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The promotion of regional integration of electricity markets: Lessons for developing countries

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HIGHLIGHTS

- This paper focuses on how to promote regional electricity cooperation.
- We develop lessons based on comparison of four international case studies.
- The cases highlight both the potential and difficulty of power pools.
- We identify preconditions, institutional arrangements and timetabling.
- We conclude that the future prospects for regional power pools are good.

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ABSTRACT

This paper focuses on how to promote regional cooperation in electricity. We begin by discussing the theory of international trade cooperation in electricity, with a view to discussing what preconditions might be important in facilitating wide area trading across national borders.

We then develop lessons based on the comparison of four case studies. These include three regional developing country power pools – the Southern African Power pool (SAPP), West African Power pool (WAPP) and the Central American Power Market (MER). We contrast these with Northern Europe's Nord Pool. These cases highlight both the potential and difficulty of having cross-jurisdictional power pools.

In the light of the theory and evidence we present, we draw key lessons in the areas of: preconditions for trading; necessary institutional arrangements; practicalities of timetabling; reasons to be hopeful about future prospects.

1. Introduction

The problem of how to promote wide-area trade in electricity is a well-known one *within* individual countries. National electricity markets in advanced countries developed over time as initially local, vertically integrated distribution companies found that there were substantial cost and quality of service advantages to horizontal integration and interconnection between service territories. While some countries developed near monopoly generation utilities which made use of a national transmission system (e.g. France), other countries did develop (limited, but in some cases substantial) trading between continuing regionally vertically integrated utilities (e.g. Japan and the United States). The creation of a national or wide area electricity transmission system which is centrally dispatched has been key to the promotion of trade in electricity.[1] Such a system physically allows energy from different power stations to be directed towards supplying given electrical loads from a common 'power pool'.

Clearly physical interconnection is necessary, because without it no electricity can flow across pre-existing electrical boundaries. Traditionally countries have been very reluctant to trade electricity across borders and hence have limited the construction of cross-border transmission lines. This is actually unusual in energy. For 2012, globally exports of electricity are around 3% of total production, in contrast to c.52% for oil (and Natural Gas Liquids), c.31% for gas and c.17% for coal (with the average for all goods and services being c.31%),[2] suggesting that there may be substantial scope

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[1] See for example Foreman-Peck and Waterson (1985) who document the emergence of a national integrated transmission system in the England and Wales.

[2] See IEA Electricity Information 2014, p.II.3–II.4; IEA Oil Information 2014, p. II.33–II.41; IEA Natural Gas Information 2014, p.II.21–II.27; IEA Coal Information 2014, p.II.4–II.10; and UNCTAD Statistics for world exports and world GDP.

for increased trade in electricity across the world.

This paper will focus on the institutional arrangements for facilitating electricity cooperation. We have in mind the application of the lessons in the paper to other regions, such as the South Asia Region (SAR), namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. These countries are part of a free trade area – SAFTA (South Asian Free Trade Area, formed in 2006).The South Asia Region currently exhibits very little trade in electricity but exhibits significant potential for beneficial trade.

We begin by discussing the theory of international trade cooperation in electricity, with a view to discussing what preconditions might be important in facilitating wide area trading across national borders. Next we will introduce four case studies. Arguably, the most successful international power market in the world is Nord Pool (which includes Norway, Sweden, Finland and Denmark). We compare this with three regional developing country power pools – the Southern African Power pool (SAPP), West African Power pool (WAPP) and the Central American Power Market (MER). We will then go on to draw key general lessons on the promotion of electricity trade across borders based on the theory and experience.

2. The theory of cooperation and international trade applied to electricity

In thinking about the institutional arrangements that might facilitate increased cross border trade in electricity, it is useful to think about ideal electricity market design and institutions. Hogan (1995) suggests that a wholesale pool spot market and an independent system operator (ISO) should go together. This is because short term generator dispatch and short term transmission system operation are 'two sides of the same coin' (Hogan, 1995, p. 26). This suggests that power trading should be associated with an institution which is also responsible for the operation of the transmission system in real time. Hogan (1998) suggests that nodal pricing of the transmission system access is also desirable unless the networks are relatively simple. Thus the US Standard Market Design – which incorporates these ideas – may be the most sophisticated market design for wide area trading, but it may not be necessary for international trade in electricity.

Other designs may work, but the institutional design of markets is undoubtedly important. Stoft (1996) correctly predicted (prior to the California electricity crisis of 2001) that the institutional conflict between the California ISO and the California Power Exchange might decrease system reliability and lead to inefficient dispatch! Efficient market design is also about the participation of the demand side in the wholesale electricity market. This is increasing in importance in many of the most sophisticated markets, such as PJM and New York (see Walawalkar et al. (2010)). For many countries demand side response inside their own country might be much cheaper at the margin than expanding international imports of power.

A key point about market design is the need for sufficient transmission capacity. Fürsch et al. (2013), in their examination of the European Union (EU), suggest that cost optimal trading within the EU would require 76% more transmission capacity. It is important to note that transmission capacity is not just required at the border to facilitate cross border trading. Loop flows in the electricity system mean that the ability to export/import electricity across one transmission link is dependant on the absence of congestion on other transmission lines, which may be internal to one or other country. Without sufficient transmission capacity cross border trade is going to be limited.

The degree of sophistication in markets may be limited when moving to cross border markets. Brunekreeft et al. (2005) note that locational marginal prices (LMPs) as recommended by Hogan and practiced in the PJM area of the eastern US may be desirable in the EU, but they are unlikely to be politically viable. This may explain why the EU has promoted market coupling between national markets and allows some merchant interconnection, rather than LMPs. Pérez-Arriaga and Olmos (2005) suggest that the problem that LMPs try to solve in the US with 200+ control areas is much less in the EU with 17 to 27 control areas. Clearly having congestion constraints (and their associated prices) imposed internationally is difficult to sell to national politicians.

International trade is always mutually beneficial under the assumption of costless adjustment of factors of production (and the other assumptions of the Heckscher–Ohlin model of international trade). However this assumption of costless adjustment is not clearly satisfied when it comes to the sectors affected by electricity trading. While one might assume that factors of production in the electricity sector can be moved to other sectors (the capital, labour and materials employed in fossil fuel based power production are reasonably fungible), it is not so obvious for electricity intensive industries. These industries, such as mining, glass, chemicals, may be dependant on cheap domestic power. If increased power exports leads to rising domestic electricity prices, this may undermine their comparative advantage, necessitating wider (costly) factor allocation adjustment within the economy.

International trade in electricity may however alter the risk profile around electricity prices. This is a version of the 'energy security' problem. In theory if two countries begin trading electricity this will normally provide some insurance against large shocks to electricity prices. This will be the case where their domestic supply/demand risks are either independent or negatively correlated. However clearly there will be some imported price volatility and the possibility of a large supply/demand shock in one country inducing a large price effect in the other country, which it could have avoided under a no-trade (autarky) in electricity situation.

Over time, there is the possibility that dependence on imports of electricity might develop and domestic production facilities might close. This could expose an importing country to a hold up problem if the other country refuses to export. However, in reality these would seem to be second order (and manageable) risks associated with increased trade dependence. It is worth pointing out that such energy security risk is two – sided, as the exporting country might become equally dependant on the export revenue from electricity sales.[3]

Trade theory has become increasingly concerned with considering departures from the assumptions of the basic Heckscher–Ohlin model. Markusen (1981) showed that if markets were initially monopolised a large country opening up to trade might suffer a loss of welfare due to the competition from another monopolist in the other country in a two country trade model. However Lahiri and Ono (1996) show that this result does not hold if new firms enter. Trade liberalisation becomes beneficial again. The general result of Dixit and Norman (1986) emphasises that trade can always be made beneficial as long as consumption and income taxes can be used to compensate losers within an economy.

An important question in international trade theory is whether trade worsens the natural environment. This might be a concern for electricity trading where exploiting low cost resources might involve burning more coal in a low generation cost country. Antweiler et al. (2001) find that trade is generally good for the

[3] We discuss the dependence of Bhutan government revenue on electricity export income in the final section. This surely makes them a more reliable supplier of electricity than would otherwise be the case.