistic (Hayashi, 2000), while for 2SLS estimations endogeneity is reported through the Wooldridge score test (Wooldridge, 1995) and regressions-based test (Durbin, 1954; Wu, 1973; Hausman, 1978). The test of instrument validity for 2SLS and GMM estimations are based on the respective F-statistics for first stage regressions to judge the explanatory power of the instruments.[36] In all cases, the F statistic exceeds 10, which allows us to reject that our instruments are weak based on Staiger and Stock's (1997) rule of thumb (for one endogenous regressor).

Our instrument (Z_i) satisfies the three conditions for a valid instrument suggested by (Angrist and Pischke, 2009) which requires that: i) the instrument is as good as randomly assigned; ii) the instrument satisfies the exclusions restriction and iii) the instrument affects the endogenous regressor. Our intuitive arguments for the first two conditions are presented as above, while the third condition is met by the 'F' statistics resulting from the first-stage regressions.

4.2 Data

The reform measures were constructed through a comprehensive survey of reforms by the authors of country-specific literature to ascertain the status and progress of electricity reforms in non-OECD Asia. The variables were scaled to per capita levels to control for size differences and were further standardised by carrying out log transformations (see Appendices for summary statistics).[37]

Tables 2 and 3 describe the variables used and the results of post-estimation tests are reported in Table 4. Other data used for this study are from recognised sources, limiting standardisa-

34. We used the heteroscedasticity and autocorrelation consistent (HAC) weighting matrix in our regressions to account for serial correlations and potential heteroscedasticity based on the Newey-West estimator (1987) for the GMM regressions. For the 2SLS estimations, we tested if the coefficient on the lagged residual is statistically different from zero based on Durbin and Watson (1951).

35. See Stata manual http://www.stata.com/support/faqs/statistics/two-stage-least-squares/

36. A test of over-identifying restrictions when feasible to perform is reported in GMM Hansen J statistic (Sargan, 1958; Hansen, 1982) for GMM estimations. The test of over-identifying restrictions is based on the Sargan (chi) (Sargan, 1975) and Basmann (chi) (Basmann, 1957) test statistics for the 2SLS estimations.

37. We log transform all variables apart from the reform measures. Log transformations linearize relationships, to remove heteroscedasticity, and to obtain residuals that are approximately symmetrically distributed. Marginal changes in the explanatory variables are interpreted in terms of multiplicative (percentage) changes in the dependent variable. When both dependent and independent variables are logged (log-log relationship), the regression coefficients are interpreted as elasticities. A log-level relationship (*logY* and *X*) is interpreted as: $\%\Delta y = 100.(e^{\beta_1} - 1)$. However, we focus mainly on the direction of causality as we aim to investigate the high-level impact of reforms as opposed to the precise magnitude of the effects.

Table 2: Summary of Hypothesis and Variables

	Dependent Variable	Explanatory Variables	Control Variables
Technical Impact	Per capita transmission & distribution losses	Individual reform scores	Per capita electric power consumption, transparency index
Economic Impact	Per capita GDP	Individual reform scores	Per capita total installed capacity, per capita electricity consumption, transparency index
	Per capita electricity trade	Individual reform scores	Per capita total installed capacity (minus hydro installed capacity), per capita hydro capacity, per capita electricity consumption transparency index
Welfare Impact	Gini coefficient	Individual reform scores	Per capita electricity consumption, transparency index
	Human Development Index	Individual reform scores	Per capita electricity consumption, transparency index

Source: Authors

Table 3: Variable Names and Units of Measurement

Variable Label	Variable Name	Units
Dependent Variables		
PTdl	Per capita transmission / distribution energy losses	Percentage
PGdp	Per capita GDP	US$
PTrade	Per capita electricity trade	Percentage
HDI	Human Development Index	Score
GINI	GINI coefficient	Score 0 to 1
	Explanatory Variables	
Reform variables		
Trfms*	Total reforms index	Score out of 6
Ipps	IPPs	0/1
Reg	Regulator	0/1
Unb	Unbundling	0/1
Corp	Corporatisation	0/1
OAccess	Open/Third Party Access	0/1
Dprv	Distribution privatisation	0/1
Physical variables		
Pepc	Per capita electric power consumption	KWh
PCap	Per capita total installed capacity	KW
PCap less hydro	Per capita installed capacity minus hydro capacity	KW
PHydro	Per capita hydro capacity	KW
Index variables		
PRights	Political freedom (Freedom House Index)	Score 1 to 7
Trpi	Transparency index	Composite index

*Dropped from instrumental variable regressions; prefix L. in results tables indicates logged variable.

tion problems. They include the World Bank World Development Indicators, International Monetary Fund, and Freedom House Index. The transparency (corruptions perception) index is originally compiled from: African Development Bank Governance Ratings, Bertelsmann Foundation Sustainable Governance Indicators, Bertelsmann Foundation Transformation Index, Economist Intelligence Unit Country Risk Ratings, Freedom House Nations in Transit, Global Insight Country

Table 4: Post- Estimation Tests

	GMM		2SLS	
Variables	Endogeneity (Ho = variables are exogeneous)	Validity (Ho = Instruments are weak)	Endogeneity (Ho = variables are exogeneous)	Validity (Ho = Instruments are weak)
L.Pgdp	(5.12)**	(41.43)***	(3.4)*	(49.16)***
L.HDI	(4.98)**	(21.74)***	(3.72)*	(22.6)***
L.GINI	(5.32)**	(12.4)***	(21.54)***	(13.65)***
L.Ptdl	(5.066)**	(17.60)***	(3.7)*	(19.47)***
L.Trade	(23.86)***	(31.47)***	(21.64)***	(46.40)***

*/**/*** indicate significance at 10, 5 and 1% respectively

Risk Ratings, IMD Competitiveness Yearbook, Political and Economic Risk Consultancy Asian Intelligence, Political Risk Services International Country Risk Guide, World Bank Country Policy and Institutional Assessment, World Economic Forum Expert Opinion Survey, and World Justice Project Rule of Law Index.

5. RESULTS

Results are reported from the 'benchmark' (OLS) model in the first column of coefficients, and from the IV models using GMM and 2SLS estimators in the subsequent columns (Tables 5–7). The sizes of the coefficients are not significantly different between the benchmark and IV models, and neither are the size of the standard errors; but the results from the IV estimations are statistically robust to endogeneity (described in Section 4). Further, within the IV model, results are largely consistent across the GMM and 2SLS estimations. The discussion of results therefore focuses on the IV model. An initial reading of our results shows that the 'standard model' of electricity reforms implemented in non-OECD Asian countries has not definitively resulted in the anticipated positive impacts.

5.1 Technical impact

The results from our first hypothesis show that one of the reform measures—corporatisation—had a significant positive technical impact, leading to a broad 14% reduction in T&D losses in non-OECD Asian economies on average (Table 5).[38] This is substantial given high T&D losses in many non-OECD Asian countries, and that the OECD average is 6–8%. In the OLS model, IPPS and distribution privatization tend to increase T&D losses—however they are not significant in the instrumented variables regressions. As expected, a percentage change in per capita electricity consumption is associated with a rise in T&D losses; however, the magnitude of this increase (roughly 60%) is very large. Regulation also appears to increase T&D losses in the IV results—this could be reflective of the limited autonomy of regulation in non-OECD Asia (supported by the negative coefficients for the transparency index (institutions) variable). The type of economic regulation such as cost-based versus incentive regulation may also be important which we do not capture in our modelling.

There is no consensus in the literature on the magnitude and impact of reforms on T&D losses: Nagayama (2007) finds that reform measures including IPPs, unbundling and regulation led

38. The coefficients for log-level relationships are computed based on the interpretation set out in footnote 37.

Table 5: Technical Impact of Reforms

	L.PTDL		
	OLS (robust)	**IV (GMM)**	**IV (2SLS)**
Ipps	0.109**	–0.063	–0.063
	(0.05)	(0.09)	(0.29)
Reg	0.034	0.100**	0.100*
	(0.03)	(0.04)	(0.05)
Unb	–0.0001	–0.074	–0.073
	(0.03)	(0.05)	(0.06)
Corp	–0.133***	–0.143***	–0.143***
	(0.03)	(0.03)	(0.04)
OAccess	0.0006	0.276**	0.276*
	(0.03)	(0.13)	(0.16)
Dprv	0.163***	0.009	0.009
	(0.03)	(0.08)	(0.09)
L.Pepc	0.64***	0.62***	0.62***
	(0.05)	(0.05)	(0.04)
L.Trpi	0.050	–0.024	–0.024
	(0.12)	(0.13)	(0.13)
_CONS	3.31***	3.82***	3.82***
	(0.62)	(0.62)	(0.53)
R^2	0.82	0.79	0.79
N	235	235	235

*/**/*** indicates significance at 10, 5 and 1% respectively; standard error in parentheses

to lower T&D losses, while Smith (2004) finds that T&D losses increased after reforms in many developing countries. However, these studies were based on global data, whereas our analysis controls for institutional and contextual differences between countries and previous literature supports the importance of these contexts. For example, Nepal and Jamasb (2012) in an econometric analysis of 27 transition countries find that reforms on their own did not produce significant effects on T&D losses, and that institutional factors along weak political commitment and implementation played an important role. Sen and Jamasb (2012) found that performance measures tended to worsen in India rather than improve in the early stages of reform, analogous with a Kuznets curve distribution.

5.2 Economic Impact

The results show a largely positive economic impact from electricity reforms in non-OECD Asia measured in terms of per capita GDP, but no significant impact on electricity trade.

5.2.1 Per Capita GDP

Results are shown in Table 6 below. The presence of regulators has a positive significant economic impact (of a magnitude of 7–9%), in line with much of the literature (Cubbin and Stern (2006) find that higher quality regulatory governance leads to positive outcomes). Further, open access has a positive economic impact of the order of around 12% (significant only for OLS)—this is in line with the expectation that third-party access in non-OECD Asia relieves consumers from dependence on a single grid-connected utility. In India, open access enables large industrial con-

Table 6: Economic Impact of Reforms

	L.Pgdp				L.Trade		
	OLS (robust)	**IV (2SLS)**	**IV (GMM)**		**OLS (robust)**	**IV (2SLS)**	**IV (GMM)**
Ipps	–0.340***	–0.381***	–0.381 ***	**Ipps**	–0.332**	–0.017	–0.017
	(0.07)	(0.10)	(0.12)		(0.12)	(0.27)	(0.29)
Reg	0.074**	0.090**	0.090*	**Reg**	0.062	–0.056	–0.056
	(0.03)	(0.04)	(0.05)		(0.08)	(0.11)	(0.23)
Unb	–0.163***	–0.181***	–0.181***	**Unb**	–0.080	0.064	0.064
	(0.03)	(0.05)	(0.04)		(0.07)	(0.14)	(0.12)
Corp	0.045	0.045	0.045	**Corp**	–0.080	–0.107	–0.107
	(0.04)	(0.04)	(0.04)		(0.07)	(0.09)	(0.07)
OAccess	0.118***	0.183	0.183	**OAccess**	0.418***	–0.041	–0.041
	(0.03)	(0.13)	(0.14)		(0.11)	(0.33)	(0.29)
Dprv	0.016	–0.020	–0.020	**Dprv**	–0.246***	–0.022	–0.022
	(0.03)	(0.08)	(0.09)		(0.10)	(0.18)	(0.16)
L.PCap	–0.097	–0.093	–0.093***	**L.PCap less hydro**	–1.483***	–1.400***	–1.400***
	(0.11)	(0.07)	(0.10)		(0.09)	(0.10)	(0.11)
L.Trpi	0.567***	0.549***	0.549***	**L.PHydro**	–0.040**	–0.041**	–0.041**
	(0.13)	(0.11)	(0.14)		(0.01)	(0.10)	(0.10)
L.Pepc	0.510***	0.499***	0.499***	**L.Pepc**	1.416***	1.392***	1.392***
	(0.12)	(0.07)	(0.11)		(0.13)	(0.12)	(0.13)
_CONS	–1.700*	–1.557***	–1.557***	**L.Trpi**	–0.160	–0.046	–0.046
	(0.88)	(0.58)	(0.83)		(0.25)	(0.26)	(0.28)
				_CONS	–8.573***	–8.953***	–8.953***
					(1.15)	(1.05)	(1.08)
R^2	0.87	0.86	0.86	**R^2**	0.68	0.64	0.64
N	235	235	235	**N**	235	235	235

*/**/*** indicates significance at 10, 5 and 1% respectively; standard error in parentheses

sumers to generate their own electricity at a preferential location, and transfer it to plants using the state grid.

On the other hand, the presence of IPPs has a negative association with GDP, reflective of the mixed and largely negative early experiences with IPPs in non-OECD Asia as described in Section 2, which are mostly connected with the breakdown of bilateral contracts between IPP and often a single state owned utility (usually over pricing disputes), which as discussed, have been partly politically motivated.

Unbundling on its own also has a negative impact on GDP, but the positive result for corporatisation underlines our early argument between the mere functional segmentation of the sector into its different functions, versus the additional 'accounting separation' which is more effective. The presence of a higher quality of institutions and transparency is associated with a substantially significant impact on GDP (around the order of 60%)—underscoring the role of this variable in catalysing some of the reform outcomes (e.g., the lack of success with IPPs) in some countries. Higher per capita electric power consumption expectedly has a large positive impact on GDP.[39]

39. The use of per capita electric power consumption as a control for estimating the impact of reforms on economic output may raise concerns of reverse causality/simultaneity. While our instrumental variables estimation (2SLS) accounts for simultaneity problems, it is noteworthy that a large literature uses time series analysis to test whether energy causes economic output or vice versa with little in the way of conclusive results or guidance on how to model the relationships (Bruns

5.2.2 Electricity trade

We do not find conclusive results for the impacts on electricity trade from reforms. Among the reform measures, while the OLS regressions yield a negative impact of IPPs on electricity trade, open access yields a large positive coefficient (40%); the former is once again reflective of experiences with IPPs in non-OECD Asia, which have not always delivered intended outcomes (i.e. higher electricity output). The latter result (open access) can be construed as being essential to engendering the competition required to enable trade—but as it is not significant across the instrumental variable estimations we cannot draw firm conclusions from the OLS model alone. Distribution privatisation has a negative impact on trade, in the OLS model. Among other variables, higher per capita electricity consumption has a large significant impact on electricity trade, reflecting that when faced with high electricity demand (and potential deficits), non-OECD Asian economies resort to cross border electricity trade (Singh et al., 2015).

Although well-functioning markets can aid regional electricity market integration, cross-border cooperation has predated reforms in most countries, occurring mostly through high-level bilateral political engagement (Singh et al., 2015). In other regions such as South America, bilateral trade evolved into market integration, with firms replacing political actors, as trade was encouraged to reduce large regional price disparities (Raineri et al., 2013). A major constraint to electricity trade in non-OECD Asia has been the rise of resource nationalism in South Asia, particularly over hydro resources.[40] This is reflected in our result that a percentage increase in per capita hydro capacity results in a 4% decrease in per capita electricity trade. Similarly, higher per capita installed capacity (minus hydro capacity) has a negative impact on trade (supporting higher domestic availability and thus less need for imports). Finally, trade is not dependent upon the quality of institutions.

5.3 Welfare Impact

As discussed in Section 3, there are two channels though which electricity reforms impact upon welfare. The first and more direct channel is through the transfer of surplus to consumers through lower prices (and hence higher disposable income), and the second is the wider welfare impact catalysed through electricity infrastructure, access and quality. We explored both in separate estimations. There are a number of factors other than reforms which can affect welfare; we have accounted for these in our model specifications, as described in Section 4.1.

5.3.1 Income distribution

The dependent variable in our first estimation is the Gini coefficient, which is a measure of income inequality between 0 and 1, with 0 representing perfect equality and 1 representing perfect inequality, and it captures both channels. The results show that different reform measures have had different directions and impact on the Gini coefficient (Table 7). While open access seems to improve the Gini coefficient, distribution privatisation is associated with an increase in income inequality of between 5–13%. This result is supported by our theoretical exposition (Section 3.1) which states

et al., 2014). The results depend to a great extent on the techniques used, time series, and sample (country or countries) being analysed.

40. Strahorn (2011) discusses these largely political constraints. Resource nationalism appears to be a constraint when hydro resources are opened up to foreign governments rather than private sector firms.

Table 7: Welfare Impact of Reforms

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

*/**/*** indicates significance at 10, 5 and 1% respectively

that the implementation of reforms in the absence of excess capacity and lack of cost-reflective pricing will have led to higher prices following distribution privatisation. This is also supported by other empirical literature (Nagayama, 2007; 2009; Sen and Jamasb, 2012).

However, the presence of a sector regulator reduces the Gini coefficient (and hence improves income disparity) by roughly 15%. This result could reflect one of two conditions: first, a regulator could intervene in electricity provision to limit price increases for the poorer consumers; and second, it could reflect lump sum transfers (e.g., cash payments) made to the poorest consumers who would otherwise be left worse off by price increases (which as we have discussed are inevitable when market reforms are carried out in a sector where prices are set below costs). Countries such as India have implemented reforms alongside mandated lump sum transfers by regulators.

IPPs seem to worsen income inequality; this is a plausible result and is in line with the theoretical trade-off between efficiency and distributional equity—if the presence of IPPs does not result in increased electrification and increased access, high income groups are by default consuming more electricity. Most IPPs tend to be located in urban or semi-urban areas, where grid infrastructure is in place along with an incumbent utility to offtake the IPP's electricity. IPPs are often brought in to plug supply shortages rather than increase competition or extend access, and as discussed in Section 3, private firms have more incentive to serve low-cost areas rather than poorer areas (which tend to be costlier to serve and have low average consumption). Other empirical literature supports this conclusion even for rural areas; e.g., Khandker et al. (2012b) using cross sectional household survey data for India for 2005 found that a larger share of gains from rural electrification accrued disproportionately to wealthier rural households. The results for the influence of institutions on income inequality are, we argue, analytically intractable, and require further investigation.

5.3.2 Human Development Index

Over two decades of attempts at electricity reforms should arguably have had broader positive welfare impacts as measured directly by the HDI. Yet, our results show that reforms have failed to yield clear welfare improvements. This has not even occurred through 'indirect' channels, as discussed in Section 3.2, where previous literature finds links between electricity access and the HDI. Leipziger et al. (2003) explore the relationship between access to electricity and educational attainment, which is one component of the HDI. Cross-country econometric studies have also found positive impacts from reforms on the quality of service and on access, particularly from regulatory governance and independent regulation (Cubbin and Stern, 2004; 2006, ESMAP, 2011; Zhang et al., 2005; 2008).

However, our results show no direct significant impacts of electricity reforms on the HDI, and the evidence is weak at best: for instance, a graphical depiction of the data shows a weak positive relationship between the HDI and per capita electricity consumption (see Appendices). There is an argument to be made, that the standard model of electricity reforms does not automatically improve access, and that access is instead provided through special and targeted electrification programmes. One could argue that reform measures such as independent regulation should facilitate this, and there is some (sparse) evidence form the literature (ESMAP, 2011) that regulation has in some cases facilitated increased access. However, as described earlier in this paper, post reform regulation under the standard model has not been independent in most non-OECD Asian developing countries, and that regulators have generally tended to be quasi–government organisations.

Table 8 summarises the impacts of explanatory variables from each of the three hypotheses (sector efficiency, economic benefit and welfare effect). Our main results can be summed as follows:

- The different reform steps implemented have had mixed impacts on sector efficiency and economic output,
- There is a trade-off between the technical and economic versus welfare impacts of electricity reform, and
- The institutional and contextual variables (control variables) have large significant effects on qualifying the outcomes of reform.

For instance, reform measures such as regulation and open access have positive impacts on economic growth and welfare. Conversely, privatisation of distribution has a negative impact on welfare as it leads to rising prices for poor consumers. Further, as we progress from technical and economic to welfare impacts, reforms have had a waning effect on improving welfare in non-OECD Asian developing countries—a surprising outcome given the long history (over 25 years) of reform implementation and the theoretical basis for carrying out reforms as described in earlier sections.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This paper has investigated the proposition from theoretical and empirical literature that the 'standard model' of electricity reform, developed over more than two decades, has led to improved efficiency, higher economic surpluses, and the transfer of surplus to consumers in developing countries. Using data from 1990–2013 for 17 non-OECD Asian countries, we applied instrumental variable regression techniques and find a tension between the efficiency, economic and welfare outcomes of the 'standard model', which can be reflective of wider trade-offs between the policy goals of efficiency, sustainability and affordability. We have therefore argued that the application of theory has not automatically translated into expected outcomes of electricity sector reforms, particularly

Table 8: Summarising impacts from each of the three hypotheses

Explanatory Variables	Var. Labels	H1. Sector Efficiency (T&D Losses)**	H2.1 Economic Benefit (GDP)	H2.2 Economic Benefit (Trade)	H3.1 Welfare Effect (Gini Coefficient)**	H3.2 Welfare Effect (HDI)
Total Reforms (Dropped)	Trfms					
Independent Power Producers	Ipps		– (0.38)	– (0.33)	+ (0.88)	
Regulator	Reg	+ (0.10)	+ (0.09)		– (0.15)	
Unbundling	Unb		– (0.18)		+ (0.13)	
Corporatisation	Corp	– (0.14)				
Open/Third Party Access (Instrumented)	OAccess	+ (0.28)	+ (0.12)	+ (0.42)	– (0.17)	
Distribution Privatisation	Dprv			– (0.25)	+ (0.13)	
Control Variables						
Per Capita Electric Power Consumption	Pepc	+ (0.62)	+ (0.50)	+ (1.40)		+ (0.11)
Transparency Index	Trpi		+ (0.55)	– (0.40)	+ (0.70)	
Per Capita Total Installed Capacity	PCap		– (0.09)			
Per Capita Installed Capacity (minus Hydro)	PCap less Hydro			– (1.40)		
Per Capita Hydro Capacity	PHydro			– (0.04)		

** a + sign for these variables indicates a negative impact, and a – sign indicates a positive impact. Where the size of coefficients varies across estimations we report the IV-GMM result.

on welfare, in developing countries—partly due to weak institutional frameworks under which any technical and economic gains have not been passed on to consumers.

Our results underscore the point that the uniform application of the standard model without reference to the inherent heterogeneity that characterises the sectors and countries in our dataset has not resulted in the anticipated reform outcomes. These results are subject to the limitations of data availability as in most econometric studies of this kind and there remains considerable scope for extending the findings and reducing the effect of omitted variables as more data becomes available or by using case study analyses. There is also scope for constructing newer indices to more closely measure the welfare impacts of reform. However, our study remains pioneering in terms of examining the trade-offs among reform outcomes despite the existing data limitations and constraints. Since reform process and impacts are multidimensional, future research can shed further light on

the important trade-offs in reform outcomes with more data for which this study provides the overarching foundation.

The results of this study points to specific policy implications. First, in many non-OECD developing countries, there was a widening price-cost margin and cross-subsidy when liberalisation took place, implying that prices would need to rise after liberalisation (Erdogdu, 2011). If prices do need to rise to encourage the efficient use of electricity, other policy measures, such as fiscal transfers to poor consumers, are needed to ensure that the surplus obtained from competition and liberalisation is transferred to poorer consumers, enhancing welfare. This lends support to the use of direct cash transfer programmes for poorer consumers being implemented in some countries (e.g. India) alongside electricity reforms, which also make tariff reforms politically palatable.

Second, although the standard reform model is applied to the entire supply chain, it is evident that competition in generation has helped to lower costs and introduce the much needed new capacity, albeit through badly managed IPP programmes in non-OECD Asia. This implies a much greater role for competition in order to meet public policy objectives, even when there are policy constraints related to final price levels. This could be through effective use of auctions to select new generation plants. Structural reform measures—particularly corporatisation—have appeared to be successful in improving technical measures and economic impacts. Future work could focus more specifically on assessing country-specific outcomes in relation to the competitiveness of markets.

We argue for a revisiting of electricity reforms, which considers the welfare dimension that is critical to a developing region such as the economies of non-OECD Asia represented in the present paper. Although the description of a 'new' reform model is beyond the purpose and scope of this paper, a rethinking of reforms would entail taking greater advantage of competition and regulation through the structural reform measures to lower system costs without raising average prices, or without raising prices to the poorest. A combination of competition, independent regulation, and stronger institutions is needed to enhance the ability of decision makers in order to manage the inherent technical, economic, and equity trade-offs involved in an electricity sector reform.

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REFERENCES

Armstrong, M. and D.E.M. Sappington (2006). "Regulation, Competition and Liberalization." *Journal of Economic Literature* XLIV: 325–66. https://doi.org/10.1257/jel.44.2.325.

Angrist, J. and J.S. Pischke, (2009). *Mostly Harmless Econometrics: An Empiricist Companion*, Princeton University Press.

Balza, L., R. Jimenez and J. Mercado (2013). *Privatization, Institutional Reform, and Performance in the Latin American Electricity Sector*, Infrastructure and Environment Department Energy Division INE/ENE Technical Note No. IDB-TN-599, Inter-American Development Bank.

Basmann, R.L. (1960). "On finite sample distributions of generalized classical linear identifiability test statistics." *Journal of the American Statistical Association* 55: 650–59. https://doi.org/10.1080/01621459.1960.10483365.

Baum, C.F., M.E. Schaffer, and S. Stillman (2003). "Instrumental Variables and GMM: Estimation and Testing." *Stata Journal* 3(1): 1–31.

Baum, C.F. (2006). *An Introduction to Modern Econometrics Using Stata*. College Station, TX: Stata Press.

Benitez, D.A., O. Chisari, and A. Estache (2001). Can the Gains from Argentina's Utilities Reform Offset Credit Shocks?, Working Paper No. DP2001/33, World Institute for Development Economic Research (UNU-WIDER), Helsinki.

Bigerna, S., C.A. Bollino, and P. Polinori (2016). Market Power and Transmission Congestion in the Italian Electricity Market, *The Energy Journal* 37(2): 133–154. https://doi.org/10.5547/01956574.37.2.sbig.

Boccanfuso, D., A. Estache, and L. Savard (2009a). A Macro-Micro Analysis of the Effects of Electricity Reform in Senegal on Poverty and Distribution, *The Journal of Development Studies* 45 (3): 351–368. https://doi.org/10.1080/00220380802582361.

Boccanfuso, D., A. Estache, and L. Savard (2009b). Electricity Reforms in Mali: A Macro Micro Analysis of the Effects on Poverty and Distribution, *South African Journal of Economics* 77(1): 127–147. https://doi.org/10.1111/j.1813-6982.2009.01205.x.

Borenstein, S. (2003). The Trouble with Electricity Markets: Understanding California's Restructuring Disaster, *Journal of Economic Perspectives* 16(1): 191–211. https://doi.org/10.1257/0895330027175.

Brenneman, A. and M. Kerf (2002). Infrastructure and Poverty Linkages: A Literature Review. The World Bank, Mimeo.

Bruno, G.S.F. (2005). "Estimation and Inference in Dynamic Unbalanced Panel Data Models with a Small Number of Individuals." CESPRI Working Paper 165.

Bruns, S. B., C. Gross, and D.I. Stern (2014). "Is There Really Granger Causality between Energy Use and Output?" *The Energy Journal* 35(4): 101–134. https://doi.org/10.5547/01956574.35.4.5.

Bun, M.J G. and J.F. Kiviet (2003). "On the diminishing returns of higher-order terms in asymptotic expansions of bias." *Economics Letters* 79(2): 145–152. https://doi.org/10.1016/S0165-1765(02)00299-9.

Bye, T. and E. Hope (2005). "Deregulation of electricity markets—The Norwegian experience", Discussion Papers 433, Statistics Norway, Research Department.

Chang, Y. and Y. Li (2013). The Singapore Electricity Market: From Partial to Full Competition, in Sioshansi, F.P. (ed.), *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*, Elsevier Global Energy Policy and Economics Series. https://doi.org/10.1016/B978-0-12-397891-2.00024-9.

Chisari, O., A. Estache, and C. Romero (1999). Winners and Losers from the Privatisation and Regulation of Utilities: Lessons from a General Equilibrium Model of Argentina, *World Bank Economic Review* 13(2), pp. 357–378. https://doi.org/10.1093/wber/13.2.357.

Cubbin, J. and J. Stern (2004). "Regulatory Effectiveness: The Impact of Good Regulatory Governance on Electricity Industry Capacity and Efficiency in Developing Countries." Policy Research Working Paper 3536, The World Bank, Washington D.C.

Cubbin, J. and J. Stern (2006). "The Impact of Regulatory Governance and Privatization on Electricity Industry Generation Capacity in Developing Economies." *World Bank Economic Review* 20(1): 115–141. https://doi.org/10.1093/wber/lhj004.

Dupuy, M., F. Weston, and A. Hove (2015). *Power Sector: Deepening Reforms to Reduce Emissions, Improve Air Quality, and Promote Economic Growth*, Paulson Institute.

Durbin, J. and G.S. Watson (1951). "Testing for Serial Correlation in Least Squares Regressions II." *Biometrika* 38(1–2): 159–179. https://doi.org/10.1093/biomet/38.1-2.159.

Durbin, J. (1954). Errors in Variables. *Review of the International Statistical Institute*, 22: 23–32. https://doi.org/10.2307/1401917.

Eberhard, A., K. Gratwick, E. Morella, and P. Antmann (2016). Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries. Directions in Development—Energy and Mining. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-0800-5.

EIA (2017). International Energy Outlook, US Energy Information Administration.

Erdogdu, E. (2011). "The Impact of Power Market Reforms on Electricity Price-Cost Margins and Cross-Subsidy Levels: A Cross Country Panel Data Analysis." *Energy Policy* 39(3): 1080–1092. https://doi.org/10.1016/j.enpol.2010.11.023.

Erdogdu, E. (2013). "Implications of Liberalization Policies on Government Support to R&D: Lessons for Electricity Markets." *Renewable and Sustainable Energy Reviews* 17: 110–118. https://doi.org/10.1016/j.rser.2012.09.030.

Erdogdu, E. (2014). "Investment, Security of Supply and Sustainability in the Aftermath of Three Decades of Power Sector Reform." *Renewable and Sustainable Energy Reviews* 31: 1–8. https://doi.org/10.1016/j.rser.2013.11.014.

ESMAP (2011). "Revisiting Policy Options on the Market Structure in the Power Sector", Energy Sector and Mining Assistance Program (ESMAP), The World Bank, Washington D.C.

Estache, A., A. Gomez-Lobo, and D. Leipziger (2000). Utility Privatization and the Needs of the Poor in Latin America, The World Bank, Mimeo.

Estache, A., O. Chisari, and C. Waddams-Price (2003). "Access by the Poor in Latin America's Utility Reform: Subsidies and Service Obligation." ULB Institutional Repository 2013/44068, ULB—Universite Libre de Bruxelles.

Frankel, J.A. and D.H. Romer (1999). "Does Trade Cause Growth?" *American Economic Review* 89(3): 379–99. https://doi.org/10.1257/aer.89.3.379.

Gratwick, K.N. and A. Eberhard (2008). "Demise of the Standard Model for Power Sector Reform and the Emergence of Hybrid Power Markets." *Energy Policy* 36(10): 3948–60. https://doi.org/10.1016/j.enpol.2008.07.021.

Grubler, A., T.B. Johansson, L. Mundaca, N. Nakicenovic, S. Pachauri, K. Riahi, H.H. Rogner, and L. Strupeit (2012): Chapter 1—Energy Primer. In *Global Energy Assessment—Toward a Sustainable Future*, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 99–150.

Hahn, J. and J.A. Hausman (2003). "Weak instruments: Diagnosis and Cures in Empirical Econometrics." American *Economic Review Papers and Proceedings* 93: 118–125. https://doi.org/10.1257/000282803321946912.

Hall, A.R. (2005). *Generalized Method of Moments*. Oxford: Oxford University Press.

Hall, D., L. Emmanuele, and R. de la Motte (2005). "Public Resistance to Privatisation in Water and Energy." *Development in Practice* 15(3; 4): 286–301.

Hansen, L.P. (1982). "Large Sample Properties of Generalized Method of Moments Estimators." *Econometrica* 50: 1029–1054. https://doi.org/10.2307/1912775.

Hattori, T. and M. Tsutsui (2004). "Economic Impact of Regulatory Reforms in the Electricity Supply Industry: A Panel Data Analysis for OECD Countries." *Energy Policy* 32: 823–32. https://doi.org/10.1016/S0301-4215(03)00004-1.

Hausman, J.A. (1978). "Specification Tests in Econometrics." *Econometrica* 46: 1251–71. https://doi.org/10.2307/1913827.

Hayashi, F. (2000). *Econometrics*. Princeton, NJ: Princeton University Press.

Henisz, W.J. and B.A. Zelner (2002). "The Political Economy of Private Electricity Provision in Southeast Asia." WP 2001–02, The Wharton School, University of Pennsylvania.

IEA (2014). "World Energy Outlook." International Energy Agency, Paris.

IEA (2016). "World Energy Outlook." International Energy Agency, Paris.

Jamasb, T., R. Mota, D. Newbery, and M. Pollitt (2005). "Electricity Sector Reform in Developing Countries: A Survey of Empirical Evidence on Determinants and Performance." World Bank Policy Research Working Paper 3549, The World Bank, March, Washington, DC. https://doi.org/10.1596/1813-9450-3549.

Jamasb, T. and A. Sen (2013). "Not Seeing the Wood for the Trees? Electricity Market Reform in India." in Sioshansi, F.P. (ed.) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*, Elsevier Global Energy Policy and Economics Series.

Jamasb, T., R. Nepal, and G. Timilsina (2017). "A Quarter Century of Effort Yet to Come of Age: A Survey of Power Sector Reforms in Developing Countries." *The Energy Journal* 38(3): 195–234. https://doi.org/10.5547/01956574.38.3.tjam.

Joseph, K.L. (2010) "The Politics of Power: Electricity Reform in India." *Energy Policy* 38(1): 503–511.

Joskow, P. L. (1998). "Electricity Sectors in Transition." *The Energy Journal* 19(2): 25–52. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol19-No2-3.

Joskow, P. L. (2008). "Lessons Learned from Electricity Market Liberalization." *The Energy Journal* 29, Special Issue No. 2: 9–42.

Judson, R.A. and A.L. Owen (1999). "Estimating Dynamic Panel Data Models: A Guide for Macroeconomists." *Economics Letters* 65: 9–15. https://doi.org/10.1016/S0165-1765(99)00130-5.

Kahn, A.E. (1979). "Applications of Economics to an Imperfect World." *American Economic Review* 69(2): 1–13.

Kennedy, P. (2008). *A Guide to Econometrics*. Oxford, Blackwell Publishing.

Kessides, I. (2012). "The Impacts of Electricity Sector Reforms in Developing Countries." *The Electricity Journal* 25(6): 79–88. https://doi.org/10.1016/j.tej.2012.07.002.

Kessides, I.N. (2013). "Chaos in Power: Pakistan's Electricity Crisis." *Energy Policy* 55: 271–85. https://doi.org/10.1016/j.enpol.2012.12.005.

Khandker, S.R., D.F. Barnes, and H.F. Samad (2012a). "Are the Energy Poor also Income Poor? Evidence from India." *Energy Policy* 47: 1–12. https://doi.org/10.1016/j.enpol.2012.02.028.

Khandker, S.R., D.F. Barnes, and H.F. Samad (2012b). "The Welfare Impacts of Rural Electrification in Bangladesh." *The Energy Journal* 33(1): 187–206. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol33-No1-7.

Kiviet, J.F. (1995). "On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Data Models." *Journal of Econometrics* 68 (1): 53–78. https://doi.org/10.1016/0304-4076(94)01643-E.

Kwoka, J. (2008). "Restructuring the U.S. Electric Power Sector: A Review of Recent Studies." *Review of Industrial Organization* 32: 165–196. https://doi.org/10.1007/s11151-008-9171-2.

Lee, K., E. Miguel, and C. Wolfram (2016). "Empirical Evidence on the Demand for and Costs of Rural Electrification." NBER Working Paper No. 22292, National Bureau of Economic Research, USA.

Leipziger, D., M. Fay, Q. Wodon, and T. Yepes (2003). "Achieving the Millennium Development Goals: The Role of Infrastructure." Policy Research Working Paper 3163, The World Bank, Washington D.C. https://doi.org/10.1596/1813-9450-3163.

Malik, K., M. Cropper, A. Limonov, and A. Singh (2015). "The Impact of Electricity Sector Restructuring on Coal-Fired Power Plants in India." *The Energy Journal* 36(4): 287–312. https://doi.org/10.5547/01956574.36.4.kmal.

MMEE (2010). Maldives Ministry of Housing and Environment. Maldives National Energy Policy, Government of Maldives.

Mukherjee, M. (2014). "Private participation in the Indian Power Sector: Lessons from Two Decades of Experience." Directions in Development: Energy and Mining, Washington D.C. https://doi.org/10.1596/978-1-4648-0339-0.

Nagayama, H. (2007). "Effects of Regulatory Reforms in the Electricity Supply Industry on Electricity Prices in Developing Countries." *Energy Policy* 35(6): 3440–62. https://doi.org/10.1016/j.enpol.2006.12.018.

Nagayama, H. (2009). "Electric Power Sector Reform Liberalisation and Electric Power Prices in Developing Countries: An Empirical Analysis Using International Panel Data." *Energy Economics* 31(3): 463–72. https://doi.org/10.1016/j.eneco.2008.12.004.

Nagayama, H. (2010). "Impacts on Investments, and Transmission/Distribution Loss through Power Sector Reforms." *Energy Policy* 38(7): 3453–67. https://doi.org/10.1016/j.enpol.2010.02.019.

Nepal, R. and T. Jamasb (2012a). "Reforming the Power Sector in Transition: Do Institutions Matter?" *Energy Economics* 34(5): 1675–82. https://doi.org/10.1016/j.eneco.2012.02.002.

Nepal, R. and T. Jamasb (2012b). "Reforming Small Electricity Systems under Political Instability: The Case of Nepal." *Energy Policy* 40: 242–51.

Newbery, D.M. (1996). "Privatisation and Liberalisation of Network Utilities." Cambridge Working Papers in Economics 9620, Faculty of Economics, University of Cambridge.

Newbery, D.M. (2005). "Electricity Liberalization in Britain: The Quest for a Satisfactory Wholesale Market Design." *The Energy Journal* 26(Special Issue): 43–70. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol26-NoSI-3.

Newey, W.K. and K.D. West (1987). "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica* 55(3): 703–708. https://doi.org/10.2307/1913610.

Ngan, H.W. (2010). "Electricity Regulation and Electricity Market Reforms in China." *Energy Policy* 38: 2142–48. https://doi.org/10.1016/j.enpol.2009.06.044.

Pollitt, M. (2004). "Electricity Reform in Chile: Lessons for Developing Countries." *Journal of Network Industries* 5(3–4): 221–62. https://doi.org/10.1177/178359170400500301.

Productivity Commission (1996). Reform and the Distribution of Income—An Economy-Wide Approach, Productivity Commission, Government of Australia.

Raineri, R., I. Dynerb, J. Gonic, N. Castrod, Y. Olayae, and Francoe, C. (2013). "The integration of Latin American Energy Markets: An Outstanding Dilemma" in Sioshansi, F.P. (ed) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*, Elsevier Global Energy Policy and Economics Series. https://doi.org/10.1016/B978-0-12-397891-2.00014-6.

Santiago, A. and F. Roxas (2010). "Understanding Electricity Market Reforms and the Case of Philippine Deregulation." *The Electricity Journal* 23(2): 48–57. https://doi.org/10.1016/j.tej.2010.02.003.

Sargan, J.D. (1958). "The Estimation of Economic Relationships Using Instrumental Variables." *Econometrica* 26: 393–415. https://doi.org/10.2307/1907619.

Sen, A. and T. Jamasb (2012). "Diversity in Unity: An Empirical Analysis of Electricity Deregulation in Indian States." *The Energy Journal* 33(1): 83–130.

Sen, A. (2014). "Divergent Paths to a Common Goal? An Overview of Challenges to Electricity Sector Reform in Developing versus Developed Countries." Oxford Institute for Energy Studies Working Paper EL14. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol33-No1-4.

Singh, A., T. Jamasb, R. Nepal, and M. Toman (2015). "Cross Border electricity Cooperation in South Asia." World Bank Policy Research Working Paper 7328, The World Bank, Washington, D.C. https://doi.org/10.1596/1813-9450-7328.

Somani, S. and W. Lim (2014). "Powering the Future: Opportunities and Challenges for IPPs." Southeast Asia Infrastructure Magazine, December.

Staiger, D. and J.H. Stock (1997). "Instrumental Variables Regression with Weak Instrument." *Econometrica* 65(3): 557–586. https://doi.org/10.2307/2171753.

Steiner, F. (2000). "Regulation, Industry Structure and Performance in the Electricity Supply Industry." OECD Economics Department Working Papers No. 238, OECD Publishing. https://doi.org/10.1787/880084226021.

Steiner, F. (2001). "Industry Structure and Performance in the Electricity Supply Industry." *OECD Economic Studies* 32(I): 143–182. https://doi.org/10.1787/eco_studies-v2001-art5-en.

Strahorn, E. (2011). "An Analysis of the Barriers to Cross Border Trade in Hydroelectricity in the Himalayas." *Himalayan Research Papers Archive* 10 (1).

Tongia, R. (2007). "The Political Economy of Indian Power Sector Reforms." In Victor, D. and Heller, T.C. (eds.), The Political Economy of Power Sector Reform: The Experiences of Five Major Developing Countries, Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511493287.005.

Victor, D. and T.C. Heller (eds.) (2007). The Political Economy of Power Sector Reform: The Experiences of Five Major Developing Countries, Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511493287.

Vu, K.M. and A. Gurtoo (2014). "Utility Sector Performance Post Reforms: Investigating the South Asian Economies." *Poverty and Public Policy* 6(2): 157–75. https://doi.org/10.1002/pop4.68.

WDI (2017). World Bank World Development Indicators, World Bank, Washington D.C.

Williams, J.H. and R. Ghanadan (2006). "Electricity Reform in Developing and Transition Countries: A Reappraisal." *Energy* 31: 815–44. https://doi.org/10.1016/j.energy.2005.02.008.

Wisuttisak, P. (2012). "Regulation and Competition Issues in Thai Electricity Sector." *Energy Policy* 44: 185–98. https://doi.org/10.1016/j.enpol.2012.01.038.

Wolak, F. (2003). "Measuring Unilateral Market Power in Wholesale Electricity Markets: The California Market, 1998–2000." *American Economic Review* 93(2): 425–430. https://doi.org/10.1257/000282803321947461.

Wooldridge, J.M. (1995). Score Diagnostics for Linear Models Estimated by Two Stage Least Squares. In *Advances in Econometrics and Quantitative Economics: Essays in Honor of Professor C.R. Rao*, ed. G.S. Maddala, P.C.B. Phillips, and T.N. Srinivasan, 66–87. Oxford: Blackwell.

Wooldridge, J.M. (2010). *Econometric Analysis of Cross Section and Panel Data*. 2nd ed. Cambridge, MA: MIT Press.

Wooldridge, J.M. (2013). *Introductory Econometrics: A Modern Approach*. 5th ed. Mason, OH: South-Western.

World Bank (1993). The World Bank's Role in the Electric Power Sector: Policies for Effective Institutional, Regulatory, and Fnancial Reform, Mimeo, The World Bank, Washington, DC.

Wu, X. and P. Sulistiyanto (2013). "Independent Power Producer (IPP) Debacle in Indonesia and the Philippines: Path Dependence and Spillover Effects." National University Singapore. Available from: http://lkyspp.nus.edu.sg/wp-content/uploads/2013/03/IPP_debacle1.pdf.

Wu, D.M. (1974). "Alternative Tests of Independence between Stochastic Regressors and Disturbances: Finite Sample Results." *Econometrica* 42: 529–46. https://doi.org/10.2307/1911789.

Wu, P.Y. (2005a). "Independent Power Producers in Thailand." Working Paper 51, Stanford Programme on Energy and Sustainable Development.

Wu, P.Y. (2005b). "China's Electric Power Market: The Rise and Fall of IPPs." Working Paper 45, Stanford Programme on Energy and Sustainable Development.

Zhang, Y.F., D. Parker, and C. Kirkpatrick (2005). "Competition, Regulation and Privatisation of Electricity Generation in Developing Countries: Does the Sequencing of the Reforms Matter?" *The Quarterly Review of Economics and Finance* 45(2–3): 358–79. https://doi.org/10.1016/j.qref.2004.12.009.

Zhang, Y.F., D. Parker, and C. Kirkpatrick (2008). "Electricity Sector Reform in Developing Countries: An Econometric Assessment of the Effects of Privatisation, Competition and Regulation." *Journal of Regulatory Economics* 33(2): 159–178. https://doi.org/10.1007/s11149-007-9039-7.

APPENDIX

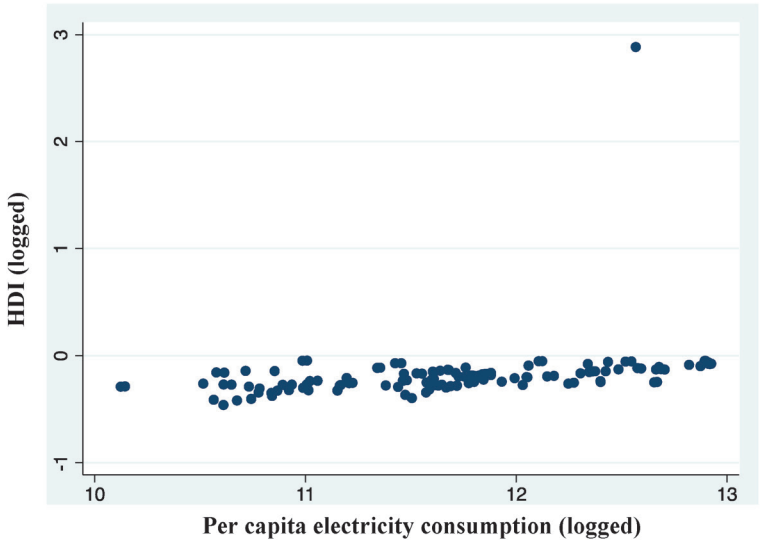
Table A.1: Variable Correlations

	L.Pgdp	L.Ptdl	L. Trpi	Ipps	Reg	Unb	Corp	OAccess	Dprv	L.Trade	L.GINI	l.HDI	L.PRights	L.Pepc
L.Pgdp	1.000													
L.Ptdl	0.719	1.000												
L.Trpi	0.744	0.640	1.000											
Ipps	–0.474	–0.308	–0.386	1.000										
Reg	–0.123	0.088	0.339	0.2303	1.000									
Unb	–0.209	–0.112	–0.008	0.297	0.429	1.000								
Corp	–0.542	–0.059	–0.045	–0.102	0.115	0.669	1.000							
OAccess	–0.558	0.387	0.505	0.210	–0.277	0.131	0.255	1.000						
Dprv	–0.122	0.245	0.205	0.075	0.289	0.198	0.133	0.240	1.000					
L.Trade	–0.042	0.023	–0.065	0.016	–0.021	–0.231	–0.418	–0.045	–0.222	1.000				
L.Gini	0.553	0.414	0.413	–0.369	–0.107	–0.138	–0.032	0.172	0.116	0.131	1.000			
L.Hdi	0.812	0.551	0.705	0.088	0.077	–0.082	–0.028	0.187	–0.098	–0.068	0.761	1.000		
L.PRights	–0.091	0.070	–0.096	0.091	0.409	0.020	–0.344	–0.576	–0.467	0.327	0.047	0.098	1.000	
L.Pepc	0.849	0.906	0.640	–0.095	–0.009	–0.160	–0.076	0.386	0.006	0.123	0.633	0.742	0.180	1.000

Table A.2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Pgdp	408	12018.43	20227.9	123	78688.4
Ptdl	408	130.294	152.18	3.475	1152.9
Pepc	408	1426.97	2234.4	13.271	8514.9
PCap	408	.45608	.65878	.0059	2.5464
PHydro	408	.27109	.74214	0	3.8462
Trade	408	10.641	25.308	0	90.310
GINI	82	38.195	6.2435	27.6	62.69
HDI	131	6.4823	66.869	.347	766
PRights	408	4.8456	1.814	2	7
Trpi	235	3.565	1.964	.40	9.40
Ipps	408	.77941	.41515	0	1
Reg	408	.375	.48478	0	1
Unb	408	.3700	.48342	0	1
Corp	408	.56618	.49620	0	1
OAccess	408	.1348	.34193	0	1
Dprv	408	.15686	.36411	0	1
PCap less Hydro	400	.35648	.62936	.0018	2.546

Figure A.1: Scatter Plot of HDI and Per Capita Electricity Consumption



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