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ECONOMICS AND THE DEVELOPMENT OF SYSTEM OPERATORS IN INFRASTRUCTURE INDUSTRIES

Martin Cave and Jon Stern
Centre for Competition and Regulatory Policy (CCRP)
City University London

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Economics and the Development of System Operators in Infrastructure Industries

by

Martin Cave[1] and Jon Stern[2]

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Abstract

This paper discusses the role of system operators (SOs) in four infrastructure industries: electricity, natural gas, railways and water supply. It describes the types of system operator and their role as co-ordinating entities. The paper relates the role of SOs to the problems of economic discrimination that arise in partially or wholly vertically integrated infrastructure companies and the introduction of upstream competition over networks. The paper discusses short, medium and long-term issues that arise and indicates the relevant economic theory framework for tackling each of them as well. It also discusses the SO variants observed for the four industries in the UK, the US and the European Union, with their strengths and weaknesses.

Keywords: System operator, infrastructure, co-ordination, discriminatory behaviour.

[1] Imperial College Business School and Competition Commission, London

[2] Centre for Competition Policy and Regulation (CCRP), Department of Economics, City University, London

1. Introduction and Scope of Paper

In this paper, we consider the role of system operators of various types (including 'virtual' system operators**)** in infrastructure industries such as electricity, natural gas, railways and water supply. We focus primarily on some general issues about system operators (SOs) – what they are and what they do as well as their historical development over the last 20 years, before a short discussion of their functions and organisation in different industries. We outline the roles of alternative types of SO both in single-area jurisdictions – primarily nation states, except for water supply; and also in multi-area jurisdictions e.g. groupings of states or, for water supply, of regional water markets[3].

Our focus is primarily on arrangements that have been agreed or are proposed for the European Union (EU). However, much of the development of SOs has been in the US. The development of 'explicit' SOs as separate institutions, i.e. *independent* system operators (ISOs), started in US electricity in the 1990s. In this paper, we discuss SO arrangements that have been implemented or proposed for (a) electricity, (b) natural gas, (c) railways and (d) water supply. These are the classic infrastructure industries relying on a monopoly physical network for the delivery of an upstream commodity to downstream retailers and customers.

Within the EU, there has been a long debate about the role of SO-type institutions for electricity and gas with extensive argument over preferred variants. The 3rd Package of 2009 appears to have settled the debate at least for *national* electricity and gas arrangements, even if a number of EU Member States have not yet transposed it into national legislation[4]. However, the EU debate has now moved on to the goal of creating an EU-wide single energy market, for which the target date of implementation is 2014. A single European energy market with *multi-national* arrangements involves major new and difficult issues: technical, economic and political – particularly in gas. Finding effective SO (and SO-type) arrangements are at the heart of this debate.

For railways, system operator functions have existed from at least the 1840s. As railway networks developed, there was a need initially for common track gauges across areas and for agreed timetables - as well as for common signalling procedures, common emergency procedures, rail network expansion plans and investments, etc. The nineteenth century compilers of railway timetables were the first modern SO, even if they were not given that label at the time. They were particularly important in countries like the UK, where there were multiple train companies operating on the tracks.

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3 This paper is very largely derived from material reported in the CERRE Study *"The role of system operators in network industries"*, July 2012 by Jon Stern, Martin Cave and Guido Cervigni. We would like to acknowledge financial support from CERRE. We are also grateful for helpful comments from Chris Bolt, Martin Crouch, Bruno Liebhaberg, Tom Kiedrowski, Cathryn Ross, Jonathan P Stern, Tim Tutton, Katja Yafimava and participants at an LSE Seminar held in June 2012. The authors alone are, however, solely responsible for all the views expressed in this paper.

4 By February 2012, according to EU Energy Commissioner Günther Oettinger, only 13 EU Member States had fully transposed the 3rd Package Directives into national legislation, something that should have been done by March 2011. 7 Member States had partially transposed it and 7 (including the Netherlands) had not transposed it even partially.

For water supply, explicit SOs are unknown outside Australia. Vertical integration without any explicit SO remains the overwhelmingly dominant - and largely unchallenged – model, although Ofwat (the England and Wales water and sewerage economic regulator) initiated a consultation about functionally separated SOs in 2010. The Ofwat proposals however attracted little support and have not been pursued.

In what follows, we will firstly discuss in more detail the general economic issues behind the SO and variants debate, including competition issues. We will use that framework to amplify and organize the discussion introduced in this section.

2. What do systems operators do, and why?

2.1 What are systems operators?

'Systems operation' and 'system operators' are terms which have only recently begun to feature in the debate about the regulation of network industries. But just as M Jourdain had spoken prose for forty years without realising it, so the systems operator function was largely unrecognised in the utility sector for decades, until liberalisation made it necessary to bring it out into the light.

The simplest definition of a system operator is that it controls access to the network by service providers and (possibly) extensions to it.

Note that this definition can readily apply within the context of:

(i) a single vertically integrated utility with multiple upstream sources and a single retailer distributing the product over a network across a wide geographic area;

(ii) a fully ownership unbundled network with competing upstream and/or downstream suppliers; and

(iii) intermediate models with (a) limited upstream and retail competition and with or without network unbundling.

The system operator is thus the key co-ordinating entity. This is set out in Keyworth and Yarrow as follows: [5]

> *"Less familiar [than regulation] is the development whereby the distinct service activity of 'co-ordination', supplied to companies in the relevant sectors, has been identified and whereby responsibility for its provision has, subject to regulatory supervision, been allocated to a specific organisation or part of an organisation (a 'system operator')."*

In classic monopoly utilities, where vertical and horizontal integration is complete (including monopoly control of imports and exports), there is still the need for some kind of SO activity. Power from various generators has to be physically delivered over a network to local supply

[5] T Keyworth and G Yarrow, Economics of Regulation, Charging and Other Policy Instruments with Particular Reference to Farming, Food and the Agri-Environment, RPI, 2005, p. 29-30.

entities and then to retail customers – and similarly for gas, water and train movements. However, one would not expect to see a separate SO entity. Rather one would expect to find one or more divisions or branches of the company undertaking the necessary co-ordination over the various SO functions. We call this an '*implicit*' SO arrangement. Its importance for the physical and engineering activities of the company is very important, even if its effect on competition and market structure is by definition zero.

At the other extreme, we observe fully unbundled systems with ownership separation of the network. In this model, SO arrangements are crucial in economic as well as administrative terms. Indeed, it is the SO arrangements and their integration with the network that is crucial for the effective operation of upstream and/or downstream markets. Here, we have '*explicit*' SOs.

2.2 Types of SO: ITSOs, ISOs, ITOs and Virtual SOs

At the single area level, the most obvious example of a fully unbundled model is where there are competitive upstream (wholesale) and downstream (retail) markets with the traded commodity being sold over a monopoly physical network which is in ownership separate from upstream and downstream markets. In this model, the SO is frequently integrated with the transmission operator into an ITSO – an independent transmission and system operator. The classic ITSO examples are US natural gas, England and Wales electricity and GB[6] railways. A key point is that the network company revenues come solely from network charges; at no stage does the network company buy, sell or trade in the relevant commodity (or service).

However, other SO variants exist along with upstream and downstream markets that are competitive at least to some degree. These other variants include ISOs and ITOs (independent transmission organisations).

ITSOs have typically been the recommended SO variant in single areas both for natural gas and electricity[7]. However, even in those circumstances, there are potential conflicts of interest between SO and TO functions over transmission investment and operation e.g. with the SO part of the ITSO having an incentive to favour the transmission development plans of the TO part.[8] In consequence, the system operation function is often weakly separated and separately regulated from the transmission function (as in Britain).

A growing pressure on ITSOs is that, increasingly, the operation of integrated transmission systems and upstream energy markets covers more than one transmission area, e.g. as the areas covered by transmission systems expand to cover more than one network; and/or transmission ownership becomes diverse within an area (viz. UK offshore transmission grids). Hence, we see ISO and similar arrangements developing out of ITSOs. This has happened in British electricity where there is a GB ISO covering the England and Wales ITSO and two Scottish ITSOs.

Similar issues are beginning to arise within railways, most obviously in the UK. In the UK, for operational purposes, Network Rail (NR) has divided its network into ten "routes". Not

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6 GB (Great Britain) covers England Wales and Scotland but not Northern Ireland.

7 See Joskow, (2007), Kwoka, (2010) and Stern (2010)

8 See Pollitt (2010).

surprisingly, this is raising questions as to whether the current NR ITSO should be unbundled into separate a national ISO and a set of regional TOs, particularly if joint ventures or similar develop between some NR "routes" and regional train operating companies.

ISOs are the main alternative to ITSOs. The explicit ISO model can be very effective at short-tem co-ordination, contract execution and even investment planning. However, some other entity has to make and finance network investment – SOs are very asset-light entities that do not fund investment other than in computer control systems and similar. That makes it very difficult to put high-powered regulatory incentives on the SO. US electricity is the classic example where explicit ISOs have developed over the last 25 years for single states California and Texas) and across regional areas (e.g. PJM and New England).

Within the EU, ITOs have been proposed as a way of avoiding the problems of vertical integration in upstream and downstream markets but without losing economies of scope and scale (including investment financing). The French and German Governments lobbied hard for ITOs to be allowed as options for electricity and gas in the 3rd Energy Package of 2009, although the German energy infrastructure now seems to be moving quite rapidly towards ITSOs in both electricity and gas.

ITOs were the chosen option in France and some other (mainly central and east European and/or small) countries for gas, and to a lesser extent for electricity. The question is whether they will result in a sufficiently significant degree of network separation and information segregation so as to result in genuine upstream competition. The fear is that, reflecting the eoonomic incentives at work, they may be just be independent on paper. However, ITO proposals in the EU have to satisfy both national energy regulatory agencies and the EU Commission. The latter, in particular, seems to be taking a tough line.[9]

In the ISO model, financing network investment is typically achieved by the designated regulatory agency allowing the recovery of efficiently incurred and approved capital and operating costs in access charges (e.g. electricity and gas transmission charges, rail network access prices).

An important recent SO variant is what we term a '*virtual*' SO. This is becoming the dominant model in the EU, particularly for multi-area markets. Consider the Nordic electricity market, which is the key model for EU regional electricity and gas markets. There is a Nordic electricity trading market (Nord Pool). In addition, each Nordic member state has its own national ITSO which is regulated by its own national regulator. These markets are physically linked by interconnectors. The co-ordination of interconnector access and access to national grids is handled by Grid Codes and inter-transmission company co-operation and not by an explicit SO.

Looking more closely at multi-area jurisdictions, the 'virtual' SO model continues for the Nordic electricity markets and appears to be the basis for the EU electricity Target Model; the latter is intended as the basis of the Single EU electricity and gas markets[10]. Already, this model has been

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[9] See ITO proposals for French electricity as regards which the Commission Opinion resulted in a significant enhancement of separation relative to what had originally been proposed.

[10] The 'virtual' SO model is important in the discussions of the EU gas Target model. However, it is not the only model under discussion and, for various reasons, progress so far has been much slower and much more contentious than for electricity. See Section 3.2 below.

used more widely in the EU as upstream electricity markets expand to cover wider areas e.g. the Central Western Europe (CWE) electricity market coupling arrangements that have been in place since 2010. CWE has also been market coupled with the Nordic electricity market since 2011.

As will be discussed below, the 'virtual ISO' model has strengths and weaknesses but it is an obvious choice where the areas covered by the generation market and the transmission network have no single regulatory agency overseeing their activities. Neither the Nordic market nor CWE nor others have a FERC (or Ofgem) equivalent. There is a recent and weak EU-wide regulatory agency in ACER, which has to approve Target Model rules and codes but it is not a 'day-to-day' regulator like the national energy regulatory agencies.

Table 1 below sets out for electricity, natural gas, railways and water the current observed incidence of the different types of system operator in the EU, the US and some other OECD countries.

Table 1: Type of System Operator by Infrastructure Industry

	Industry		**Electricity**	**Natural Gas**		**Railways**	**Water Supply**
Type of SO							
Implicit SO			Very frequent in traditional vertically integrated companies	Very frequent in traditional vertically integrated companies		Very frequent – timetabling and similar functions	Extremely frequent since vertically integrated monopoly franchises still the norm
Explicit ISO			Dominant model in US multi-area jurisdictions. Of growing use in other multi-area contexts e.g. Great Britain	Observed in some single area EU and other jurisdictions (e.g. Ireland, Netherlands and Sweden). Suggested for multi-area jurisdictions e.g. in EU.		Rare but some initial proposals emerging for EU multi-area and some larger countries.	Embryonic SOs in Australia; otherwise not known
ITO			An EU model to adopted in France and some small EU	An EU model adopted in France, some central and East		Not found	Not found

			countries.	European countries and small countries			
ITSO			Dominant model in single area EU countries and similar, except for France and some smaller EU countries.	Dominant model for US inter-State gas transport. Common for larger individual EU countries, including GB, Germany, Italy, Spain.		UK and Australian interstate rail network main known examples	Unknown
Virtual ISO			Becoming important in EU – Nord Pool and developing model for EU Single Electricity Market (Unclear whether will evolve into explicit ISO at least for interconnectors)	Proposed for EU Single Gas Market (Unclear whether might evolve into explicit ISO at least for interconnectors)		Possible for EU international rail but no proposals as yet	Unknown

Sources: Various as reported in CERRE Report on SOs, July 2012

3. A competition policy perspective

This section discusses how the application of competition law gives rise to pressure to develop the types of SO discussed in the previous section.

The main reason for focusing on competition issues is that the modern discussion of SOs starts with their role and development in US electricity as upstream generation competition was introduced into a world of vertically integrated utilities from the 1980s[11]. The US electricity SOs were primarily devised to try to prevent the discrimination by these vertically integrated

[11] During the 1970s and after, the US gas industry created a set of fully unbundled interstate high pressure gas transportation companies as ITSOs. They (unlike the electricity ISOs) have a single regulator – FERC. The US gas history is thus very different – and much more successful in competition policy and other terms than the equivalent gas history. See Joskow (2009) and Stern (2011).

companies against outsider generation e.g. generation commissioned under the 1978 PURPA (Public Utilities Regulatory Policy Act) onwards. This process was accompanied by the evolution during the 1990s of the 'tight pools' of the Eastern US into integrated multi-State wholesale generation markets. Successive reforms to the resulting wholesale electricity markets has led to the development of ISOs with progressively more autonomy[12].

The starting point for a competition perspective is that *some ownership structures give the former monopolist the means and the motive to distort competition and to foreclose entry into the competitive service provision segments of the network industry value chain*. This has attracted competition authorities to the notion that <u>either</u> (a) the motive should removed by full ownership separation <u>or</u> (b) that the means to distort competition should be removed by separation, better regulatory enforcement - or by the insertion of an independent SO. (Note that the creation of a separate SO – particularly ITSOs - is typically a major part of a separation approach.)

This section briefly reviews where competition investigations have led, taking the EU's 2006-7 Energy Market Inquiries as a classic example. As has already been noted, the issues raised by the energy inquiry have been addressed both by the Commission's use of its competition law enforcement powers, and in the 3rd energy package of 2009. But it follows from the discussion which follows that inadequate SO arrangements leave a vertically integrated incumbent in any sector open to charges of abuse of a dominant position.

3.1 A summary of the relevant competition theory.

We begin with the case of a fully separated network operator. From a competition law point of view, this operator could maximise its profits by acting as a perfect price discriminator. Even if it were imperfectly price regulated it would still have an incentive to make excess returns and to price discriminate.

A network operator also permitted to be active in the services market would have no reason to take up that opportunity if it could extract the full monopoly profit from its control of the network, unless it were more efficient than its rivals in the service activity. This follows from the proposition that 'you can only make a monopoly profit once'. However, as noted above a network monopolist is likely to be regulated to some degree as to its prices and constrained in the profit it can make there. This will give it an additional incentive to gain power in the service market, for example by applying a margin squeeze and eliminating or weakening its competitors there. However, this is unlikely to escape detection.

Accordingly, it may have to fall back on non-price discrimination, also known more colourfully as 'sabotage.' Such a policy is likely to be profitable if the network operator satisfies the following conditions: [13]

- its monopoly activities are regulated to be cost reflective;

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12 The most obvious examples are Texas and the PJM RTO. See CERRE Report (2012), Stern (2011) and Pollitt (2010).

13 Beard, T., Kaserman, R.D.I. &.Mayo, J.W. (2001) Regulation, vertical integration and sabotage. Journal of industrial Economics, 49(3), 2001, 319-333.

- the services market is homogeneous;
- the integrated firm is an efficient service provider.

Since for most infrastructure industries these conditions are likely broadly to be fulfilled, the possibility of non-price discrimination is a very real one.

The traditional response is to sharpen regulatory oversight and enforcement – regulation by conduct, but this may fail, especially if the conditions for convicting and punishing a transgressor are stiff. Accordingly, attention may turn to some form of separation – regulation by structure - which will either remove the motive to discriminate or make it harder to get away with.

Only full ownership separation of the network (i.e. creating a fully ownership unbundled ITSO) totally removes the motive to discriminate. Various forms of separation less than ownership separation, including functional separation, may go part of the way – for instance, if they make it easier to establish whether service providers affiliated with the network are being treated in an equivalent manner to those not so affiliated. It may also help to detach the bonuses of network employees from the financial success or otherwise of the service providers, but if the labour markets are not separated, this may not work if a manager might switch from one activity to the other.

One form which the separation could take is hiving off the key tasks of traffic management and capacity allocation – but not the transmission network - to an independent body. The latter becomes an explicit ISO or similar. ITOs and 'virtual' ISOs create a semi-independent version of this.

We now turn to a worked example of a competition authority going through precisely the thought process outlined above.

3.2 The European Commission's Energy Market Inquiry 2006-07.[14]

One of the fullest explorations of the issues discussed above is in the EU Energy Inquiries carried out and published by DG (Comp) in 2006-07. Subsequent changes, including the 3rd Energy Package of 2009 and the plans to introduce integrated EU electricity and gas markets by 2014, arise directly from this set of inquiries.   These have led to moves towards ITSOs at national level in most West European EU countries at national level for electricity – (with the exception of France) and, to a lesser extent, in gas. They have also led to the successful development of inter-linked 'virtual' ISO models for regional electricity markets (e.g. CWE and Iberian electricity markets) and some embryonic proposals for similar multi-area 'virtual' ISO models in natural gas[15].

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14 See Communication from the Commission: Inquiry pursuant to Article 17 of Regulation (EC) No 1/2003 into the European gas and electricity sectors (Final Report). {SEC(2006) 1724}

15 There have been some suggestions of explicit ISO models for multi-area EU electricity and gas ISOs e.g. from Glachant and Newbery, but so far, these have had little impact. See CERRE Report Section 4 for more details and references.

The energy market inquiry, published in 2007, found many serious defects in the operation of supposedly competitive electricity and gas markets in Europe, which can be summarised as follows:[16]

(i) at the wholesale level in particular, market concentration was found to be high.

(ii) an insufficient level of unbundling between network operation on the one side and supply and/or generation activities on the other side resulted in vertical foreclosure preventing potential competitors from entering the market and threatening security of supply.

(iii) insufficient cross-border capacities and different market designs constituted an obstacle to further market integration. Existing network capacities were found to be largely controlled by incumbent companies which had only slight incentives to expand their network capacity for the benefit of their competitors.

(iv) market entry of new competitors was further hampered by information asymmetry between incumbents and market entrants.

(v) the lack of efficient and transparent price formation was a key reason why the opening of the energy market had failed to result in benefits for consumers.

(vi) long contract durations, the lack of competitive offers from non-incumbent suppliers and restrictive practices in relation to the operation of supply contracts had resulted in the foreclosure of downstream markets.

The focus in the points above is on breaches of competition law relevant to the co-ordination function carried out by SOs. *The basis conclusion of the inquiry was that each of the three of the core SO activities identified below ('traffic management,' capacity allocation, and 'network expansion') was seriously tainted by discrimination in favour of vertically integrated incumbents.*

The instantaneous traffic management abuse is illustrated by the case taken by the Commission against E.ON, the (previously) integrated German energy firm.[17] The 'balancing' component of that case found that in performance of its necessary balancing function, E.ON as a transmission systems operator favoured its own generation affiliates when purchasing balancing services. It did so by choosing to purchase the form of balancing power which was produced by its generators, rather than one produced by their rivals, thus abusing its dominant position under Article 82 TFEU.

The capacity allocation issue is illustrated in a variety of cases concerned with refusal to supply transportation capacity to competitors by a number of stratagems carried out by the vertically integrated incumbent, including:

(a) inadequate capacity management, particularly on interconnectors where there was relatively significant amounts of unused capacity

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16 Ulrich Scholz and Stephan Purps, 'The Application of EC Competition Law in the Energy Sector', Journal of European Competition Law & Practice, 2010, Vol. 1, No. 1, pp. 37-51.

17 Ph. Chauve et al. The E.ON electricity cases: an antitrust decision with structural remedies', Competition Policy Newsletter, no. 1, 2009, pp. 51-54.

(b) capacity hoarding and degradation

(c) long term interconnector capacity bookings by the incumbent vertically integrated electricity and gas companies

(d) evidence of serious margin squeeze.

Finally, in relation to network expansion, the energy sector inquiry addressed the issue of strategic underinvestment. This occurs when a network operator deliberately creates a shortage on capacity on the back of which it discriminates in favour of its affiliated service providers. From the networks point of view, the merit of this weapon, compared with foreclosure of existing capacity, is that what is required is not activity but inactivity.

The Commission made it clear in the E.ON decision that underinvestment can be an abuse:[18]

> "… the mere fact that the current capacities may have been actually used by the essential facility holder for its supply business is not sufficient to exclude an abuse under Article 102 TFEU...
> … a dominant essential facility holder is under the obligation to take all possible measures to remove the constraints imposed by the lack of capacity (e.g. by limiting the duration and volume of its own bookings or by expanding its capacities)."

It is noteworthy that, since this EU competition case was concluded, E.ON has sold both its electricity and its gas transmission networks which now operate as fully independent ITSOs[19].

The Commission's stance in the ENI gas case was stronger. It concluded that, to protect its profits in down-stream gas markets, ENI was prepared to forego investments in expanding transport networks which were likely to be profitable on their own terms. As with the E.ON case, a structural commitment was accepted, which involved ENI divesting its shareholdings in the relevant transmission networks.[20]

It is thus clear that the absence of an independent SO can lead to outcomes in which a network operator might be found to have committed an abuse in respect of each of the time dimensions in which we argue an SO can play a role. Conversely, the presence of a disinterested and fully independent SO can prevent abuses in traffic management, remove the motive to foreclose existing network capacity and, by intervening in the network expansion process avoid strategic underinvestment without jeopardising a regulatory arrangement whereby the network operator is allowed to recover efficiently incurred costs.

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18 E.ON Decision, para. 40 and fn 46

19 See CERRE Report Chapter 3.

20 F. Maier-Rigaud et al. 'Strategic underinvestment and gas network foreclosure – the ENI case', Competition Policy Newsletter, No 1, 2011, pp 18-23.

4. System Operator Functions: Short, Medium and Long-term Co-ordination.

As we have discussed above, there is a need in network industries for an explicit co-ordination function, which differs both from regulation and the operation of the network. This is needed to cope with the significant pecuniary and non-pecuniary externalities which link the now increasingly separated functions of running the network, providing services over it, and protecting end users. [21]

To be more concrete, three key co-ordination problems come to light immediately:

1) ***Short-term traffic management***

With energy/trains/water/voice and data communications coming from all directions, there is a short- term traffic management problem, if congestion is to be avoided. There are also important issues of system recovery, transmission constraint management plus short-term interactions with upstream and downstream markets, including contract fulfilment/compensation.

2) ***Medium-term network access allocation***

The allocation of network access 1-7 days, 1-4 weeks and up to 12 or more months ahead has three dimensions of major consequence for the industry as a whole[22]:

(i) how best to allocate available network capacity among service providers, including allowance for planned maintenance;

(ii) how to ensure that network revenues cover costs[23], particularly when the network itself is investor-owned and self-supporting; and

(iii) how to do the above without distorting competition among or between service providers.

3) Long-run investment and network expansion

Decisions about the expansion/contraction of network capacity have to be made in a way which benefits end users and which does not distort competition among or between upstream or downstream service providers. These decisions are typically regulated by a specified (independent) regulatory agency. However, government departments are also often involved if public funds are involved (as is typical in railways and common in water supply).

SOs can be seen as attempting to answer all of these problems. This is most obvious with ITSOs but it applies in different ways to ISOs - explicit and virtual.

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[21] In this section. we avoid use of the terms 'upstream' and 'downstream', to accommodate different ways in which monopolistic and competitive segments can be combined in a network industry.

[22] It could be longer than 12 months ahead but is shorter than the relevant period for investment planning. Network access bids for gas interconnectors have been made for many years ahead as reported in the EU Energy Inquiry 2006-7.

[23] Including explicit or implicit subsidies where relevant (e.g. railways)

We set out below in more detail what functions an SO may have to deploy to deal with some or all of these problems.

4.1 Short-term traffic management and contract execution: Transactions costs economics

The nature of the ‘real time’ traffic management problem varies from sector to sector. In electricity, the need continuously to balance the network requires very frequent scheduling and the ability to intervene almost instantaneously. Trains run to a timetable, but are subject to sudden variation in the face of unexpected events and, importantly, to emergencies (network failures, derailments, crashes, etc). Other than in emergencies, gas and water are less subject to the need for immediate intervention because the physical systems are less interwoven and less sensitive. In addition, both electricity and water have substantial storage capabilities.

Transactions costs economics (TCE) is exactly about this kind of issue. According to Tadelis and Williamson 2012,[24] TCE deals primarily with adaptation to changes of circumstances in a contractual or other context. ‘Market' and hierarchy’ differ in how they mediate the exchange between parties and settle disputes.

One type of dispute is how to deal with situations in which, because of an unexpected circumstance, two service providers vie with one another for a limited amount of network access. This creates the problem of how best to take immediate account of pecuniary and non-pecuniary externalities. The following diagram shows the two alternatives of an adaptive market transaction and hierarchical one based on an authority-endowed interface co-ordinator or SO. This is shown in Figure 1 below (SP is service provider)[25].

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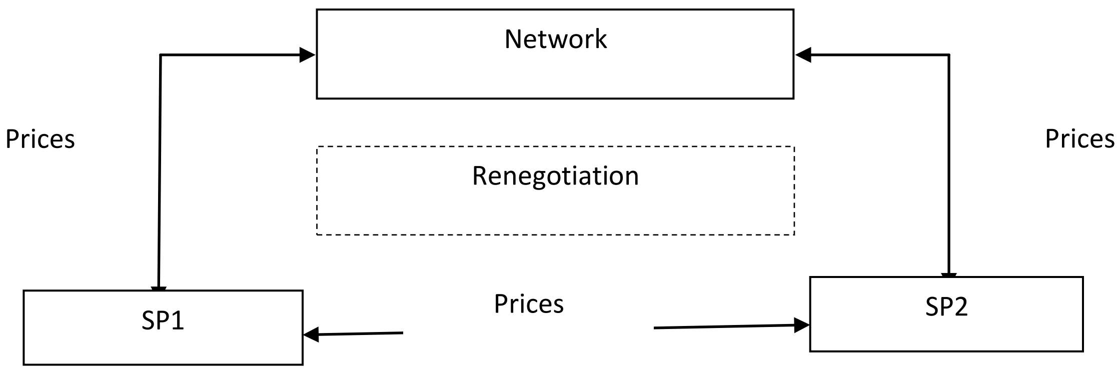
[24] S Tadelis and O Williamson, ‘Transaction Cost Economics’, in R Gibbons and John Roberts (eds.) The Handbook of Organizational Economics, Princeton University Press, 2013, pp. 159-192.

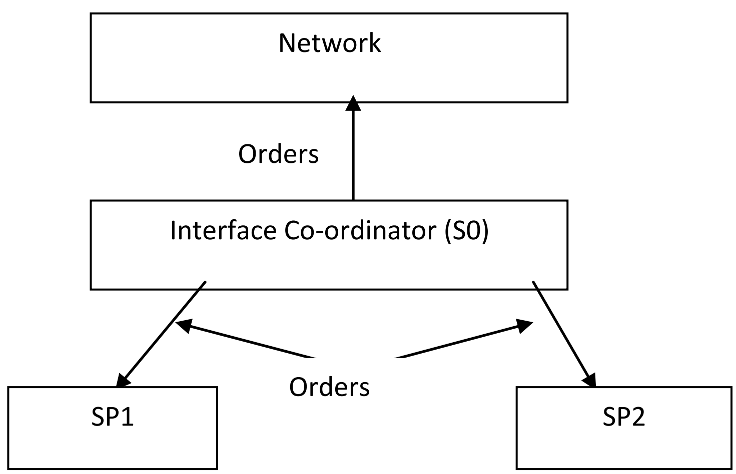
[25] The diagram is a modified version of that on p.167 of Tadelis and Williamson, op. cit.

FIGURE 1 Adaptive and Hierarchical Co-ordination in Infrastructure Industries

(a) Adaptive Co-ordination



(b) *Hierarchical Co-ordination*



In the upper part of the diagram, the independent actors have to scramble to adapt to the problem by renegotiating quantities and prices, leaving contractual disputed to be settled by the courts. In the lower part of the diagram, a bespoke entity - an 'interface co-ordinator' or SO - is created. The parties report to this entity and they receive administrative direction and control back from it. The powers vested in the SO are a proxy for vertical integration. The SO performs its function without using a 'high-powered' incentive system, because, the essence of hierarchy is that it combines low-powered incentives and administrative control.

The advantage of hierarchy is linked with asset specificity. When the asset in question is time-specific access to a specific part of a network, with no alternative use, it is doubly specific. This creates close interdependencies among the parties. TCE suggests that if (a) the network assets were not specific and (b) outside options were available, then market- mediated transactions relying on orderly bidding responses to changing relative prices would have a greater comparative advantage.

Another notion widely utilised in TCE is that of the *incomplete contract*. In an SO context, this can cover unforeseen circumstances which were not specifically accounted for when writing the original contract. Transactions characterised by higher degrees of exogenous complexity result in endogenously chosen contracts that are more incomplete. A useful method of dealing with this is to allow the routine tasks to be performed as planned; but, when disturbances occur, decisions are made by the SO, which exercises unified control over production and adaptation.

An SO-type interface–co-ordinator is also a way of dealing with another concept in TCE as developed by Williamson – *information impactedness*. This occurs when one group has more understanding or information involved in an exchange process than the other group(s). This disadvantage (known or unknown) can make negotiations difficult and/or increase the risk of the exchange. Once again, this situation is more serious when there are small numbers of exchangers in uncertain, boundedly rational situations where the potential for opportunism exists. An impartial separate SO can inhibit opportunism in such situations of information disadvantage.

The second major function an SO typically performs in this time frame is *contract execution*. This may well require sophisticated measurement and calculation, and it also requires the presence in the architecture of the sector of a trusted organisation. As Arrow says, [26]

> "There is an element of trust in every transaction; typically, one object of value changes hands before the other does, and there is a confidence that the counter-value will in fact be given up. It is not adequate to argue that there are enforcement mechanisms, such as police and the courts; these are themselves services which are bought and sold…"

A separated SO can also fulfil this function.

4.2 Medium-term Network Access: Anti-trust Economics

There is a prior question: why have an explicit and independent SO in the first place? Why not just allow vertical integration? This is the question discussed in theoretical terms in the last section. The practical explanation may be found when we move from ex post adaptation to ex ante regulation of network access. The key issue is the much greater problems that vertical integration creates where a monopoly physical network is an essential facility relative to the much lesser problems in other industries.

The recent literature of the causes and consequences of vertical integration in, mostly, non-network industries reach unexpectedly strong conclusions. Two relatively recent papers illustrate this.

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[26] K J Arrow, Information and Economic Behaviour, 1973, p. 24.

Firstly, according to Lafontaine and Slade (2007),[27]

> "We did not have any particular conclusion in mind when we began to collect the evidence. We are therefore somewhat surprised at what the weight of evidence is telling us. It says that in most circumstances, profit maximising vertical integration decisions are efficient, not just from the firms' but also from the consumers' point of view. The vast majority of studies support this claim ... even in industries which are highly concentrated."

Secondly, Joskow (2008) concludes[28]:

> "Overall I would argue that there is substantial support in the empirical literature for various efficiency motivations for vertical integration. There is minimal empirical support for anticompetitive foreclosure motivations. This suggests that there is little empirical support for antitrust law's traditional suspicion of and hostility toward vertical integration and related non-standard vertical contractual relationships except under extreme conditions where firms controlling bottleneck have the incentive and ability to exercise an anticompetitive foreclosure strategy".

This may be true for most industries, but it does not hold for industries with monopoly physical networks. The sad truth seems to be that in network industries 'firms controlling bottlenecks' *do* seem 'to have the incentive and ability to exercise an anti-competitive foreclosure strategy'. Indeed, Joskow himself comes down firmly, in his review of electricity market liberalisation, against the "vertical integration between transmission and generation that creates the incentive and opportunity for exclusionary behaviour." [29]

However, this is the second step. A monopoly network could simply not bother to compete in the services/retail market, and could instead choose to sell access to the network, probably in a complex, non-linear and discriminatory manner, to maximise its short term profits, and expand its network capacity (or not) to maximise its profits in the longer run.

The obvious solution to this problem is regulation. If regulation removes most or all excess profits, the network operator will seek to leverage whatever market power it has to build a strong and profitable position in the downstream market. This can be done by either price or non-price discrimination; the former being more direct but also easier to detect.

The conditions for this being profitable are quite likely to be satisfied, so it is natural to look for counter-measures. One such is vigilant enforcement of regulation. Another is separation of various kinds. A third is to introduce a separated and disinterested SO (an ISO or ITSO) to implement the access regime.

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27 F Lafontaine & M Slade (2007). 'Vertical integration and firm boundaries: the evidence.' *Journal of Economic Literature*, 45, p. 679.

28 P Joskow, Vertical integration. American Bar Association. 2008, http://econ-www.mit.edu/files/1191

29 P Joskow, P. (2008). 'Lessons learned from electricity market liberalisation.' *The Energy Journal* . 29(2), p. 22.

4.3 Long-term Issues: Network expansion and the co-ordination of investment

How can an investment plan for a network be determined? Doing so involves 'integrating' the projected demand of all network users. That can be done by addressing end users. But where the *location* of transmission demand is relevant (as is typically the case), it may be necessary to go to the suppliers. This creates an 'adding up' problem: the sum of the projections of individual suppliers' may not match the overall demand, creating the risk of over-or under-development of the network. An SO, separated from any provider can undertake this investment planning task.

This is an issue which raises for a single sector a topic which some decades ago was much discussed in application to the economy as a whole. The theory of indicative planning addresses the question of whether it is impossible to eliminate some forms of market uncertainty in an economy through co-ordination of forecasts.[30] It was recognised that uncertainty about the environment was impossible to eliminate but hoped that the following types of situation might be avoided: a new investment is required. Either all firms invest, or (in the more sophisticated version) all firms conjecture that all others will invest and so none does. In the latter case, 'an opportunity for all is an opportunity for none.'[31]

The notion of indicative *national* economic planning, after enjoying some apparent successes in the middle of the last century, foundered primarily on the increasing openness of national economies, which made meaningful long term forecasting increasingly difficult.[32] Yet markets for many network industry outputs are predominantly national, so the problem of unforeseeable supplies from outside the national territory is likely to be less damaging to the information content in a forecast. Hence, in practice, we find that indicative planning variants for network and related investment in monopoly infrastructure industries are quite common in many countries.

How might a co-ordinated investment plan be generated? Basically, by two methods, called analytic and synthetic. In the former, the planner forecasts demand, derives where it should be produced and checks the results with the firms involved. This iterative process manages expectations and is intended to generate a consistent plan.

The synthetic route starts from suppliers' expectations or projections. The planner tests these for consistency in the 'adding up 'sense and reports back. Again an iterative process ensues, which is intended to lead to a commonly held, published prognosis of the future.

These methods are reflected in the investment planning of electricity transmission networks. For instance, in the UK, National Grid (from 2002-2011) published annually a 7-year ahead statement of generation proposals in England and Wales plus transmission investment proposals etc. The generation proposals were <u>not</u> forecasts but were generation and transmission investment (and scrapping) proposals that were currently known to National Grid and against which it could plan its transmission investment – but which National Grid expected

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30 J Meade, The Controlled Economy, 1971.

31 G B Richardson, 'Planning versus competition', Soviet Studies, vol. 22, 1971, pp. 433-447.

32 M Cave and P Hare, Alternative Approaches to Economic Planning, 1981, Ch. 7.

to be revised. The projections in the 7-Year Statement were also compared to likely demand and were annually updated by National Grid.

The resulting process was a classic indicative planning approach as applied to an infrastructure industry with a core central (monopoly) physical network which was expanded only by high cost, long lead-time investment[33]. Similar arrangements exist in other infrastructure industries and countries, if less formalised.

4.4 Summary of Short-term, Medium and Long-term SO Functions by Infrastructure Industry

Table 2 below sets out the functions discussed for electricity, natural gas, railways and water and the relative importance of short, medium and long-term SO functions for each of them.

[33] See http://www.nationalgrid.com/uk/Electricity/SYS/current/ for the last National Grid 7 Year Statement. National Grid were proposing for 2012 to replace the 7 Year Statement with a 10 Year Statement; but, instead of that, Ofgem published a much shorter and less detailed Electricity Capacity Statement as advice to the Secretary of State for Energy. See http://www.ofgem.gov.uk/Markets/WhlMkts/monitoring-energy-security/elec-capacity-assessment/Documents1/Electricity%20Capacity%20Assessment%202012.pdf. This reflects the changes in the UK electricity market from a decentralized market model for wholesale generation to a much less decentralized model. Generation planning in England and Wales has since 2008 become more directive rather than simply indicative.

Table 2
Importance by Industry of SO Short, Medium and Long-term Functions

	Industry		*Electricity*	*Natural Gas*		*Railways*	*Water Supply*
Time Period							
Short-term SO Functions (Daily – emergency responses, handling transmission constraint problems, linkage with markets)			**Extremely important** Need for minute-by-minute transmission network flow balancing in conjunction with generation and related markets	**Very Important** Need for balancing on half-daily or daily basis, but gas systems have extensive storage		**Very Important, particularly in meshed networks** Responses to emergencies, failed trains, etc	**Unimportant** Slow speed of water flows, storage opportunities and very limited upstream trade
Medium-term SO Functions (Capacity allocation and			**Extremely important** Especially where transmission	**Very Important**		**Very Important**	**Unimportant** No evidence of any significant network capacity shortage or

related)			constraints or interconnectors are important	Relatively important for single area networks but extremely important on interconnector and transit pipelines		Particularly important in meshed/congested networks and for international services	allocation problems as yet
Long-term SO Functions (Investment planning and transmission investment implementation)			**Very Important** Crucial function – transmission and especially interconnection capacity perceived to be low in both US and EU	**Very Important** Crucial function – especially on interconnector/transit pipelines		**Very Important** Crucial – but in EU countries governments have major role, especially on financing	**Important** Of growing importance, particularly for countries with current or prospective water shortages

5. Effectiveness of SOs

There have been few official studies of the effectiveness of system operator arrangements. The main examples are the 2008 GAO (Government Accounting Office) Study for the US Senate[34] and the 2006-07 European Commission Energy Inquiry discussed above. There have been a number of (mainly US) academic and consultancy appraisals of the effectiveness of electricity and (to a lesser extent) natural gas SOs of varying quality. This literature is surveyed in some detail in Pollitt (2010), Stern (2011) and CERRE (2012). The first two papers extend the discussion to the potential use of SOs in the water supply industry while the last also discusses potential rail SOs.

5.1 Effectiveness of Energy SOs

Over 85% the discussion of the effectiveness of SOs focuses on the effectiveness of SO arrangements in electricity and natural gas and over two-thirds of that discusses electricity. This is reflected in what follows.

Stern (2011) summarises the lessons of the US energy SO literature as follows:

1) Pre-2000 ITOs (first generation SOs with functional separation of single company utility transmission networks) achieved very little. The losses in economies of scope e.g. between generation and retail sales/distribution were not met by any corresponding market or trade benefits. In particular, they failed to provide any adequate remedy to eliminate or even significantly reduce discrimination in favour of own company generation.

2) The general conclusion on electricity ISOs is that they seem to have improved competition in generation, reduced wholesale prices and increased the effectiveness of transmission grid use. They may have reduced prices to retail consumers taking account of all relevant factors but, if so, only by a small amount (e.g. 5-10%).

3) Second generation ISOs (RTOs[35] and 'deep' ISOs with ownership separation of SO functions and transmission management facilities) – but excluding separation of transmission ownership - were more successful but have major problems. The organizational ambiguities create serious problems in terms of corporate governance, cost control and incentive design. ISO co-ordination of transmission maintenance and investment across utilities is difficult.

4) A particular problem with RTOs is on transmission investment - particularly on major investments. Low levels of investment and relatively high levels of congestion costs have continued – at least until end-2008. Interconnection with neighbouring areas remains a serious problem.

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34 *Electricity Restructuring*: A GAO (Government Accountability Office) Report to the US Senate Committee on Homeland Security and Governmental Affairs, September 2008.

35 Regional Transmission Organizations e.g. PJM. New England ISO.

5) The main academic observers (e.g. Joskow and Kwoka) favour ITSOs over RTOs. There is considerable evidence that ERCOT, the Texas ISO, performs well but that is the closest to an ITSO with a single regulator.

6) There have been major weaknesses both in regulatory arrangements (e.g. the division of responsibility between Federal and State regulators) and in competition oversight where monitoring of the new markets has been less than ideal. These also seem to contribute significantly to the much less than wholly successful performance of second generation RTO/ISOs. At best, the verdict on the 2nd generation 'deep' ISOs is "a glass half-full". This is in marked contrast to the US natural gas ITSO model which seems to work very successfully[36].

Stern (2011) cited this evidence and that assembled by the EU Energy Inquiry as strong evidence in favour of the greater effectiveness of ITSO models relative to ISO models in both electricity and gas, where feasible. As will be discussed further below, ITSO feasibility may well be diminishing, particularly for multi-area arrangements, so the validity of the evidence for future EU-wide and similar arrangements may be declining.

On balance, Pollitt (2010) was more sympathetic to ISO models (but also very sceptical about ITOs). However, appraisal of the evidence led him strongly to recommend not-for-profit ISOs. These, he argued had a lot of merit where the benefits from trade are relatively small as compared to the costs of creating an ITSO. Nevertheless, he recognised the problems that ISOs have in sufficiently incentivising new transmission investment, particularly interconnectors. However, against that, he pointed to UK experience with commissioning off-shore transmission, where the bids from non-transmission entities (e.g. financial entities) were much lower, as evidence in favour of ITSO based entities only exercising weak pressure on the proposals for their own transmission arm. But, he suggested that the evidence did not yet point to any clear conclusion as to whether, for electricity and gas,

> " … a not-for-profit ISO with weak financial incentives, or alternatively a for-profit ISO ITSO with potentially perverse financial incentives (in conjunction with the regulator) is likely to give rise to better investment planning." (Pollitt op cit p. 22).

The recent Ofgem review of networks[37] considered unbundling electricity and gas ITSOs but rejected the idea. However, GB electricity remains as an ISO under which separate ITSOs operate.

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36 See Joskow (2009) for a good introduction to US natural gas market developments and the role of the Interstate gas transport ITSOs.

37 RPI-X@20 which later became the RIIO project. See http://www.ofgem.gov.uk/Networks/rpix20/Pages/RPIX20.aspx for a description of the review and links to the main papers, including decision documents.

The experience discussed in the papers listed above also provides useful evidence for the future of EU energy VISOs as they exist in the Nordic electricity market, CWE and elsewhere in electricity and have been suggested for EU gas. One of the main problems with ISOs is their poor performance at encouraging the growth of interconnection transmission. But, VISOs are weaker than ISOs. Hence, there must be even more doubt as to the effectiveness of VISOs with respect to encouraging electricity and gas interconnection. The need for greater interconnection is an issue which EU authorities (and the Energy Inquiry) regularly point up as a major issue for the integration of EU energy markets. This has led some economists to advocate explicit ISOs for the relevant areas[38].

However, VISOs governed by codes as in the Nordic electricity market may also be useful as a pragmatic transitional institutional device to alleviate the worst potential anti-competitive discrimination where it is not possible to have either an area-wide transmission company or an area-wide regulatory agency. Both of these conditions hold in the Nordic electricity market as well as the CWE and the other new multi-area electricity markets. However, given the economic logic as well as experience in the US and elsewhere, experience suggests that the EU VISOs are likely to evolve over time into multi-area ISOs – at least for some functions.

Such developments would, one hopes, also induce regulatory consolidation or at least much greater regulatory co-operation between the national regulators involved in the multi-area markets. (The absence of the last has been a major weakness with the US multi-state ISOs as set out by Joskow and Kwoka.) In its 2006 report defining system operators' core activities, NordREG (the Nordic energy regulators group) hint at this suggesting that good functioning of the Nordel market might need a legally binding Nordic agreement to replace the Nordel Grid Code and four national laws[39].

5.2 Lessons from SO Experience and Railways

There seem to be no extant models of explicit ISO arrangements in rail. The UK experience with a fully-ownership separated ITSO is highly controversial. However, within the EU, train operations have now been at least legally separated from track operations in exactly half of the EU member states, although most of them have been separated only recently so there is little evidence on the relative performance of separated and unseparated rail companies. In addition, OECD and other studies cited in CERRE (2012) come to no clear conclusion as to whether explicit SO unbundling is or is not beneficial in net terms.

The following points are, however, clear about SO arrangements in rail:

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38 See Booz & Company, with D. Newbery and G Strbac (2011), *'Physical and Financial Capacity Rights for Cross-Border Trade'*, R01071. See also Newbery, D. (2012) *'Are current power markets proof-checked for the 2020 challenges?'* Eurelectric Conference, January 2012, Brussels and various papers on both electricity and gas by Glachant.

39 NordREG (2006), *"A Common definition of the System Operators' Core Activities"*.

1) The impetus for explicit SOs in energy has largely been driven by the advance of upstream competition in generation and gas production and the need to reconcile that with control of and access to a monopoly network. As yet, there is very little UK, EU or other 'on-rail' competition and limited 'for-the-market' competition for passenger services[40].

2) For the reasons discussed in CERRE (2012) Chapter 5, there are good arguments for allocating timetabling to be a separated ISO function. These arguments seem particularly relevant in the UK context, particularly if the Network Rail route unbundling is accompanied by train-track regional co-operative ventures.

3) Putting rail network investment planning into an ISO may be useful if (but only if) it provides better information. Given the pervasive role of government subsidies to support rail investment, an explicit ISO might improve transparency. The Pollitt arguments on the incentives for SO arms of ITSOs to favour their own TO arms – or at least to see the world through the lens of their TO arm – would support lodging rail network investment planning in a separated ISO..

However, all of the above is highly conjectural and, as yet, there is little extant evidence to come to any clear-cut recommendation. There may be interesting evidence from economic history, especially from countries (like the UK) where a number of privately owned railway companies operated until well into the twentieth century.

5.3 SOs in the Water Supply Industry

There is little evidence about the relative merits of the alternative models in the water supply industry as opposed to other industries. Australia is perhaps the best example of water restructuring with an explicit SO entity. Single buyer model variants have been introduced e.g. in Melbourne, Victoria and Queensland. The approach adopted is to separate bulk supply from retail distribution and supply. Where there is resource competition, the bulk supplier operates the single buyer facility and sells the water on to the retail distribution and supply company/ies. However, note that there is, as yet, no retail competition in any of these areas. It is also worth noting that Australia is particularly prone to long periods of drought and also of major flooding.

In Melbourne, Melbourne water acts as an ITSO acquiring water from various sources, treating it and selling it to three local (monopoly) distribution and supply companies. A more radical version of this model has been put in place in SE Queensland where Seqwater is responsible for bulk water supplies (a single buyer SO), but Linkwater - a separate company - owns all the major pipelines while the SE Queensland, the water grid manager (and TO) operates the newly constructed water grid. There are also three publicly owned retail-distributors. This structure is clearly familiar to that found in

40 There is more competition in as well as for the market in freight. The degree of such competition is much greater in freight dominated rail systems in large countries, particularly where raw material s are a major element of freight traffic. The US, Australia and Chile are examples of this.

electricity and gas for single areas where there is significant upstream competition. It should also eliminate problems of vertical discrimination.

As this and the other Australian examples have only recently been put into operation, there is little evidence as to the net benefits (or costs) of these new arrangements. However, there are questions about whether the volume and intensity of upstream competition is sufficient to justify this relatively complex structure. Nevertheless, the Australian Government Productivity Commission has proposed taking these and more unbundled models as its recommended basis for the future of Australian urban water supply arrangements[41].

In the UK, Ofwat in 2010 launched a discussion of functionally separated ISOs (ITOs in the terminology of this paper) to operate within vertically integrated water companies in England and Wales. These were intended to foster upstream water trade relative to autarchy and it was hoped that they might successfully address the discrimination problems encouraging excessive investment in – and uneconomic use of - own upstream resources. Both Pollitt (2010) and Stern (2011) were commissioned to provide evidence for that discussion.

Given the absence of direct evidence on the issues from competition in water supply, both Pollitt and Stern made recommendations based on the evidence from electricity and gas experience. Both papers were unenthusiastic about water ITOs. However, Pollitt suggested encouraged bilateral trading and voluntary trading pools so as to move towards one or more water ISOs. He suggested that the benefits from greater trade in water were unlikely to justify the costs of water ITSOs or an early ISO. Conversely, Stern advocated moving towards regional water ITSOs because of the need to encourage significant water reinforcement of and new investment in interconnection. Given EU and US gas as well as electricity experience, he argued that ISOs would do little to foster the interconnection needed to boost inter-company (and inter-area) upstream water trade. He suggested that moving towards regional ITSOs could be combined with the development of scarcity based abstraction prices and enhanced regional water resource planning to foster a water supply industry that would have sufficient flexibility to face the challenges of forecast scarcities in water supplies from medium and long term climate change.

Neither of these proposals has gone far. The England and Wales water companies were strongly opposed even to mandatory ITOs and Ofwat dropped the 2010 proposals, but it has indicated that it might return to the issue after 2014. However, the England and Wales water SO debate shows how the underlying economic logic combined with experience in other industries can help clarify issues and produce potentially useful proposals to develop trade and competition.

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41 See Australian Government Productivity Commission, August 2011, 'Australia's Urban Water Sector'.

6. Concluding Comments

This paper has explained what system operators in network infrastructure industries are as well as what they do and the forms which they can take. This exposition has been put in the context of competition policy and the economic analysis of the consequences of vertical integration of such industries relative to non-network industries.

In general, the required form of SO needed depends on the question being asked. SOs are often seen as the answer to a lot of current questions in infrastructure industries, but the appropriate form depends on the *particular* question being asked e.g. whether the dominant concerns relate primarily to short-term supply and demand balancing, to upstream market co-ordination, to network access arrangements, to investment planning or to investment procurement[42].

The main message of the paper is that SO institutional forms have developed in response to market developments and pressures from the industries. That is as true of railways in the nineteenth century as of twenty-first century infrastructure industries.

The main developments of SO institutional forms – ISOs, ITOs, ITSOs and VISOs – have all been responses to developments in competition, particularly upstream competition in the relevant industry. This is most obvious in electricity where in the US, the EU and elsewhere, the development of competitive generation markets has led to the development of SO variants. These have been devised to address (at least to some degree) the underlying incentives for discriminatory behaviour by incumbents while suiting local circumstances. The latter include area specific transmission network ownership arrangements, generation options, local regulatory arrangements, etc.

SO arrangements also respond to technical developments. The development of small-scale electricity generation plants, the introduction of LNG to gas trading and, above all, the growth in what computerised systems can achieve has allowed the development of markets to an extent that could not have been anticipated 20 years ago. This has been accompanied by contractual and settlement arrangements of much greater sophistication – but which require far more monitoring.

These trends will continue and SOs will respond to these and other pressures. For the reasons explained in this paper, they have become a useful and flexible tool for short, medium and long-term co-ordination in network infrastructure industries. We hope that this paper helps explain why this is so and sets out useful analytic tools for taking forward these ideas into the non-energy network industries as well as developing existing energy sector SOs.

January 2013

42 See Tutton (2013).

References

Arrow, K .J. (1973), *Information and Economic Behaviour*, p. 24. Reprinted in The Economics of Information, Vol. 4 ,1984, Harvard University Press.

Australian Government Productivity Commission, (2011), '*Australia's Urban Water Sector*'.

Beard, T., Kaserman, R.D.I. &.Mayo, J.W. (2001) 'Regulation, vertical integration and sabotage', *Journal of Industrial Economics*, 49(3), 2001, 319-333.

Booz & Company, with D. Newbery and G Strbac (2011), *'Physical and Financial Capacity Rights for Cross-Border Trade'*, R01071.

Cave, M. and Hare, P. (1981) *Alternative Approaches to Economic Planning*, Ch. 7. Macmillan, London

CERRE, (2012) *'The role of systems operators in network industries'* by Jon Stern, Martin Cave and Guido Cervigni.

Chauve P. et al. (2009) 'The E.ON electricity cases: an antitrust decision with structural remedies', *Competition Policy Newsletter*, no. 1, 2009, pp. 51-54.

DG Competition Report on Energy Sector Inquiry, (2007), http://ec.europa.eu/competition/sectors/energy/inquiry/index.html

GAO, (2008). *Electricity Restructuring: Report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate*, GAO-08-987, http://www.gao.gov/new.items/d08987.pdf

Glachant J-M. (2011) 'A Vision for the EU Gas Target Model: The MECO-S Model', *RSCAS 2011/38*.

Glachant J-M. (2011) 'Identifying Benefits and Allocating Costs for European Cross-Border Infrastructure Projects' *EU Energy Policy Blog.*

Joskow, P., (2007), *Independent System Operators (VI + Access Rules vs. ISO vs. ITSO)*, http://econ-www.mit.edu/files/1577

Joskow, P., (2008), 'Vertical integration'. *American Bar Association*. 2008, http://econ-www.mit.edu/files/1191

Joskow, P., (2008). 'Lessons learned from electricity market liberalisation.' *The Energy Journal* . 29(2), p. 22.

Joskow, P., (2009), *Deregulation*, http://econ-www.mit.edu/files/3875

Keyworth, T. and Yarrow G., (2005) 'Economics of Regulation, Charging and Other Policy Instruments with Particular Reference to Farming, Food and the Agri-Environment', *Regulatory Policy Institute Report*, p. 29-30.

Kwoka, J.E. (2010). *Market Structure, Competition and Regulation in Electricity Market Reforms*. Presentation at World Bank Energy Practice Day.
http://www.ios.neu.edu/j.kwoka/WorldbankJK.pdf

Lafontaine, F and Slade, M. (2007). 'Vertical integration and firm boundaries: the evidence.' *Journal of Economic Literature*, 45, p. 679.

Maier-Rigaud, F. et al. (2011) 'Strategic underinvestment and gas network foreclosure – the ENI case', *Competition Policy Newsletter*, No 1, 2011, pp 18-23.

Meade, J. (1971), *The Controlled Economy*, Allen and Unwin, London.

Newbery, D. (2012) *'Are current power markets proof-checked for the 2020 challenges?'* Eurelectric Conference, January 2012, Brussels.

NordREG (2006), *"A Common definition of the System Operators' Core Activities".*

Pollitt, M.G. (2010), 'Lessons from the History of Independent System Operators in the Energy Sector with applications to the Water Sector' *EPRG Working Paper*

Richardson G. B. (1971), 'Planning versus competition', *Soviet Studies*, vol. 22, pp. 433-447

Scholz, U. and Purps, S. (2010), 'The Application of EC Competition Law in the Energy Sector', *Journal of European Competition Law & Practice*, 2010, Vol. 1, No. 1, pp. 37-51.

Stern, J. (2011). 'System Operators: Lessons from US and EU Energy Industry Experience and Implications for the England and Wales Water Industry'. *City University, CCRP Working Paper No.18*.

Tadelis, S. and Williamson, O., (2013) 'Transaction Cost Economics', in R Gibbons and John Roberts (eds.) *The Handbook of Organizational Economics*, Princeton University Press, 2013, pp. 159-192.

Tutton, T. (2013), 'Comments on the role of system operators in network industries', CCRP Research Workshop, City University, London.