Empirical studies on the impacts of economic regulation

A report for Vector Limited

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1. Executive summary

1. This report surveys the academic literature on the evidence of the performance of economic regulation in practice. A particular focus is experience with the introduction of incentive regulation over the past 30 years across a range of network industries including energy, telecommunications, transport and water. We draw upon a large number of studies conducted across a diverse range of countries. The international experience offers useful insights for the development of New Zealand regulation, albeit with the need to be alert to differences between jurisdictions and industries.

2. Incentive regulation in the energy sector has generally lived up to its promise over time. In particular, the opportunity to retain cost savings under price cap regulation led to lower costs and higher productivity in distribution and transmission networks compared with outcomes under rate of return regulation. Empirical studies confirm the existence of a trade-off between promoting allocative efficiency (by seeking to limit differences between price and costs and thereby capping returns at the cost of capital) and promoting dynamic efficiency through creating the appropriate incentives for firms to innovate and undertake risky investment over time. Nonetheless, different models of incentive regulation have had varying success - the detailed design of incentive regulation matters.

3. The experience with incentive regulation has led to regulatory design being adapted over time. The focus of early incentive regulation on reducing operating costs was found to have created adverse impacts on investment and quality of service. In electricity, the evidence from Europe and the US is that the price caps led to deteriorating service quality, particularly in terms of the duration of outages. However, reflecting this experience, over the last decade many regulators have moved to introduce specific reward/penalty schemes by which utilities are given financial incentives to meet and even exceed specified performance targets. This regulation has been effective in improving service quality. Regulators are continuing to enhance this regulation, although it still falls short of fully integrating quality with other parameters in a single incentive mechanism that reflects customers' valuation of quality relative to their valuation of the other parameters.

4. In telecommunications, studies of the impact of incentive regulation have found that it has promoted network modernisation, higher productivity and lower prices for certain services (while allowing higher returns to regulated suppliers). Evidence of harm to quality of service has generally not been an issue in relation to telecommunications which is likely to reflect industry specific factors such as that telecommunications networks are generally used to supply both regulated and non-regulated, competitively-provided services and hence poor network quality risks harming an operator's competitive position. Incentive regulation when assessed across countries has also been found to raise efficiency in the drinking water industry. The evidence of the UK water industry is somewhat more mixed and a particular concern that has been identified recently is declining R&D expenditure. A review for the UK Government recommended the introduction of a specific scheme to fund R&D in the water industry.

5. Efficiency improvements from the introduction of incentive regulation have also been found in studies relating to the bus, airport and rail freight industries. The study of the rail freight industry also estimated the extent of a trade-off (if any) between quality and quantity and addressed the design of regulation to optimally balance quality with volumes.

6. We have also examined insights from recent literature relating to public procurement auctions. A feature of these auctions, with similarities to economic regulation, is that purchasing governments' objectives cover not only price but also quality parameters (such as completion times for road construction). Evidence from the outcomes of these auctions shows how consumer welfare can be raised through mechanisms that enable customers' valuations of quality to be taken into account simultaneously with reducing prices and costs.

7. Finally, we have examined empirical studies on the impact of changes in patent laws. These studies find that allowing prices above costs for a period of time can raise welfare through encouraging higher R&D spending and higher innovation over time.

8. Our survey suggests that while incentive regulation can bring significant benefits, it also carries risks. In particular, international experience has demonstrated that incentive regulation focused only on aligning prices with costs can lead to inferior quality of service and investment outcomes than regulation that is designed to optimise across the range of parameters that impact on overall consumer welfare. While regulators can seek to administratively set requirements in relation to non-price parameters, these are unlikely to reflect the actual trade-offs between different parameters in practice. Rather, international best practice is moving towards integrating the range of key price and non-price parameters in regulatory mechanisms that motivate firms themselves to balance the different parameters in a way that promotes overall consumer welfare. The use of more sophisticated regulatory approaches has brought significant welfare gains in other countries. Significant welfare gains can also be expected by their adoption in New Zealand.

2. Empirical studies on the overall impact of the regulatory approach

9. In this section, we survey the empirical literature on the general impact of incentive based regulation, particularly in relation to the energy sector.

2.1. The rise of incentive regulation

10. Much early regulation was simply aimed at aligning prices with costs (i.e. reducing monopoly profits) with little focus on achieving reductions in costs over time or on striking an optimal balance between the cost and quality of service delivery. However, the potential for the design of traditional regulation to give rise to inefficiency has long been recognised. For example, Averch and Johnson's (1962) identified that rate of return regulation could encourage companies to over-invest so that they earn higher absolute profits from their regulated rate of return being applied to a larger capital base.[1] More generally, it is now recognised that traditional regulatory design paid insufficient attention to the facts that:

    - businesses will respond to the incentives (or lack of incentives) they face;
    - regulation itself can significantly affect the level of costs and service quality; and
    - regulators generally have less information about firms' current and potential cost functions (including the relationship between costs and quality) and about the detailed nature of demand than the firms themselves.

11. Incentive regulation (also known as performance based regulation) is designed to provide incentives for regulated businesses to improve efficiency so as to increase consumer welfare over time. Such incentives can include financial rewards for improvements in outcomes or penalties for under-performance. Price caps or revenue caps are the most common types of incentive regulation, although there are a wide variety of other types of incentive regulation.

12. The modern take-up of incentive regulation commenced with the imposition of price caps on British Telecom (BT) in the UK in 1984. Incentive regulation was subsequently extended to other industries and to other markets. We turn next to the case of the UK electricity industry and then consider energy regulation in other countries.

2.2. Incentive regulation in the UK electricity industry

13. The UK provides important evidence on the effects of incentive regulation. The UK was one of the first countries to introduce incentive regulation to many industries and thus provides a substantial period over which to assess its impact in practice. This is

[1] Averch, H. and L. Johnson, "Behaviour of the firm under regulatory constraint", American Economic Review 52, 1962, p.1052-1069

[2] Jamasb, T. and M. Pollitt, "Incentive regulation of electricity distribution networks: lessons of experience from Britain",

particular useful as the full effects of regulation on factors such as costs and quality are likely to be clear only after a significant period of time.

14. 1990 saw the commencement of the privatisation of the UK electricity industry and the establishment of an independent regulator (the Office of Energy Regulation, a forerunner of OFGEM). A series of price caps controls were set for electricity supply beginning with the first price control period which ran from 1990/91 to 1994/95.

15. Jamasb and Pollitt provided a survey of studies examining the experience with price caps in the privatised sector in the UK. They show that prior to privatisation and the introduction of price caps, there had been a long period (dating from the 1970s) of relatively low investment in the UK electricity distribution network, whereas investment levels were substantially higher in the 1990s than in the 1980s.[2] With the new regulation, labour productivity of the regional electricity companies nearly doubled between 1990-91 and 1997-98.[3]

16. Data reported by de Oliveira and Tolmasquim[4] show that efficiency improvements were much larger in the first decade of the price caps and privatisation compared with the previous decade (see Table 1).

Table 1 – Efficiency improvements in the UK electricity industry

	Average annual change 1980/81 to 1990/91	Average annual change 1990/91 to 1999/00
Customers/employee	2.8%	9.4%
GW/h/employee	3.6%	10.2%

Based on data in de Oliveira and Tolmasquim (2004)

17. Jamasb and Pollitt also report a finding that reduced distribution and transmission charges over 1991/92 to 1998/99 delivered a 9 per cent reduction in prices for domestic users.[5] Price reductions were greater later in the period. This suggests that while price caps can allow for increased productivity and higher profits for a period, regulators can share the benefits of higher productivity with consumers by reducing prices in subsequent periods. The authors also find that by 2005, the UK had the lowest distribution and transmission access charges in the EU and that the share of income spent on electricity by low-income consumers in the UK was among the lowest in the EU.[6]

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2 Jamasb, T. and M. Pollitt, "Incentive regulation of electricity distribution networks: lessons of experience from Britain", EPRG 0701, June 2007, Figure 12.

3 Ibid, p.9.

4 De Oliveira and Tolmasquim, "Regulatory performance analysis case study: Britain's electricity industry", Energy Policy 32, 2004, Table 4.

5 Jamasb, T. and M. Pollitt, "Incentive regulation of electricity distribution networks: lessons of experience from Britain", EPRG 0701, June 2007, Table 1.

6 Ibid, p.12.

18. Pollitt examines the use of efficiency analysis (benchmarking) by Ofgem within electricity distribution and transmission price reviews. Pollitt identifies a number of areas where regulation could be improved including moving away from individual firm X factors, greater attention to quality and the modelling of opex-capex trade-offs. Pollitt, nonetheless, concludes:

> *In spite of the above criticisms, during the period 1990 – 2004 the incentive based regulation of electricity distribution and transmission has produced impressive price reductions and productivity improvements while maintaining industry profitability.*[7]

19. Joskow has summarised the experience with profit sharing regulation of transmission in the UK.[8] In this sector, forward targets were established for the costs of system balancing services and system losses with the transmission operator at risk for a fraction of deviations from the targets with caps on profits and losses. The transmission operator could choose from a menu of three alternative incentive arrangements with different sharing fractions and different caps and floors. Under the previous simple cost pass-through regulation, the transmission operator's costs had escalated rapidly. After the profit sharing regulation was introduced in 1994, its costs fell by about $400 million between 1994 and 2001. The costs fell by nearly 20% further following the introduction of a new incentive scheme in 2001.

2.3. Incentive regulation in other energy markets

20. Goulding provides some comparisons between the experience of price caps imposed on the UK electricity distribution networks with the cost of service regulation prevailing in the US industry during the 1990s. He finds that:

> *Whereas electricity distribution sector productivity in the US has languished at 1.2% per annum, and few jurisdictions have exceeded productivity gains of 2% per year, the UK has seen annual gains of 3.5%.*[9]

21. Goulding also finds that the average return on capital employed in the UK remained above the cost of capital during the 1990s, indicating that the industry was able to achieve greater cost savings that the targets imposed in their regulation.

22. Mountain and Littlechild have compared regulation of the electricity distribution networks in NSW and the UK. They found that capital employed per customer was much higher in NSW than in the UK and that the outcome in NSW has grown rapidly

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[7] Pollitt, M., "The role of efficiency estimates in regulatory price reviews: Ofgem's approach to benchmarking electricity networks", Utilities Policy 13, 279 – 288, 2005, p. 288

[8] Joskow, P., "Incentive regulation and its application to electricity networks", Review of Network Economics, Vol. 7, Issue 4, December 2008

[9] Golding, I., "X marks the spot: how performance-based ratemaking (PBR) affected returns to wirecos in the UK", June 2001, p.1.

since 1990.[10] A key factor in explaining this difference is likely to be differences in how regulation has applied in practice. In the UK, the opex and capex allowances set by the regulation have been enforced and the authors found that the privately owned utilities in the UK generally beat the allowances (thereby enabling them to realise higher profits). The NSW regulators imposed no penalty on the NSW distribution companies for overspending their capex target in one period and in the following period they only prevented the companies from earning a return on the overspend until the end of that period.

23. Hattori, Jamasb and Pollitt compared the outcomes from the introduction of the price cap regime in the UK with rate-of-return regulation in Japan.[11] The study covered data over the period 1985/86 to 1997/98. The authors found that productivity gains in electricity distribution utilities were greater in the UK than in Japan, with the difference increasing the longer the period from the introduction of the price caps in the 1990s.

24. Gugler et al examined data for 16 European countries over 1998 to 2007 and found that in the long run 10% higher electricity prices subsequently led to 5.7% higher investment in generation, distribution and transmission assets.[12] The authors' comment that:

> *This indicates that higher prices while inducing static or allocative inefficiencies, increase the rents that can be earned from investments and trigger more investments, which presumably increase dynamic efficiency.*[13]

25. Kwoka has examined whether incentive regulation leads to under-investment to boost profit in the short-term at the expense of quality in the future.[14] Kwoka notes that many US states have moved to hybrid plans under which capital expenditure is subject to a form of rate of return regulation while imposing incentive regulation for operating costs. However, Kwoka notes that the evidence on the effect of these hybrid schemes remains sparse.

26. Knittel has examined the impact of differing regulatory approaches applied to coal and gas electricity generation in the US.[15] In particular, Knittel has examined the impact of:

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[10] Mountain , B. and S. Littlechild, "Comparing electricity distribution network costs and revenues in New South Wales and Great Britain", EPRG Working Paper 0930, p.21.

[11] Hattori, T., T. Jamasb and M. Pollitt, "A comparison of UK and Japanese electricity distribution performance 1985-1998: lessons for incentive regulation", CMI Working Paper 03.

[12] Gugler, K., M. Rammerstorker and S. Schmitt, "The trade-off between static and dynamic efficiency in electricity markets – a cross country study", Vienna University of Economics and Business, May 2011

[13] Ibid, p.13

[14] Kwoka, J., "Investment adequacy under incentive regulation", Northeastern University, 2009

[15] Knittel, C., "Alternative regulatory methods and firm efficiency: stochastic frontier evidence from the US electricity industry", The Review of Economics and Statistics, August 2002, 84(3): 530-540.

- direct efficiency reward programmes such as where generation firms are allowed to retain additional profits if they operate at a lower heat rate than the average heat rate for the programme;
- partial fuel cost pass through programmes in which if fuel costs exceed forecast levels only a proportion of the excess is allowed to be passed through to consumers; and
- revenue decoupling programmes in which electricity utilities are required to rebate the difference between the marginal price paid by customers and the marginal cost of generation with the aim of supporting demand reduction programmes by removing the incentive to grow demand (albeit that there is less incentive to reduce costs).

27. Knittel found that the programmes to increase efficiency (i.e. the direct efficiency reward programmes and the partial fuel cost pass through programmes) led to a reduction in unnecessary inputs of $49.70 million per coal plant. The study also found that the revenue decoupling programmes[16] did not lead to reduced efficiency. The study found similar results for gas plants for efficiency-enhancing programmes but of smaller magnitudes because gas plants were already much less inefficient than the coal plants.

2.4. Summary

28. The evidence indicates that the introduction of incentive regulation in the UK electricity sector led to lower costs and greater efficiency a decade later than would have resulted from historical trend rates or compared with other countries with rate of return regulation. This is consistent with the rationale of incentive regulation that, by allowing utilities the opportunity to improve profitability for a time by cutting costs, ultimately customers will gain by lower costs and lower prices. Nonetheless, changing network infrastructure and business processes to realise cost savings may take time. Further, regulators have continued to refine the design of incentive regulation, particularly in relation to specific consideration of capital expenditures and quality of service. We turn to consider the impact of regulation on quality of service next.

[16] Revenue decoupling programs are designed to reduce the amount of electricity consumed by preventing suppliers from retaining profits once a specified level of sales has been reached (however, the firm is still allowed to recover the cost of higher sales).

3. Regulatory impacts on quality of service in the energy sector

29. The focus of incentive regulation in reducing costs creates the risk that businesses may reduce quality of supply below optimal levels where the regulation does not adequately distinguish between costs savings from greater efficiency and cost savings from quality degradation. Reflecting this concern, the US National Association of Regulatory Utility Commissioners noted in 1997 that:

> *...by placing pressure on utilities to reduce costs, PBR [performance based regulation] can result in unacceptable declines in service quality. When designing a PBR mechanism, it is necessary to compensate for this effect by establishing targeted incentives to maintain or improve quality of service.*[17]

30. Ter-Martirosyan and Kwoka examined the impact on quality of the shift from rate of return regulation to incentive regulation in US electricity markets between 1993 and 1999.[18] The authors found that, whilst there were adverse quality effects of incentive regulation, the incorporation of explicit measures to provide for service quality were effective in preventing the increase in the duration of outages.

31. The authors found that incentive regulation was associated with a decrease in operations and maintenance expenditures and an increase in the average duration of electricity outages (by nearly 115 minutes). They found no significant change in the frequency of outages, which they note could be explained by outages being mainly caused by equipment failure which is only partially within the control of a utility (whereas the duration of the outages is more within their control). The authors note that:

> *The single most common cause of outages is equipment failure, but this is something only partially within the control of a utility (APPA 1996). As a result, the association between incentive regulation and outage frequency may be difficult to discern empirically. In contrast, once such a failure has occurred and been detected, the duration of the resulting outage is a function of repair crew readiness, equipment availability, etc., matters more within the control of the firm (Oregon Public Utility Commission 1997). That implies that duration, more than frequency, would be affected by incentive regulation, much as been found here.*[19]

32. Ter-Martirosyan and Kwoka proceed by noting that the attribution of a number of electricity outages in the US and Canada at least in part to cost-cutting led to policies

[17] NARUC, Performance Based Regulation in a Restructured Electric Industry, 1997, p.4.

[18] Ter-Martirosyan, A. and J. Kwoka "Incentive regulation, service quality, and standards in US electricity distribution". Journal of Regulatory Economics, Vol. 38, 2010, p. 258-273.

[19] Ibid, p. 268

designed to ensure an appropriate quality of service. For example, in 2001 in Massachusetts a service quality metric was established based on eight factors (i.e. frequency and duration of outages, five aspects of customer service, and one measure of workplace safety), with each factor being given a weight and the electric and gas utilities able to earn or lose up to 2% of its revenues based on its performance relative to the composite index.

33. The study finds that the incorporation of explicit measures to provide for service quality were effective in preventing the increase in the duration of outages. The authors conclude:

> *From a policy perspective, these results are quite important in that they not only underscore the adverse quality effects of incentive regulation, but also suggest how the adverse effects may be offset while preserving the incentive plan itself. That can be accomplished by the simple expedient of incorporating quality standards into the plan.*[20]

34. Giannakis, Jamasb and Pollitt examined the experience in the UK over the 1990s. The authors found that some firms that performed well in cost-only models did not score high in the quality-only model, and the correlation coefficients between cost only and quality only scores were 'somewhat low'. The authors conclude that:

> *This indicates a possible-trade-off between costs and quality of service. These findings show that, at least conceptually, it is plausible and desirable to integrate quality of service and capital expenditure in benchmarking and incentive regulation of electricity networks.*[21]

35. Domah and Pollitt found that the experience in relation to quality of service in the UK was mixed in the first decade since privatisation and the introduction of incentive regulation: the minutes of supply lost per customer had fallen although customers in rural areas were still experiencing significant unplanned power cuts.[22]

36. Jamasb and Pollitt have reviewed the evidence on quality of service in the UK where specified guaranteed standards of performance have been tightened over time and in April 2002 a quality of service incentive scheme was introduced which linked quality of service to the allowed revenue of the distribution operators. Under the scheme, utilities are penalised for not meeting targets and are rewarded for exceeding targets while frontier performance is also rewarded by a less strict standard being imposed for the next period. However, the rewards and penalties are not determined in an

[20] Ter-Martirosyan, A. and J. Kwoka "Incentive regulation, service quality, and standards in US electricity distribution". Journal of Regulatory Economics, Vol. 38, 2010, p. 267.

[21] Giannakis, Jamasb and Pollitt, "Benchmarking and incentive regulation of quality of service: an application to the UK electricity distribution networks", Energy Policy 33, 2256 – 2271, 2005, p. 2269

[22] Domah, P. and M. Pollitt, "The restructuring and privatization of electricity distribution and supply businesses in England and Wales: A social cost-benefit analysis", Fiscal Studies, vol. 22, no. 1, 2001, p. 107-146.

integrated manner with respect to opex and capex, i.e. incorporating the actual trade-offs so as to create the incentive for the socially optimal level of quality of service.

37. Jamasb and Pollitt found that since 2002 the average number of interruptions per 100 customers has fallen and the average number of minutes lost per connected customer per year has also fallen (although they note that some variation from one year to another could be caused by measurement errors and weather conditions).[23] They also found that there was a marked reduction in network energy losses during the 2001/02 to 2003/04 period.[24] The distribution firms are also subject to a reward/penalty scheme based on whether they achieve lower/higher energy losses than a yardstick level.

38. The authors conclude their review of the UK experience by noting that:

> *Although the fragmented regulation and benchmarking approach consisting of the benchmarking of operating expenditures, the review of capital investment plans, and penalty/reward schemes for quality of service and network energy losses do not strictly conform to an ideal integrated theoretical framework, this approach has performed well and has given the regulator flexibility to address and incentivise specific aspects of network regulation.*[25]

and

> *The use of performance targets combined with a penalty and reward incentive system has improved the quality of service in the UK distribution utilities. This approach, though perhaps not perfect, is in contrast to a purely cost-oriented benchmarking, which could lead to perverse economic incentives. It is important for countries to take quality of service and related investments into account when introducing incentive regulation. The British example shows that incentive regulation can also be effective for improving quality of service and security of supply of the networks.*[26]

39. Jamasb and Pollitt conclude that quality should be integrated into the incentive mechanism in a consistent manner to its value.

40. The performance of regulation in relation to quality of service should ultimately be assessed against a benchmark of the socially optimal level of quality. The ultimate aim should be for the regulated business to take into account the costs of lower quality performance in its decision-making so that quality will be provided where the marginal benefit of extra quality received by customers (e.g. the reductions in costs from energy

[23] See Jamasb, T. and M. Pollitt, "Incentive regulation of electricity distribution networks: lessons of experience from Britain", EPRG 0701, 2007, Figures 8 and 9.

[24] Ibid, p.33.

[25] Ibid, p.40.

[26] Ibid, p.43.

not supplied) equals the marginal cost of additional quality provision by the network. As Growitsch et al argue:

> *Modern regulatory practice therefore aims to include the social welfare surplus for quality (from a customer's point of view) into the network operator's decision-making. More specifically, the external cost of energy not supplied (CENS), i.e. the cost incurred by network users due to energy not supplied (ENS) subsequent to an interruption is equated with the customer's willingness-to-pay (WTP) for network reliability. Within such an incentive scheme the regulated firm will aim to optimise its trade-off between CENS and total network expenditures (TOTEX)….This implies that network operators will only increase quality*…[until the quality level at which] *the marginal costs to provide more quality equal*[s] *the reduction in CENS incurred by customers.*[27]

41. Jamasb, Orea and Pollitt (2010) have assessed the incentive schemes established by Ofgem to reduce network energy losses.[28] The study found that while the UK incentive schemes led to improved sector performance, they were not set at a sufficient level to provide utilities with optimal incentives to avoid power interruptions (in particular, a higher level of incentives, consistent with the benefits to customers from reduced power interruptions, would have led to higher customer welfare). As such, the authors conclude that, while there were significant improvements in quality between 1995 and 2003, there was the potential for substantial further gains in customer welfare.

42. A number of studies have examined the experience in Norway where the regulator was one of the first to incorporate customer valuation of service quality into its regulation. In the 1990s, Norwegian regulation was based on a revenue cap but without any incentive for quality management apart from reporting of interruptions and outages. In 2001, the formula to determine the revenue cap for the regulatory period 2001 to 2006 incorporated an element in relation to the cost of energy not supplied. Network operators were set individual quality targets and the revenue cap was increased in following years by the extent to which an operator exceeded its quality target or decreased where actual quality was below the target level. The Norwegian regulator has used surveys of customer preferences in relation to network reliability to help regulate quality.

43. Growitsch et al found that incorporation of an external cost of quality in the revenue caps in Norway did not have a major impact on quality performance or on cost efficiency. However, the authors note that this may reflect the comparatively high quality level prior to the implementation of quality regulation and that their data only

[27] Growitsch, C., T.Jamasb, C.Muller and M.Wissner, "Quality of supply in energy regulation: measurement, assessment and experience from Norway", EPRG 0920, August 2009, p. 3.

[28] Jamasb, T., L.Orea and M.Pollitt, "Estimating marginal cost of quality improvements: the case of the UK electricity distribution companies", EPRG Working Paper 1027, September 2010.

covered the first few years following the introduction of a quality component to the revenue cap.[29]

44. The CPB Netherlands Bureau for Economic Policy Analysis undertook a significant survey of the performance of policies to promote reliability based on case studies across a range of network industries including electricity, natural gas, drinking water, wastewater and railways. The Bureau concluded that:

> *In the electricity market (chapter 4), high-powered price regulation, supplemented by quality regulation of relevant contractible dimensions of reliability is likely to be welfare improving: in the year when such regulation was introduced in Norway, Norwegian companies responded by reducing costs and decreasing the amount of energy non-supplied (ENS), the indicator for reliability that was contracted by the regulator. Also the other case studies demonstrate that if high-powered incentives are combined with quality regulation positive results can be expected. In particular, we have observed the English and Welsh water companies (chapter 6) also responded to such regulation in a similar vein. The opposite is also true: without quality regulation high-powered incentives can backfire. In the electricity case we observed that under price caps, i.e. before the quality regulation was introduced, the performance of companies on ENS improved (however less than under quality regulation), while their performance in terms of duration and number of interruptions worsened.*[30]

45. The CPB also noted that quality regulation is particularly needed where managers' incentives would otherwise not be aligned with society's objectives. On the other hand, in some industries, there may be less need for high-powered quality incentives because managers can be expected to already have the appropriate incentives (such as where the costs of accidents are so large for the business that managers would already be adopting efficient policies to minimise accidents). Further, the CPB found that only certain elements of quality may be able to be adequately incorporated into contracts and that high-power price regulation carries the risk of harming quality in a welfare-reducing way in relation to non-contractible quality parameters. The CPB found that regulated businesses in the UK and Norway responded to quality of service incentives and that aspects of reliability that were not subject to incentives did not necessarily improve.

46. Fumagalli notes that financial incentives based on quality performance relative to specified performance standard have been introduced in 12 EU countries over the period 2000 to 2009. Focusing on the Italian experience, she finds significant reductions in customer minutes lost and in the average number of interruptions. Fumagalli concludes that the lessons of quality regulation are that: (i) measurement rules play a fundamental role; (ii) quality regulation is an evolutionary process; (iii)

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[29] Growitsch, C., T. Jamasb, C. Muller and M. Wissner, "Quality of supply in energy regulation: measurement, assessment and experience from Norway", EPRG 0920, August 2009, p. 23.

[30] The CPB Netherlands Bureau for Economic Policy Analysis, Better safe than sorry – reliability policy in network industries, December 2004, p.135

regulation needs to be adapted to the specific factors of each country; and (iv) that effective consultation and transparency are important.[31]

3.1. Summary

47. The experience of the energy industry in many jurisdictions is that regulation can harm quality of service unless specific measures are implemented to protect and promote quality. In particular, the introduction of specific rewards and penalties for suppliers based on their delivered quality levels relative to target levels has been effective at achieving superior quality relative to other jurisdictions which have not introduced such measures. To fully achieve the socially optimal quality of service it is important to integrate quality of service into a single incentive mechanism reflecting the relative weight attached by customers to changes in quality levels compared with changes in other parameters including prices. Utilities will then face the appropriate incentives in trading off quality with other parameters taking into account customer preferences as well as their own cost trade-offs.

[31] Fumagalli, E., "Service quality regulation: framework and experience", Presentation to Florence School of Regulation, 2011.

4. Lessons from studies of economic regulation in other sectors

48. In this section, we review studies of the impact of regulation on a number of other sectors of the economy where incentive regulation has been adopted. The experience indicates that the precise impact of regulation reflects the specific circumstances of each industry. Nonetheless, many aspects of the experience in the energy sector have also been found in the other industries.

4.1. Telecommunications

49. RPI-X price caps were first applied to telecommunications sector in the UK following the privatisation of British Telecom in 1984. Since then, price cap regulation has been applied to telecommunications sectors around the world. In telecommunications, price caps have tended to be set for 4 year periods in the UK and 3 to 4 years in the US.

50. An early survey of empirical studies by Kridel, Sappington and Weisman found that:

> *…productivity, infrastructure investment, profit levels, telephone penetration, and new service offerings have increased under incentive regulation. Service rates have generally remained stable or decreased slightly, and service quality does not appear to have been affected adversely.*[32]

51. Similarly, Abel concludes that price cap regulation has delivered superior outcomes for consumers (and the industry) compared with alternative regulation including earning sharing approaches:

> *Under price-cap regulation, telephone prices have either fallen or remained the same, productivity has generally increased, modern infrastructure has been deployed at a more rapid pace, and firms have performed at least as well financially relative to the other methods of regulation available. … In addition, the evidence so far suggests that the response has been more pronounced under pure price-cap regulation compared to hybrid plans having an earnings sharing component. This result is particularly true along the productivity and network modernization dimensions. Therefore, the existing evidence suggests that it is likely that the introduction of price-cap regulation in the United States telecommunications industry has produced benefits to consumers, producers, and regulators alike.*[33]

[32] Kridel, D., D. Sappington and D. Weisman, "The effects of incentive regulation in the telecommunications industry: A survey", Journal of Regulatory Economics, Vol. 9, Number 3, 1996, p.269-306.

[33] Abel, "The performance of the state telecommunications industry under price-cap regulation: An assessment of the empirical evidence", The National Regulatory Research Institute, 2000, p.66-68.

52. Ai, Martinez and Sappington have examined the impact of incentive regulation on the quality of retail telecommunications services in the US between 1991 and 2002.[34] Over this period, rate of return regulation was largely replaced by price caps based on some sort of engineering estimate of efficient 'normal' as the predominant form of regulation in the US telecommunications industry. The result was that a firm's revenues were no longer directly linked to its costs. The authors examine the impact of the change in regulation across US states, while controlling for other factors found to impact service quality. The authors find that incentive regulation was associated with significantly higher service quality on most dimensions, including installation times for new services, fewer reports of troubles with existing services and increased customer satisfaction. However, incentive regulation was associated with lower quality on some dimensions (i.e. fewer installation commitments met and longer delays in resolving reported service problems). The authors note that earlier studies found broadly similar results. The authors conclude that assessing the impact of incentive regulation on quality requires a detailed investigation of the details of the regulation including what quality dimensions are mandated and what specific financial penalties and/or rewards for service quality the regulated firm faces.

53. Sappington and Weisman review recent empirical studies on the impact of price cap regulation particularly on the US telecommunications industry and conclude:

> *In summary, recent studies add some support for the general conclusions that incentive regulation plans like PCR tend to promote increased network modernization, productivity growth rates, and lower prices for some services while admitting higher earnings for regulated suppliers. Recent studies also suggest that PCR may promote some cost reduction, particularly in the presence of substantial industry competition. In addition, the studies confirm the lack of a systematic relationship between PCR and service quality.*[35]

54. Sappington and Weisman also draw a number of general lessons from the experience with price cap regulation. They note that the regulation can be adapted so as to give greater weight to particular objectives such as by ensuring more consistent, moderate returns to attract investment in developing the network or to allow regulated firms to retain the benefit of cost savings for longer to provide enhance incentives for innovation and cost reduction.[36] The authors identify that the impact of price caps can be modified by means of the X factor, the Z factor (allowing price changes to some extent for certain exogenous events), the duration of the price cap plan, how new price caps are determined in light of performance under the previous cap and the scope of the price cap in terms of what services are included in the cap. Specifically in relation to quality of service, the authors note that specific measures to promote quality of service may be more important in energy than telecommunications as:

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[34] Ai, C., S. Martinez and D. Sappington, "Incentive regulation and telecommunications service quality", Journal of Regulatory Economics, 26:3, 2004, p.263-285

[35] Sappington, D. and D. Weisman, "Price cap regulation: What have we learned from twenty five years of experience in the telecommunications industry?", 2010, p.15-16

[36] Ibid, p. 30

…unlike telecommunications suppliers, energy suppliers typically do not sell other, relatively profitable, unregulated services. Consequently, energy suppliers typically will not be as concerned with negative financial repercussions in other markets caused by service quality problems in energy markets.[37]

55. Eckenrod, in a study on the local exchange market in the United States between 1991 and 2002, examines the price markup before and after implementation of price cap regulation to measure effects of the change on consumer welfare. She observed that the implementation of the price cap regulation was associated with higher earnings for regulated suppliers reflecting reductions in both price and production costs:

The average price markup increased slightly after price-cap regulation; however, the average price decreased, indicating that consumers benefited without firms losing from the regulatory shift.[38]

4.2. Regulation of drinking water

56. De Witte and Marques have examined the role of incentive schemes in the drinking water sector.[39] Specifically the authors investigated if regulatory and benchmark incentive schemes improve the efficiency of utilities.

57. The authors conclude that:

[...] our results provide significant evidence for the positive effects of incentive schemes on efficiency. The analysis demonstrates that in absence of clear and structural incentives the average efficiency of the utilities falls in comparison with utilities which are encouraged by incentives. The presence of benchmarking (in the sense of sunshine regulation or yardstick competition) is a key element which replaces competition in the market or competition for the market by competition by comparison.[40]

58. The authors compare efficiency schemes in five countries, including the Netherlands, England and Wales, Australia, Portugal and Belgium – all of which have differing incentive schemes for the drinking water sector. The drinking water sector is characterised by benchmarking in the Netherlands, by privatization and price cap regulation in England and Wales, by a unique incentive scheme based on strict regulation in Australia, by provision with private sector participation in Portugal and finally by different levels of public management in Belgium.

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[37] Sappington, D. and D. Weisman, "Price cap regulation: What have we learned from twenty five years of experience in the telecommunications industry?", 2010,, p.32

[38] Eckenrod, "Incentive regulation in local telecommunications: The effects on price mark-ups", Journal of Regulatory Economics, 30(2), 217 – 231, 2006, p. 217

[39] De Witte & Marques "Designing incentives in local public utilities, an international comparison of the drinking water sector", Centre for Economics Studies Discussion Paper Series (DPS) 07.32, 2007.

[40] Ibid, p. 28

59. In the study, Dutch, English and Welsh, Australian, Portuguese and Belgian drinking water utilities are benchmarked against each other. The authors assume a common frontier technology, as opposed to a national frontier production function, which allows utilities from different countries to support the envelope. The authors use Data Envelope Analysis (DEA) to estimate the production frontier.

60. The results of the analysis show the benchmarked Dutch drinking water companies are performing better, with an average efficiency score of 1.40, followed by the privatised English and Welsh companies, which have an average efficiency score of 1.55. The drinking water companies operating under the strict regulatory model implemented in Australia have an average efficiency score of 1.66, followed by the companies under the municipal provision system in Belgium (1.80) and finally the municipal provision system with private participation in Portugal (1.90).

61. The authors also proceed to control for the extent to which inefficiencies can be attributed to physical, social and institutional environmental factors and examine the impact of incentive regulation. The authors find the results indicate that the utilities that face incentive regulation produce more efficiently.

4.2.1. Productivity and price performance in the privatized water and sewage companies in England and Wales

62. Saal and Parker have analysed the impact of the new RPI+K regulatory regime introduced in England and Wales following privatisation in 1989.[41]

63. The authors conclude that their estimates of productivity growth (derived using quality adjusted output indices) show that although labour usage has fallen, the total factor productivity growth (TFP) has not improved since privatisation. Additionally, increases in output prices have outstripped increases in input prices leading to higher profits.

64. The authors find that labour costs make up a large portion of operating costs, so increased labour productivity points to increased operational efficiency post privatisation.

65. Similar trends were not seen in terms of capital inputs. The authors note that more stringent water and environment standards and a backlog of maintenance from under-investment during public ownership may have been the cause of extra investment in capital inputs – meaning that the poor TFP results could, at least partly, be explained by factors other than water industry management.

66. The authors observe that most of the labour productivity gains were attributable to the period post 1995. Overall productivity growth declined after the 1994/95 price review. The authors conclude that:

[41] Saal & Parker "Productivity and price performance in the privatised water and sewage companies in England and Wales", Journal of Regulatory Economics 20:1 61-90, 2010, p. 87

This result could well be, however, attributable to diminishing marginal returns to legally mandated environmental investment, as evidenced by a statistically significant decline in the rate of quality improvement after 1995, rather than actual regulatory failure. Indeed, a statistically significant decline in the aggregate and the company level economic profitability indexes after 1995 confirms that the new price caps that were put into place had their intended effect. These results are consistent with the notion of more rigorous regulation after 1995 to prevent excess profitability growth, compared with the first five years in private ownership.[42]

4.2.2. Encouraging innovation in water supply

67. Cave conducted an independent review of competition and innovation in water markets for the UK Government.[43] Cave found that the innovation that had taken place in the UK industry had been driven by top-down quality standards and was distorted by the structure of the regulation to substitute capital expenditure for labour so as to reduce operating expenditure. Cave concluded that innovation should be supported through market mechanisms and regulation. Specifically in relation to regulation, Cave supported Ofwat's decision as part of its 2009 periodic review to introduce a new incentive scheme for capital expenditure in which firms are rewarded or penalised in proportion to their out or underperformance relative to a specified efficient baseline. Cave also recommended that such an approach should also be applied consistently to operating expenditure.

68. Cave noted that R&D capacity appears to have declined in recent years in the UK and that the UK water industry was producing fewer innovations per capita than other comparable countries. Cave found that:

The current framework of economic regulation does not always encourage significant investment in research and development or the trialling or adoption of innovations. This is because, depending on the level of investment, the probability of a successful outcome and value of the saving, the current outperformance period of between five and seven and a half years may be insufficient. Moreover, any increase in operating expenditure may be viewed as an apparent increase in inefficiency.

While such a system ensures that companies consider the short-term value-for-money of spending, in the long-term it may also lead to a decline in research and development and in companies' ability to drive innovation, which will be important in meeting the new challenges of climate change and population growth. The short-term protection of customers may therefore come at the expense of long-term industry performance.[44]

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[42] Ibid, p. 88

[43] Cave, M., Independent review of competition and innovation in water markets: final report, 2009.

[44] Ibid, p.14.

69. Cave recommended the establishment of an industry R&D body supported by funding partly recoverable from customers and allocated on a competitive basis to organisations undertaking the R&D.

4.3. Bus transport

70. Dalen and Gomez-Lobo investigated how different types of regulatory contracts, including yardstick regulation, affected performance in the Norwegian bus transport industry.[45]

71. The authors found that adopting more high-powered schemes based on yardstick type regulation significantly reduced operating costs relative to standard contracts, and that their results confirm the dynamic benefits of yardstick competition.

4.3.1. Local transport regulation in Norway

72. In Norway, regional governments (counties) are responsible for local transport, and each county can choose its own regulatory policy. Originally, most counties bargained annually and individually with every transport company over costs and transfers (Norwegian transport companies received large government subsidies). This scheme is considered low-powered in terms of incentives to reduce costs, as increased costs can be used by transport companies to argue for increased subsidies, and decreased costs make it harder to argue for maintaining the subsidy at the previous level.

73. In the late 1980s, some counties started adopting a standard cost model to determine the level of annual transfers. The standard cost model was applied to all companies within a county, and involved the county and companies agreeing on criteria to calculate costs of operating a bus network. Realised costs by one company did not affect the level of its next annual subsidy.

74. Under the standard cost model the companies would not have the same incentive to maintain higher costs in order to maintain annual subsidies, particularly as the level of annual subsidy under the standard cost model is set based on a large sample of companies. Rather, the companies would have a greater incentive to reduce their costs because the impact of their own cost reduction would only partially be reflected in the standard cost model and therefore in the subsidy they receive.

75. By the mid 1990s, both types of contracts were being replaced by a "subsidy cap" contract. Within the framework of the subsidy cap contract, the companies and county agree to reduce the level of government transfers by X per cent per year, over five years.

[45] Dalen & Gomez-Lobo, "Yardsticks on the road: Regulatory contracts and cost efficient in the Norwegian bus industry", Transportation, Volume 30, issue 4, 2003, p. 5

76. The authors selected an eleven year sample period from 1987 to 1997. The number of counties using each type of contract in this period is summarised in the table below. The table shows the shift from individual negotiation to a standard-cost model in the late 1980s/early 1990s, to a subsidy cap in the mid 1990s.

Table 2: Number of counties using each type of contracts

Contract type	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Individual negotiation	16	13	12	11	11	9	8	7	2	1	0
Standard cost	4	6	7	8	8	9	9	9	10	7	3
Subsidy cap	0	0	0	0	0	1	2	3	7	11	16

4.3.2. Results

77. The authors conclude that the introduction of yardstick contracts lowered costs by close to 9 per cent on average, relative to individually negotiated contracts. Also subsidy cap contracts lowered costs relative to the individually negotiated contracts, however only by about half as much.

78. The authors also estimated that firms regulated under an individually negotiated contract had a cost inefficiency of 17.9 per cent on average over the period. The corresponding figures for yardstick regulation and subsidy cap regulation were 7.6 per cent and 13.2 per cent respectively. Similar results were generated using the second model specification; however the results for the subsidy cap contract showed that these firms were even more inefficient on average than those under an individually negotiated contract. The authors also found that yardstick regulation led to significantly larger cost reductions over time than the use of individually negotiated contracts.

79. The authors conclude that:

> *Overall the results suggest that firms regulated under the yardstick type contract exhibit less than half the cost inefficiency compared to those firms regulated under the traditional contract. In addition [...] the firms regulated with the yardstick type contract reduce cost inefficiencies faster. This contract type provides more dynamic incentives for cost reduction by firms. As regards the subsidy cap system, the recent introduction of these contracts and the general switch of counties to this new system do not allow us to make strong conclusions regarding their incentive properties. The results contained in this paper thus confirm theoretical predictions regarding the incentive properties of high powered incentive schemes and in particular the dynamic benefits of yardstick competition.* [46]

[46] Dalen & Gomez-Lobo, "Yardsticks on the road: Regulatory contracts and cost efficient in the Norwegian bus industry", Transportation, Volume 30, issue 4, 2003, p. 19

80. The general relevance of this study is that the change from annual negotiations to regulation based on a regulatory-determined cost level enabled companies to boost profits by reducing costs below that level. The opportunity to obtain higher profits through finding cost savings was effective in driving significant improvements in cost efficiency.

4.4. Airport regulation

81. Oum, Zhang and Zhang investigate the effect of different forms of price regulation on airport efficiency and the interaction between concession profits and cost-based price regulations.[47]

82. One distinctive aspects of airports is that they rely on both aviation-related revenue and revenue from airport concessions. Airport concession revenue has been growing strongly over recent decades. Given the financial significance of concessional activities to airports, the paper notes that airports themselves may be willing to limit aviation-related charges so as to increase traffic and concession sales. However, one result of the empirical analysis of their paper (based on 60 major airports located in the Asia-Pacific, Europe and North America) is the finding that unregulated airports set prices above the socially optimal level so that regulation could still be beneficial.

83. The existence of concession revenue has also led to two particular types of airport regulation:

- A single-till approach under which regulation is applied to an airport's total revenues/profits including from both aeronautical and concession activities; and
- A dual-till approach under which specific regulation is applied to aeronautical revenues/profits, with concession operations either left unregulated or subject to their own regulation.

84. The authors find that the particular form of regulation has implications for efficiency. They find that while price-cap regulation creates incentives for improved efficiency, it can also lead to under-investment in capacity. In particular, by preventing airport owners from capturing any of the benefit to customers from reduced congestion, price cap regulation will lead to airport owners investing less than is optimal in expanding capacity. This effect is particularly severe under a single-till approach whereas the greater pricing flexibility under a dual-till approach moderates this effect to some degree.

85. The authors find that rate of return regulation under a single-till approach leads to the Averch-Johnson effect of over-investment so as to maximise nominal returns. However, they note that under dual-till rate of return regulation, the airport owner will aim to maximise profit from concession activities and this will lead to productive

[47] Oum, Zhang & Zhang , "Alternative forms of economic regulation and their efficiency implications for airports", Journal of Transport Economics and Policy, Volume 38, Part 2, April 2004.

efficiency and investment to reduce concessional costs. Nonetheless, the authors did not have sufficient data to test this last proposition.

86. The case of airport regulation highlights the importance of assessing the impact of regulation in relation to the specific industry context. Further, while price cap regulation has attractive features, it can also fail to adequately take into account quality effects (such as congestion delays in the case of airports).

4.5. Freight railway regulation

87. Estache, Perelman and Trujillo examined the trade-off in regulation between quantity and quality in the Brazilian freight railways sector.[48] Brazil was the first country to adopt incentive based regulation for the railway sector in which operators are assessed on both their output and a quality dimension (i.e. the number of accidents).

88. Brazil's railway system was unbundled into 6 regional monopolies in 1996 and the right to operate the rail network was auctioned for each region. Two specific targets were set for each operator relating to minimum net ton-kilometres carried per year and a maximum number of accidents per train-kilometres during the first five years. The targets were reviewed and relied upon to establish new goals from 2005 onwards.

89. The authors collect data for 10 years, from 1992 – 2001. For the purposes of their analysis they define three sub-periods; pre-reform (1992-1994), reform (1995-1998) and post-reform (1999-2001). The authors comment that the first sub-period is characterised by traditional public sector management, the second sub-period is characterised by extreme operational changes including staff redundancies, and the third sub-period is characterised by a stable post-privatisation situation.

90. The analysis is based on a Malmquist productivity index. The rate of change in the overall index was 2.1 per cent during sub-period 1 (public sector management), 4.4 per cent during sub-period 2 (reform period) and 5.6 per cent during sub-period 3 (after privatisation). The authors found that quality improved for all operators once they faced incentives to improve quality as well as quantity. The authors also identified that while there was initially a trade-off between quantity and quality, in the last period, higher quality helps grow traffic. The authors conclude:

> *These results illustrate the possibilities offered by the FGR (1995) Malmquist decomposition for regulation purposes. In particular, they show that the computation of a TFP change index that takes into account simultaneously quantity and quality improvements and its decomposition can be helpful (i) for increasing the transparency of possible strategic quantity-quality trade-off behaviours by operators and (ii) for the design of regulatory incentive schemes that require an integrated assessment of the quantity and the quality*

[48] Estache, Perelman, Trujillo "Measuring quantity-quality trade-offs in regulation: The Brazilian freight railways case", Annals of Public and Cooperative Economics, 2007

performance of an operator aimed at minimizing the risk of undesirable strategic behaviours.[49]

4.6. Summary

91. The general experience of incentive regulation in the industries reviewed has been positive. In particular, incentive regulation has encouraged firms to identify and implement cost savings with the effect that efficiency and customer benefits have been higher over time. Our review has also shown that, depending on the circumstances of the industry, basic incentive regulation may lead to sub-optimal quality level and that these quality levels can be improved through incorporating quality levels into the overall incentive regulation.

[49] Estache, Perelman, Trujillo, "Measuring quantity-quality trade-offs in regulation: The Brazilian freight railways case", Annals of Public and Cooperative Economics, 2007, p.16

5. Evidence from the procurement and patent literature

92. Empirical studies of the impact of policies more generally also offer useful insights.

93. In public sector procurement, governments can hold similar objectives as for economic regulation particularly to minimise the cost of service provision while also achieving optimal levels of quality of service. Many standard procurement mechanisms however award contracts to the lowest bidder subject to only meeting some minimum requirements (and with no reward for providing higher quality than those minimum requirements). Such mechanisms do not enable the optimal trade-off between price and quality of service to be determined. However, there is now a signficant literature on optimal procurement design and auctions with multidimensional allocation criteria.[50] A key insight of this literature is that welfare can be improved by applying mechanisms which enable the optimal level of price and non-price parameters to be determined in an integrated way, particularly by taking into account the costs and benefits of changes in the level of non-price parameters along side price bids.

94. A study by Bajari and Lewis has examined the effects of standard procurement mechanisms for highway construction in California compared with more recent auctions in which the winning contractor is determined on the basis of a combination of the price bid as well as the total number of days required to complete the project that they bid.[51] In particular, weightings are applied to both the price bid and the completion time bid and the contract is awarded to the bid with the lowest weighted overall score. Completion time on projects is explicitly taken into account because it can significantly impact commuters, particularly while works are being undertaken, as well as in the delay before the new road is able to be used. Under standard contracts, the completion time is instead set by the highway department with a fixed penalty also being set for each day late (under the newer auctions, penalties were also imposed for late days passed the completion date specified in the winning bid and these penalties were generally higher than under standard contracts).

95. The study found that the newer auctions led to faster completion times (generating benefits to commuters of $6.4 million per contract on average) while the winning bids were only $1.5 million higher on average than those under the standard contracts. Thus the newer, more sophisticated auctions led to significant increases in commuter welfare relative to costs. The authors also examine the additional costs accrued by contractors in accelerating construction. The study concludes that while the new auctions significantly increase commuter welfare relative to contractors, higher gains were possible. In particular, the authors find that the weight assigned to completion time in the auction relative to the weight assigned to the bid price could be modified so

[50] For example, see F. Branco, "The design of multidimensional auctions", Rand Journal of Economics 1997, 28(1), p.63-81 and J. asker and E. Cantillon, "Optimal procurement when both price and quality matter", CEPR Discussion Paper No. 5276.

[51] Bajari, P. and G. Lewis, "Procurement contracting with time incentives: theory and evidence", NBER Working Paper 14855, April 2009.

as to lead to substantially higher increases in commuter surplus relative to contractor costs. This study is another example of how mechanisms that enable businesses themselves to reveal information on the trade-off between price and non-price parameters can lead to higher welfare levels than administratively set non-price parameters.

96. We have also reviewed empirical studies on the impact of patent laws. Patents effectively allow the patent-holder an exclusive right and thus the ability to earn higher revenues over the life of the patent with the aim that the potential for higher revenues will encourage higher R&D spending. Patent laws are based on the expectation that, despite prices being above costs during the patent term, welfare will nevertheless be higher in the long run because of the higher rates of innovation. Some period of exclusive rights can be expected to induce higher innovation, although the extra innovation induced by granting a longer period of exclusive rights can be expected to decline the longer the period (e.g. more innovation is likely to be induced by allowing an initial 20 year period of exclusive rights compared with the extra innovation induced by extending the exclusive rights period from 20 years to 40 years).[52] To maximise welfare, patent terms should be set sufficiently long so that the marginal benefit from increased innovation just equals the marginal cost of the deadweight loss created by prices being above costs. On the other hand, welfare would be lower if patent terms are set longer that this as too little extra innovation is induced relative to the costs of customers facing higher prices for longer.

97. Abrams studied the impact of extensions to patent terms in the US following the international Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).[53] As a result of the TRIPS agreement, patent terms in the US were extended from 17 years from the date the patent was granted to 20 years from the date the patent was applied for. Patent applications that could be processed within 3 years (i.e. between the date of application and the date when the protection was actually granted) thus received a longer period of protection. However, other patents that required longer than 3 years to process ended up with a shorter period of protection. Abrams identified that patents in different industries take differing periods to process and this allows him to estimate the impact of the TRIPS agreement by comparing changes in the number of patents granted in industries that effectively received an extension to patent terms compared with those that did not. Abrams also examined changes in the number of patents weighted by how often they are cited (i.e. as a proxy for the value of the innovation captured by the patent). Abrams finds that the extension of the period of protection for particular industries under the TRIPS agreement led to statistically significant increases in the number of patents and in the number of patents weighted by citations.

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[52] A paper by Petra Moser found a diminishing marginal incentive effect of patent duration ("How do patent laws influence innovation? Evidence from nineteenth century's world's fair", American Economic Review, 95, 2005, p.1214. Indeed, very long patent duration may actually reduce innovation because of the restrictions on the use of the existing patented knowledge to develop new innovations.

[53] Abrams, D., "Did TRIPS spur innovation? An analysis of patent duration and incentives to innovate", University of Pennsylvania Law Review, Vol. 157.

98. The economics literature on patents more generally highlights that intellectual property protection can be improved by being tailored to specific technologies[54] and to differing national circumstances.[55]

99. Studies on the impact of patent laws indicate that there can be a trade-off between allocative efficiency (in terms of prices being set above costs at a particular point of time) and dynamic efficiency (i.e. ensuring firms have the appropriate incentives to invest and innovate so as to maximise overall welfare over time). These studies also suggest that striking the right balance will depend on weighing up the additional costs and benefits of changes to patent laws as they affect specific industries.

[54] For instance, see N. Gallini, "The economics of patents: lessons from recent US patent reform", Journal of Economic Perspectives, Vol. 16(2), p. 131-154.

[55] For example, see Y. Qian, "Do national patent laws stimulate domestic innovation in a global patenting environment?", The Review of Economics and Statistics, August 2007, p. 436-453.