

## Paul Lewis Joskow (1947-)

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**JEL Classification**    L43, L51, Q53, Q54, L94

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Paul Lewis Joskow has long been recognised as one of MIT's foremost applied economists of industrial organization. I discuss Paul's research under three main headings: regulatory economics, applied contract theory and energy and environmental economics. What is impressive about Paul's work is the range from theory through to empirical work and his attention to institutional detail. A recurring motif is that he challenges lazy calls for deregulation by carefully pointing out the conditions under which deregulation can work and where the need for continuing regulation lies. All of this he does in the context of listening carefully to what regulators and industry players say about the issues they face, the decisions they need to make and how their industries actually function.

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## Paul Lewis Joskow (1947-)<sup>1</sup>

Michael G. Pollitt<sup>2</sup>

Paul Lewis Joskow has long been recognised as one of MIT's foremost applied economists of industrial organization. He has 25 papers and books with more than 500 Google Scholar Citations as of 27 May 2024.<sup>3</sup> Within the wider profession Paul has been responsible for some of the papers in top journals which have brought the issues of incentive regulation, power market reform and environmental markets into the mainstream.

I first got to know Paul as part of the Cambridge-MIT Initiative (CMI) in 2000. This was a UK government funded collaboration between MIT and the University of Cambridge. In 2024 our research groups are planning our 22<sup>nd</sup> annual joint meeting on energy and environmental policy research. It was Paul who invited me to spend a formative period as a visiting Associate Professor of MIT in the first half of 2003. We had five happy years (2011-16) working together as founding co-editors (with Jean-Michel Glachant as founding Editor-in-Chief) of a new International Association for Energy Economics (IAEE) journal: *Economics of Energy and Environmental Policy*. Paul, Jean-Michel and I have gone on to work on two large edited volumes for Edward Elgar on the basis of our friendship and our shared interests in electricity markets and electricity regulation.<sup>4</sup>

It is a sweet pleasure to be asked to write this review of Paul's contribution to the literature, in the light of my earlier review of David Newbery's contributions in Robert Cord's previous volume (2017)<sup>5</sup>. There is no doubt that Paul and David have been the biggest intellectual influences on my own thinking on electricity market reform. When I think of how an academic economist should approach problems in the area of energy and climate research, I think of them, for both are united in wanting to combine state of the art economic analysis with deep industry knowledge.

Paul's writings are extensive (160 papers by 1 Jan 2024)<sup>6</sup> and I can only offer a flavour of what has been a remarkably productive writing career. As those familiar with Paul's work will know that he writes beautifully but, also, fulsomely! I take Paul's top cited papers as my starting point.<sup>7</sup>

Paul has worked with the best microeconomists in the world. He counts Nobel Laureate, Jean Tirole, and his MIT colleague, Richard Schmalensee, as close

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<sup>1</sup> This is a pre-print version of the following chapter: Michael G. Pollitt, Paul Lewis Joskow (1947-), published in *The Palgrave Companion to MIT Economics*, edited by Robert A. Cord, 2024, Palgrave Macmillan reproduced with permission of Palgrave Macmillan.

<sup>2</sup> With great thanks to Paul L. Joskow for some kind suggestions and Bob Cord for his encouragement. All errors are my own.

<sup>3</sup> <https://scholar.google.com/citations?user=8mQJTxIAAAAJ&hl=en>

<sup>4</sup> Glachant et al. (2021) and Glachant et al. (2024).

<sup>5</sup> Pollitt (2017).

<sup>6</sup> <https://economics.mit.edu/sites/default/files/2024-01/Paul%20Joskow-CV-%20January%201%202024.pdf> Accessed 6 June 2024.

<sup>7</sup> See footnote 1.

collaborators. He has an impressive number of single authored top journal papers. His interests have ranged widely from economic regulation, vertical integration, electricity market design, emissions markets through to CEO compensation and hospital efficiency. His interests have been global: in the US, Europe and Central and South America. Paul is one of the few US academics seriously interested – to the point having researched it thoroughly - in regulatory developments in the United Kingdom (UK) and the European Union (EU). This is marked contrast to many otherwise competent US economists who seem surprisingly ignorant of the world leading incentive regulation experience of incentive regulation in the UK and of the world’s largest (by value) and most successful environmental emissions market: the EU Emissions Trading Scheme for carbon dioxide.

As an undergraduate, Paul studied at Cornell 1965-1968 majoring in Economics. There he was influenced by the great Alfred Kahn – who was a family friend - as Kahn was writing his two volume opus: *The Economics of Regulation*.<sup>8</sup> After Cornell, Paul went Yale to study for his M.Phil. 1968-70 and PhD 1970-72. His PhD thesis was ‘A Behavioral Theory of Public Utility Regulation’ and his advisors were Alvin Klevorick, Richard Nelson and John McGowan. While at Yale, Richard Nelson introduced him to Nobel Laureates Ronald Coase and Oliver Williamson and Williamson became soon became a mentor and good friend. On gaining his PhD, Paul began a glittering career in the Department of Economics at MIT, becoming Head of Department from 1994 to 1998. He finally retired from MIT in 2023 (after only 51 years!) but is still doing research at MIT.

Paul has been active in stakeholder engagement, serving as Director of MIT’s Center for Energy and Environmental Policy Research, CEEPR<sup>9</sup>, from 1999-2007. CEEPR works closely with corporates and regulators and was the inspiration for the Energy Policy Research Group (EPRG)<sup>10</sup> at the University of Cambridge (of which I am part). Paul has been globally influential in spreading good ideas to regulators, companies and the wider stakeholder groups through his extensive corporate work – he has been on the main board of the New England Electricity System (NEES) and of the UK’s National Grid, inter alia.

Paul took leave from MIT from 2008-2017 to serve as President and Chief Executive Officer of the Alfred P. Sloan Foundation. This was a significant contribution to wider academic research as the Foundation gives away c.\$100m p.a. to support research and education in science, technology, engineering, mathematics and economics. He returned to MIT in 2018. Paul has had many excellent PhD students who have gone on to very successful academic careers including Severin Borenstein, Judy Chevalier, Christine Jolls, Daniel Kessler, Donald Marron, Mar Reguant, Nancy Rose, Andrew Sweeting and Catherine Wolfram.

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<sup>8</sup> Kahn (1970) and (1971). See Joskow’s own review of the development of incentive regulation in electricity networks since Kahn’s seminal works (Joskow, 2008a). For a transcript of a nice interview of Paul by Robert Stavins, see [https://heep.hks.harvard.edu/files/heep/files/joskow\\_podcast\\_transcript.pdf](https://heep.hks.harvard.edu/files/heep/files/joskow_podcast_transcript.pdf)

<sup>9</sup> <https://ceepr.mit.edu>

<sup>10</sup> <https://www.eprg.group.cam.ac.uk>

Paul's research brilliance and academic leadership skills have been widely recognised. He was the President of the International Society for New Institutional Economics (now Society for Institutional & Organizational Economics, SIOE) in 2002-03. He is a distinguished member of the International Association for Energy Economics (IAEE), being the 2003 recipient of Outstanding Contributions to The Profession Award. In 2013 he was made a Distinguished Fellow of the American Economic Association (AEA).

Paul's AEA Distinguished Fellow citation says:

'Paul Joskow has made fundamental contributions in three fields: the economics of regulation, organizational economics/applied contract theory, and energy and environmental economics. His research reflects a masterful blend of applied economic theory, detailed institutional analysis, and careful econometrics. Joskow's research has not only advanced economic knowledge, it has also contributed directly to the design of regulatory policy.'<sup>11</sup>

Drawing inspiration from this citation, I discuss Paul's research under three main headings: regulatory economics, applied contract theory and energy and environmental economics. However, given Paul's extensive writings on the final one of these I further subdivide the last heading into: on power markets and their shortcomings; the problem of electricity transmission; emissions markets; and explaining and measuring power market reform. As a bonus, I end with a discussion of two of Paul's other papers on hospitals and CEO compensation.

## **Regulatory Economics**

Paul's first full paper (1972) is 'The Determination of the Allowed Rate of Return in a Formal Regulatory Hearing', which is based on a chapter of his PhD thesis. This paper also combines Paul's interests in theory, empirical analysis and real world behaviour. It includes a beautifully simple behavioural model of regulatory decision making to characterise how the New York State Public Service Commission (NYPSC) is making decisions on requests by regulated utilities to raise rates of return via raising rates (i.e. regulated prices). The model attempts to predict what the allowed rate of return will be with reference to some key regulatory variables, such as the degree of contestation (opposition at the hearing to the rate rise) and the 'reasonableness' of the requested rate rise. This is then tested empirically by analysing the decisions of the New York regulator in response to electricity and gas company requests to the NYPSC over the period 1960-70. The 'reasonableness' variable is measured by comparing the requested return to a predicted return. Paul finds that allowed rates of return, for a sample of 20 rate reviews, are significantly positively correlated with a lack of contestation and a more reasonable request for a rate of return rise.

This is followed by 'Pricing decisions of regulated firms: A behavioural approach' (1973a), develops the theme of his first paper. It examines the actual behaviour of regulated electricity firms in New York State in the 1960s. What Paul finds is that the famous Averch and Johnson (AJ) (1962) effect – where rate of return regulated firms

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<sup>11</sup> <https://www.aeaweb.org/about-aea/honors-awards/distinguished-fellows/paul-joskow>

have an incentive to inefficiently over-invest in capital (so called 'gold-plating') - is an oversimplification. The reality is that firms seek to avoid a rate review, by effectively taking their current prices as fixed, maximising profits subject to these prices. It is only as they approach a lower profit bound would they be forced to seek a price review and only as they approach a higher profit bound would they seek to avoid triggering a rate review. The characterisation of US utilities as being subject to short run profit regulation which encourages inefficient gold plating is thus not the reality and US regulation in conditions of low inflation looks much more like price cap regulation, with a variable regulatory lag.

Paul's general interest in deregulation and the introduction of competition in heavily regulated industries is on display in 'Cartels, competition and regulation in the property-liability insurance industry' (1973b). This paper shines a light on the insurance market (e.g. for property and automobiles) in the US, which was characterised by the early 1970s as exhibiting cost barriers to entry due to intrusive state level regulation specifying high capital requirements and an inefficient system of selling insurance through brokers – the American Agency System. This resulted in high mark-ups and costs relative to using direct sales of insurance through competitive firms. Paul shows that the industry appears to be characterised by constant returns to scale and many actual entrants. However, these entrants face high regulator imposed costs and high regulated prices. He concludes that with reduced regulation, costs and prices would fall substantially. This would in turn produce large welfare benefits and reduce high levels of self-insurance. The paper notes that states with competitive insurance markets, such as California, are not characterised by insurance company failures (as incumbent insurers might claim), but rather by lower prices and higher coverage, as predicted by the analysis. It is recommended that insurance regulators should move away from approving rates to focusing on consumer information and protection. The paper is an early example of detailed institutional description of the industry, empirical analysis of underlying costs and clear policy recommendations.

Paul returns to the theme of the behavioural inadequacy of the AJ model as a representation of the US regulatory system for electric utilities in 'Inflation and environmental concern: Structural change in the process of public utility price regulation' (1974). This paper introduces a number of ideas which have turned out to be significant in the future of regulation, based on detailed observation of actual electricity and gas rate cases from 1949 through to 1972. First, the number of rate cases was low through most of the 1950s and 60s across the US because firms could keep rates (prices) fixed in a low inflation, high productivity environment. It was only in periods when commodity prices rose sharply (1949-52) or when general inflation rose more quickly (1969-72) than productivity that firms were compelled to seek rate rises. Second, environmentalists rightly questioned why utilities were encouraging electricity consumption via falling block rates and encouraged companies to raise the block rates. Paul points out that this has the advantage – for utilities - that average revenue might rise as demand rises, reducing the need to seek rate reviews. Third, the idea of there being a 'regulatory technology' is introduced, whereby regulators have their own way of doing things which is changed by new challenges. The US system of rate reviews worked well for most of the 1950s and 1960s because it facilitated efficiency, falling

real prices and low regulatory costs. However, as inflation and environmentalism took off it had to change. Novel concepts such as cost-pass through of fuel costs or forward looking adjustments to rates in the face of expected cost increases were introduced to reduce the frequency of rate reviews. Similarly environmental pressure led to pressure to increase marginal tariffs thus encouraging energy efficiency and slowing demand growth, but meaning that inflation was less easy to absorb. Finally, Paul notes that regulators often copy each other in implementing new ideas for improving regulation, suggesting that regulatory technology is subject to a diffusion process. Paul's work suggests that the regulatory innovation was happening in the early 1970s, predating the emergence of what we now think of as models of incentive regulation (discussed below).

Paul moves into competition policy in 'A framework for analyzing predatory pricing policy' (1979, with A.K. Klevorick). Predatory pricing occurs when a dominant firm deliberately reduces prices in a way that is designed to deter actual or potential entry into its market. Economic analysis was becoming important in judging whether predation was likely at the time of writing. The paper examines whether a per se test – where a practice is deemed good or bad without further investigation - could be introduced into the process. In predation one such per se test is the Areeda-Turner (A-T) (1975) rule, whereby if a firm is charging below average variable cost, this is prima facie evidence of predation. The paper provides a comprehensive review of the issues around how courts might use economic analysis to identify predatory pricing. Joskow and Klevorick propose a two tier approach. At the first tier, potential cases are screened with a view to not proceeding in cases where the structural pre-conditions indicate that predatory pricing is unlikely, such as where there has been successful recent entry into the market. At the second tier, further economic analysis is warranted. Joskow and Klevorick point out that while the A-T test is one condition for predation, pricing between average total cost and average variable cost could still be predatory, because in the long run the efficient firm must cover average total cost. They also suggest that any temporary price reduction which left prices above average variable cost would not be predatory.

Paul's 'Regulation in Theory and Practice: An overview' (1981 with Roger Noll) is a masterful review of what was known about economic regulation at that date. It was published at an opportune time with incentive regulation about to make a significant and formal entrance into the regulation of utilities, with Littlechild's (1983) paper on RPI-X regulation and Shleifer's (1985) 'A theory of yardstick regulation' (drafted around the same time and with editorial assistance from Paul when Shleifer was an MIT graduate student).

As the authors say '*No comprehensive review of the recent literature exists in any easily available form. For anyone interested in the field—especially students—this makes life fairly difficult.*' (p.2). This paper drives home a number of important themes in what is known and not known about regulatory economics. First, that economists agree that entry regulation is bad for welfare in potentially competitive industries (e.g. airlines, oil and gas production etc.). Second, that environmental, health and product quality regulation are at the frontier of economic regulation research. Third, that economic

analysis needs to move beyond saying that regulation is good or bad or difficult to giving more practical help to the implementation of regulation. Fourth, that economic regulation needs a better understanding of the motivations of legislators and the practical working of regulation itself, suggestion closer working between economists, political scientists and psychologists. Fifth, that new techniques such as information economics, disequilibrium price dynamics, experiments and trails will be important for potential advances. Finally, the article notes that the distributional implications of changes to regulation need to be considered, as these matter more to policy makers than economists tend to acknowledge.

Regulatory economics did indeed move on by the time of Paul's paper on 'Incentive regulation for electric utilities' (1986, with R.Schmalensee). This paper discusses regulation in the light of regulatory practice and the emergence of CPI-X regulation, whereby regulated utilities prices or revenue can be subjected, ex ante, to an adjustment for the rate of inflation (CPI) minus an efficiency factor. This paper highlights that the idea of CPI-X regulation emerged during the inflation of the 1970s (it was first suggested in Kendrick, 1975). However it was only implemented a couple of times prior to 1986 in a reasonably comprehensive form for electric utilities in the US and was subject to legal challenge. Thus by 1986 no electric utilities were subject to CPI-X regulation, but 20 states had some form of partial incentive regulation. These partial approaches targeted generation plant heat rate improvements, reductions in construction costs etc. This paper hints at the difficulty of applying CPI-X to all costs and suggests that it should only be applied to operation and maintenance costs not fuel costs due to fossil fuel price volatility and not to capital costs due to accounting problems. This paper provides a great historical snapshot of the state of incentive regulation in the US electricity sector prior to the deregulation which created competitive wholesale power markets. It also includes reference to the development of RPI-X regulation, evidencing Paul's early interest in lessons from UK deregulation for the US.

### **Applied Contract Theory**

This brings us to Paul's most three most cited papers<sup>12</sup>. These all relate to Paul's interest in transactions cost economics.

'Vertical Integration and long-term contracts: The case of coal-burning electric generating plants' (1985) is squarely located in the transactions cost literature. Taking inspiration from Williamson's (1975) seminal work on transaction costs and vertical relationships between firms, Paul uses his knowledge of the nature of contracts between utilities and coal mines to look at the applicability of transactions cost thinking in this regulated sector. Transactions costs occur when a firm has to renegotiate or monitor a contractual relationship with a supplier firm: they are a significant part of total costs and relate to a firm's decision on whether to conduct activity in house, make use of spot markets to purchase inputs or enter into longer term contracts with suppliers. The focus here is on whether the core concepts from transactions cost theory can explain the contractual and ownership arrangements

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<sup>12</sup> According to Google Scholar Citations, 5 June 2024.



between coal generators and coal mines in the US. As Paul shows, they explain this very well, especially for mine mouth coal generating plants. These mines are all subject to site specificity (deliberate collocation of the power plant to minimise fuel transport costs), physical asset specificity (the coal mine burns a particular type of coal) and dedicated assets (the mine is built to supply the power station). These asset characteristics all suggest transaction cost advantages to close integration of the mine and power plant. All of the reviewed mine-mouth plants are either owned by generating companies or subject to very long term contracts, with contract clauses designed to incentivise the efficiency of the coal mine (often via a form of CPI-X coal price indexing). The conclusion is that these contractual arrangements are both efficient and in line with the predictions of transaction cost theory, and should be encouraged by the utility's regulator. This paper remains one of the best case studies of how transactions cost theory can explain the nature of vertical integration and vertical contracting.

Paul reinforces his earlier results econometrically in "Contract Duration and Relationship Specific Investments: Empirical evidence from coal markets" (1987). This paper looks at 277 coal contracts in force in 1979, written between 1960 and 1979, and regresses contract duration on measures of asset specificity (such as whether it is a mine-mouth plant) which capture the three types of asset specificity which he identified in his previous paper. Paul indeed finds that some measures of asset specificity are strongly correlated (such as being with a mine-mouth plant) with longer contract duration. This paper beautifully highlights how industry knowledge can help with the identification of variables that can then be used in regression analysis to test theoretical predictions.

The third paper in this set is 'Asset specificity and the structure of vertical relationships: empirical evidence' (1988). This was first delivered at a conference to celebrate 50 years of since the publication of Ronald Coase's *The nature of the firm* (1937). Paul's paper showcases recent empirical work on transactions costs and how this relates to asset specificity. He points out that the combination of theoretical understanding and empirical work has been very beneficial in this area. As he says '*I believe that good empirical work aimed at testing theories such as those I have been discussing here requires that we know a lot about the characteristics of firms and products that we are relying on in the empirical work.*' (p.111).

The introduction to this paper includes some insights on Paul's own intellectual journey. He recounts how his own introduction to industrial organization came via a class with Richard Nelson who introduced him to Coase and Williamson and how he read early drafts of Williamson's *Markets and Heirarchies* (1975). Revealingly, he discusses how reading Goldberg (1976) led him to the idea that in assessing the effectiveness of regulation an idealised free market was not a realistic benchmark. This unfairly favoured market based solutions rather than regulatory ones. He also describes how his approach to electricity deregulation was to assume that existing vertical relationships – characterised by the integration of generation, transmission, distribution and retail in electricity - had some efficiency basis. This meant that forced separation of different parts of the industry to create competitive wholesale and retail

markets was less good than a gradualist approach which encouraged voluntary separation.

Paul returns to the topic of vertical integration in 'Vertical Integration' (2010), which is a celebration of Williamson's work on transactions costs and vertical integration. In this paper Paul discusses how transactions costs theory compares to other theories of vertical integration and concludes that it holds up well theoretically and empirically compared to competing theories, while acknowledging that there is no unified theory of vertical integration. What is interesting is that Paul challenges three main alternative theories. First, neoclassical theory which explains, inter alia, vertical integration as a way of internalising externalities. The main problem with this being that two part pricing or contractual alternatives could solve these externalities without vertical integration. Second, property rights theories which emphasise residual control rights in the absence of vertical integration. The challenge here is that the empirical evidence is lacking to distinguish residual control loss (the central concept in property rights theories) from asset specificity in transactions cost theory. Third, principal agent problems of getting the agent to behave optimally which emphasise inefficient risk transfer between the principal and agent as the incentive to vertically integrate. Paul again suggests that it is difficult to distinguish between the risk properties of incentive contracts and vertical integration in practice.

## **Energy and environmental economics**

This has been Paul's most extensive work and it divides into a number of elements.

### ***On power markets and their shortcomings***

As Paul reports in Joskow (1988, p.102) above, he and Richard Schmalensee were commissioned by the Department of Energy in the US, '*to do a study on the prospects and problems associated with deregulation for the electric utility industry*'.

This became their book *Markets for Power* (1983). This book is often cited as a landmark study in support of the liberalisation of wholesale power markets, due to its title and lack of a question mark. It outlines four possible reform scenarios of which one is the creation of competitive power markets, independent transmission entities and separate distribution-retailers.<sup>13</sup> The book points out that existing regulation limits competition and entry into generation and that removing such barriers would likely improve efficiency. However it also gives a more nuanced analysis of the potential for and limitations of deregulation in the power industry. In line with Paul's work on the benefits of market based vertical arrangements, the book cautiously suggests that there are benefits from encouragement to voluntary vertical separation to create competitive power markets. It also suggests that such separation would require new longer term contractual arrangements between generators and transmission entities and between generators and retailers. As one reviewer points out the book gives 'two

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<sup>13</sup> For a review see Dubin (1984).

and one-half cheers for deregulation'.<sup>14</sup> The book's call to proceed with caution, employing a step-by-step and experimental approach<sup>15</sup> when doing electricity market deregulation, even in context of the US, echoes down the following decades in the mixed experience of many developing countries that attempted radical, but botched reforms.

A key problem with competitive wholesale markets is that there remain large numbers of customers on regulated retail tariffs, that regulators are reluctant to expose to wholesale market price fluctuations. This creates a reliability problem whereby electricity demand may not adjust to reductions in available supply via responding to a higher price. This situation is theoretically explored by Paul in 'Reliability and competitive electricity markets' (2007, with Jean Tirole). This paper discusses two problems with the non-responsiveness of demand. Namely, that it may lead to underinvestment in reliability and that it might actually worsen the reliability issue via non-responsiveness. The paper nicely shows that while it might be tempting to suggest that reliability can be left to the market, the possibility of a network collapse due to mismatched supply and demand creates large negative externalities because in a network collapse no generator gets rewarded for being available and hence underinvestment in reliability is likely. The paper therefore shows that regulators desire to protect consumers from wholesale prices necessitates creating regulatory incentives to improve reliability. This can be done by requiring retailers to over procure generation or paying generators to over-supply capacity.

Once US deregulation happened Paul turned his attention to the one of the key problems that it gave rise to: the apparent problem of underinvestment due to the 'missing money' problem. This is discussed in Paul's 'Capacity payments in imperfect electricity markets: need and design' (2008b), as part of an excellent special issue on *Capacity Mechanisms in Imperfect Electricity Markets*. Paul carefully explains why a missing money problem arises: the fact that wholesale prices in a competitive market are at marginal cost and do not cover the capital cost of new plant. This gives rise to a need for an additional payment for providing reliability through additional capacity. This can be delivered by either placing an obligation on retailers to over procure capacity to the value of, say 18% of expected maximum demand, or by allowing the wholesale price to reach the value of lost load in peak scarcity hours or by introducing a capacity market. Capacity markets themselves need to deliver prices which would compensate a new entrant generator. This paper contains clear worked examples of the nature of the missing money issue and its potential solutions.

In the short but well-crafted 'Comparing the costs of intermittent and dispatchable electricity generating technologies' (2011), Paul carefully takes aim at the concept of the levelized cost of generation in the context of comparisons between intermittent (e.g. wind) and dispatchable (e.g. gas) technologies. He argues, rightly, that simply taking the total annual cost per unit of capacity (MW) and dividing it by the number of operating hours to get a levelized cost (per MWh) does not make sense given that the power price fluctuates and that intermittent generation may be more or less available in

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<sup>14</sup> Philipps (1984, p.290).

<sup>15</sup> See Kafoglis (1985, p.162).

high or low price hours. He suggests that the metric of expected profitability per MWh is a better one and provides a more reliable basis for judging whether new technologies such as wind, solar and storage are 'competitive'.

### ***The problem of electricity transmission***

In line with his earlier interest in vertical relationships in the electricity sector that identified the importance of transmission arrangements in deregulated electricity markets, Paul wrote a couple of papers with Jean Tirole on the problem of optimal transmission arrangements.

In 'Transmission rights and market power on electric power networks' (2000) the authors discuss how the allocation of access rights to the transmission system can enhance the local market power of generators, using two and three node representations of the power system. Transmission rights can be two types: physical or financial. Physical rights give a generator the physical right to export from node A (in the North) where it is located to node B (in the South) where the demand is predominantly at B and generation predominantly at A. Where these exports are constrained from A to B, this would mean allowing the generator to access the higher price at B, up to the transmission capacity limit. Financial rights would give the a generator the right to the congestion revenue arising between node A and B, which is the difference between price at A and B, i.e. the difference between the higher price paid by consumers at B and the lower price paid to producers at A. What the authors show is that physical rights in conditions of market power would lead to generators not fully utilising their available transmission rights in order to drive up power prices, while with financial rights they would not be able to prevent sale of the rights to a competitor generator. They go on to suggest that regulators need to pay attention to how transmission rights are being used to increase market power and that physical rights should be subject to 'lose it or use it' clauses to prevent withholding. The paper incidentally demonstrates how continued ownership integration between generation and transmission would lead to increased generation prices and denial of access to third-party generators.

As deregulation of power progressed in the 2000s there was rising interest in whether transmission could be deregulated, in the same way as generation, and the provision of transmission capacity left to 'merchant', i.e. unregulated, investment. This is addressed in 'Merchant Transmission Investment' (2005 with J.Tirole). This paper starts with reviewing earlier work (e.g. Hogan 1992) which had shown that for wholesale power markets characterised by nodal prices allowing transmission owners to collect the congestion rent between A and B (above) would lead to the optimal building of transmission lines (under stylised conditions). This mirrored the actual building of merchant transmission lines in Australia and between the UK and continental Europe. However what the paper then does is to show that merchant investment would not ensure competitive provision of transmission capacity under real world conditions. Specifically, the authors show that in conditions of generator market power, lumpy transmission investment and stochastic use and availability of the transmission capacity, regulated transmission investment was likely to continue to be necessary. This paper nicely explains both why regulated transmission investment remains the

norm but also why in a small number of cases merchant investments have occurred and been very successful.

### ***Emissions markets***

There are two emissions markets that every student of environmental economics must know about. They are: the US market for sulfur dioxide which commenced in 1994; and the European Union's emissions trading system for carbon dioxide which started in 2005. Paul has written definitive accounts of their early successes (and limitations).

The US market for sulfur dioxide (SO<sub>2</sub>) was a large national environmental market, which was enacted in 1990 and commenced operation in 1994. It covered SO<sub>2</sub> emissions from, mostly coal, power plants. These emissions are the primary cause of acid rain, a form of environmental pollution with extensive effects on the natural environment and human health. Joskow served on the Environmental Protection Agency's Acid Rain Advisory Committee tasked with designing the details of the cap and trade system authorized by the Clean Air Act Amendments of 1990. He and his colleagues subsequently went on to document the market's remarkable early success in *Markets for Clean Air: The U.S. Acid Rain Program* (2000, with A.D. Ellerman et al.). It covered around 70% of all SO<sub>2</sub> emissions and led to a significant reduction in emissions of 80% due to economic incentives due to switching to low sulphur coal and the installation of economically efficient flue gas desulphurisation units (FDGs). This market based scheme, covering a non-national pollutant, reduced the compliance costs by an amount of 55%. The scheme also demonstrated the value of banking, trading of emissions between entities and efficient price discovery. Importantly it also illustrates significant lessons on the political economy of introducing price based environmental instruments, as most permits were grandfathered to existing polluters to get them to support the scheme instead of using the revenue to produce a double dividend of efficient emissions reduction and the reduction of other distortionary taxes (as suggested by most environmental economics text books). It was also enacted by a right-of-center administration (under President George H. W. Bush) keen to use market instruments to achieve environmental objectives. With Paul's typical caution in recommending market based solutions, the book points out that carbon dioxide emissions trading would be more complicated due to the many more sources involved, something that happily turned out not to be a big issue in the EU ETS<sup>16</sup>, discussed below.

While *Markets for Clean Air* is a comprehensive assessment of the market, it was precursored in a very accessible 'The Market for Sulfur Dioxide Emissions' (1998, with R. Schmalensee and E. Bailey). This paper provides a great introduction to US Acid Rain program but also focusses on the specific issue of how quickly it took the market to become efficient in terms of price discovery over the period 1993-1997. It does this by comparing prices of emissions permits on different platforms. A focus of this is an examination of the trading in the official Environmental Protection Agency (EPA) auction, which released 2.8% of total permits via a regular auction and prices in

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<sup>16</sup> For an excellent review of the book, pointing this caution out, see Cramton (2000).

secondary markets. Prices in the EPA auction rapidly converged to those of the secondary markets, at the same time as the number of permits traded in secondary markets rapidly increased to dominate total trading. This was in spite of the fact that the EPA auction was not itself as well-designed as it might have been.

Paul's Report on 'The European Union's emissions trading system in perspective' (2008, with A.D.Ellerman) is a rare and remarkable analysis, by non-Europeans, of the EU's emissions trading system for CO<sub>2</sub> emissions (the primary greenhouse gas). The Report brought the experience of its first – trial - trading period 1 Jan 2005 to 31 Dec 2007 to a US audience in the context of early congressional debates about the introduction of a US cap and trade scheme for CO<sub>2</sub>, something which has still not happened at the national level, even though it has at the level of certain individual states. Ellerman and Joskow provide an admiring assessment pointing out the relative speed with which the scheme was implemented and that the associated final market trading of permits rapidly and efficiently established itself. They discuss the early problems of the first phase. These included the over-allocation of permits, combined with a lack of banking of permits to the next trading period, resulting in permits trading at minimal prices towards the end of the period. A key lesson from a multi-country regime being that, individual countries cannot be free to decide their initial allocation of permits. This was however fixed from 1 January 2008, with the scheme remaining in operation -successfully - at the time of writing. As the authors say '*The initial challenge is simply to establish a system that will demonstrate the societal decision that GHG emissions shall have a price and to provide the signal of what constitutes appropriate short-term and long-term measures to limit GHG emissions.*' (p.iv). It remains a sad observation that too few US economists continue to look seriously at the now considerable, successful EU experience of the EU ETS in the way that Ellerman and Joskow did.

### ***Explaining and measuring power market reform***

We next come to a series of papers on power market reform which I remember reading for the first time with great fondness, as each of them have become old friends to which I make regular reference in my teaching and research. These papers exhibit Paul's attention to the facts and a desire to bring issues in the deregulation of the power industry to a wider audience within the profession.

Paul's 'Restructuring, competition and regulatory reform in the US electricity sector' (1997) is a wonderful introduction to the background and motivations behind power market reform in the US. A central point that Paul makes is that the states that are most motivated by power market reform (e.g. California, Massachusetts and New York) are those with the highest prices, while states with the lowest prices (e.g. Oregon and Indiana) are the least motivated. This is because competition and trading of electricity will reduce prices for consumers in high price states, but likely increase them in low price states. While this may raise welfare in all states, it will raise consumer welfare by more in high price states and this is what politicians care about. This prediction turned out to be more true in the US with hindsight, where the subsequent California electricity crisis of 2000-2001 (of which more below) largely put an end to further state level power

market reform. Another prescient point made in this paper was the suggestion that the short run gains from power market reform, in terms of bringing power prices down in high price states, might come at the expense of the loss of dynamic efficiencies due to reductions in vertical integration. This paper also highlights the need for reforms to include the protection of wholesale competition from distortions arising from continuing vertical control between transmission and some generation and the need for incentive regulation of monopoly networks.

This brings us to Paul's papers on the California electricity crisis. Paul's earlier cautious support for wholesale electricity market deregulation on the basis of the continuing benefits of longer term contracting between generation and retail seem to be fully justified when it comes to the experience of California's wholesale market deregulation.

Paul documents the sorry affair in his 'California's electricity crisis' (2001). California had a reasonably comprehensive electricity deregulation from 1998 with a power exchange. This involved the creation of a wholesale power market, forced divestiture of large quantities of generation plants by incumbent utilities and, most notably, a restriction on the use of longer term contracting by retailers for generation from third parties. The result was an initially successful reform with a competitive wholesale generation market. From May 2000 demand and supply factors combined to significantly increase wholesale prices. Hot weather raised demand by 12% (from a year earlier) and gas and local emissions prices increased significantly. Added to this generator scarcity then induced gaming by generators. Many customers were still on regulated rates or fixed prices and retailers had not hedged much of their demand in the wholesale market. The result was retailers were driven to bankruptcy by prolonged high wholesale prices which continued until the power exchange collapsed in February 2001. Bad market design coupled with bad behaviour made for a cocktail which resulted in the eventual collapse of the market and political intervention – in the form of the purchasing of expensive long term generation contracts by the government of California.

The gaming behaviour of generators in the power crisis is investigated specifically in 'A quantitative analysis of pricing behaviour in California's wholesale electricity market during summer 2000' (2002 with E.Kahn). This paper provides a detailed analysis of the apparent strategic withdrawal of generator capacity during the power crisis to estimate the size of the strategic effect was on wholesale power prices. The paper carefully analyses the behaviour of major generators to show that during the key months of the crisis the unavailability (outage rate) of name plate capacity was very high. For one key group of generators it was 26% in June 2000, compared to normal outage rates of 6-13%. The paper combines a well-documented analysis of the supply and demand for electricity in the key months of the crisis, with a detailed counterfactual of what generation might have been available in the absence of strategic behaviour.

In 'Markets for power in the United States: An interim assessment' (2006) Paul examines what the actual size of the initial effect of market deregulation has been on power prices in the US. The paper nicely summarises progress with reform particularly

following various Federal Energy Regulatory Commission (FERC) Orders (888, 889 and 2000) which encouraged the creation of wholesale and retail power markets and the voluntary creation of Regional Transmission Organizations (RTOs) to facilitate interstate power trading and system operation. The paper includes a regression analysis of US states for the period 1970-2003 and finds that both retail deregulation (the ability to select alternative suppliers) and a higher share non-utility generation are both negatively and significantly correlated with lower industrial and residential prices. The size of the retail competition effect being around 5-10% lower residential and 5% lower industrial prices. This shows the significant early benefits from retail market reform in the US, notwithstanding the meltdown experienced in California. As Paul concludes *'My interim assessment is that the glass is half full rather than half empty at the present time.'*(p.33).

Paul's 'Lessons learned from electricity market liberalization' (2008c) is a wonderful paper that remains a fantastic one paper summary of the lessons from the early years of power market reform. It is, as Paul points out, written 25 years on from *Markets for Power*. In it Paul summarises what we have learned in thirteen points. I cannot summarise them completely here, but I do draw out some highlights. 1. Power market reform can go wrong if not done properly. 2. The textbook reform model does work (see Great Britain!). 3. Not following the textbook will (negatively) affect performance. 4. Transmission capacity allocation is important. 5. Market power needs to be regulated by design. 6. Network regulation is a key element of reform. 7. Regulating transmission investment is difficult. 8. Ancillary markets to prevent blackouts are important. 9. Successful retail competition for small consumers depends on default service arrangements. 10. Vertical integration between generators and retailers remains likely and requires monitoring. 11. Encouraging demand response is valuable in power markets. 12. Power market reform is not a one off but a continuing process of reform of reforms. 13. Political support for reform is important. Electricity market liberalisation may be difficult, but as Paul so aptly puts it: *'The problems that have emerged are now much better understood and solutions to many of them are at hand.'* (p.38).

It seems fitting to end the discussion of Paul's work on electricity market reform with reference to his work on energy network regulation, following liberalisation. While several high profile US economists have paid attention to the competitive aspects of power market reform, only Paul has also exhibited an interest in network regulation following reforms. This reflects both his early interests and his corporate work with NEES and then National Grid. Among his writing in this area is the masterful 'Incentive regulation in theory and practice: electricity distribution and transmission networks' (2014). This paper comprehensively reviews both the theory of incentive regulation and discusses the practical experience of regulating transmission and distribution networks in the US and the UK.

Paul concludes with a list of excellent lessons from which I briefly highlight some key takeaways<sup>17</sup>. 1. Incentive regulation is not a simple alternative to rate of return regulation. 2. Incentive regulation exhibits the capacity to learn from experience. 3.

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<sup>17</sup> I take the numbering from the earlier working paper version (Joskow, 2005).



Effective price cap regulation requires more than a simple price cap. 4. Price caps and price structures are to be considered differently. 5. Menu regulation, where regulated firms are given choices which reveal information, can be developed further. 6. Benchmarking is an important part of the regulator's toolkit. 7. Incentive regulation can involve more variables than just operating cost. 8. Hard incentive caps are to be avoided in regulation as they may soften incentives. 9. Incentive regulation is easier to implement when the underlying entities have incentives to respond to incentives. 10. More work on the performance effects of incentive regulation is warranted. In a world where many energy regulators still do not make good use of incentive regulation, this paper is a powerful call to consider best practice experience with incentive regulation of networks.

### **In addition**

Paul has displayed several other interests in his published work. Honourable mentions should be made of his work on hospitals and on chief executive officer (CEO) compensation.

'The effects of competition and regulation on hospital bed supply and the reservation quality of the hospital' (1980) examines the impact of competition and regulation on hospital bed supply, using a queuing model. It theoretically and empirically demonstrates that competition between hospitals in the presence of price regulation of hospital charges leads to increased bed supply relative to demand. By contrast increased regulation via restrictions on new building of capacity leads to reduced bed supply relative to demand. The paper draws general lessons for regulation. These include the observation that price regulation in a competitive industry will lead to excessive non-price competition (like in airlines); and that, by contrast, restrictions on entry will lead to undersupply of capacity (as might happen in energy). The paper uses detailed information on 346 US hospitals in 1976 to find support for these hypotheses.

In 'Regulatory constraints on CEO compensation' (1993 with N. Rose and A. Shepard) Paul looks at the determinants of CEO pay for a sample of more than 1000 firms (and 2000 CEOs) for the period 1970-90. The sample includes non-regulated firms and regulated firms (from rail, trucking, airlines, telecoms, electricity and gas utilities and natural gas pipelines). Regulation restraints pay to 30-50% of the unregulated sector and the degree of restraint is higher for utilities covered by a single state regulator and during the 1978-84 period of heightened regulatory scrutiny. An hypothesis that CEOs do not drive as high productivity in regulated sectors does not seem to be supported. Interestingly the authors conclude that regulatory scrutiny does have the effect of limiting CEO pay and that heightened scrutiny on currently unregulated sectors may reduce pay.

### **Concluding thoughts**

Unsurprisingly MIT's emphasis on Engineering overall has provided a rich environment for the sort of hands on industrial organization that Paul has spent his career working

on. An economist, like Paul, with interests in wires, pipes and big bits of infrastructure is at home at MIT.

What is impressive about Paul's work is the range from theory through to empirical work and his attention to institutional detail.

A recurring motif is that he challenges lazy calls for deregulation by carefully pointing the conditions under which deregulation can work and where the need for continuing regulation lies. All of this he does in the context of listening carefully to what regulators and industry players say about the issues they face, the decisions they need to make and how their industries actually function.

Paul is a wonderful example to the economics profession of someone who has always sought to do work on topics that are important to society and to apply economic tools to complex problems which society actually wants to know the answer to. It has been a genuine pleasure to study his writings and to work with him.

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