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Dynamic efficiency in the English and Welsh water and sewerage industry

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ABSTRACT

The English and Welsh water and sewerage industry is characterised by indivisible capital which has a long service life. Previous studies of efficiency for the English and Welsh water and sewerage industry take a static framework, assuming all inputs can be adjusted instantaneously. This paper measures dynamic efficiency by incorporating intertemporal links of capital within the production function for the English and Welsh water and sewerage industry for the period 1997–2011. Dynamic Data Envelopment Analysis (DEA) considers capital as a quasi-fixed input and is modelled as a contemporaneous output into current production and an input from past production. The results show that the inadequate intertemporal allocation of quasi-fixed inputs is the largest contributor of inefficiency.
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1. Introduction[1]

The English and Welsh water and sewerage sector is a long-life capital intensive industry, characterised by regional monopolies. The industry was privatised in 1989 and is regulated by Ofwat (Office of Water Services), the water service regulatory authority which acts as a proxy for a competitive market. Ofwat ensures that utility companies obtain a specified return on capital which is unique to the water sector whilst ensuring a competitive price for customers. To guarantee quality standards the industry is also regulated by the Drinking Water Inspectorate (DWI), National Resources Wales (NRW) and the Environment Agency (EA).

The aims of this paper are twofold: firstly to compare the conclusions from static and dynamic DEA highlighting the inefficiencies that arise out of a dynamic framework, and secondly to investigate the presence of a preference for capital expenditure known as the *capex bias*. The bias arises because of differing incentive rates between operating and capital expenditure, or due to the nature of the industry as much of the infrastructure is built in order to meet expected future demand. The presence of the bias drives to the heart of the brief set by regulators to guarantee consumer value.

Data Envelopment Analysis (DEA) is used to measure efficiency within a dynamic context by examining the presence of quasi-fixed capital. The English and Welsh water and sewerage industry is characterised by quasi-fixed inputs such as mains, sewers and treatment works which have a long service life and cannot be adjusted to their optimal level instantaneously. A dynamic perspective of the measurement of efficiency is required as decisions on quasi-fixed inputs not only influence current production, but also future production. Intertemporal effects are incorporated through the inclusion of capital as an output in the current period production as well as an input from the previous period's production. Firms therefore face a trade-off between increasing output today and producing capital to increase outputs in the future [21]. Dynamic DEA determines the optimal allocation of resources over the period by minimising dynamic costs given the technology. We allow for overall efficiency to be decomposed into a dynamic component and a static component. This approach determines the level of efficiency due to variable inputs and the inefficiency due to quasi-fixed inputs. We use a three stage approach by including environmental variables[2] within the dynamic framework to ensure firms are compared on a level playing field. Input slacks ratios are obtained from the dynamic DEA which are then regressed upon the environmental variables. The predicted slack ratios are used to adjust the input variables upwards for those firms operating in a relatively favourable environment. The DEA is repeated including the adjusted inputs to obtain adjusted efficiency scores accounting for differences in the operating environments.

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[2] Fried et al. [19,20].

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The remainder of the paper is organised as follows: Section 2 describes the regulatory environment; Section 3 briefly reviews the extant literature; Section 4 outlines the methodology to measure dynamic efficiency; Section 5 outlines the sample data and variable definitions; Section 6 presents and discusses the results and Section 7 concludes the paper.

2. Regulation of the water industry

The English and Welsh water and sewerage industry in 1989 consisted of ten water and sewerage companies (WaSCs) and 29 water only companies (WoCs). Privatisation has seen a series of mergers and acquisitions resulting in ten WaSCs and nine WoCs within the industry. The companies are vertically integrated monopolies undertaking all activities of the value chain. WaSCs undertake both water and sewerage activities and WoCs only undertake water activities. Water services are provided by a single company that extracts, treates, distributes and retails the water whereas for sewerage activities a company collects, treats and disposes of the sewerage. WaSCs are considerably larger than WoCs undertaking 78% of water supply to the population and serve 85% of the total area of England and Wales [30].

The local provider of water and sewerage services is a monopoly; therefore Ofwat regulates prices through the use of price-cap regulation based on $RPI+K$ which allows companies to change prices according to the inflation rate (*RPI*, Retail Price Index) and a K factor determined by the regulator. The K factor has two components: a positive component which allows for price increases to accommodate large investment programmes and a negative component (X-efficiency) which reflects Ofwat's estimate of the scope for efficiency improvements. Ofwat's determination of the K factor is based on a building block approach to determine the “Required Revenue” which involves the individual assessment of utility operating costs, capital charges and return on capital. The first price-cap was set by the Government at the start of privatisation in 1989 and subsequent price reviews have been undertaken by Ofwat every 5 years in 1994, 1999, 2004 and 2009[3].

The allowed level of operating costs is determined through the use of yardstick competition and menu regulation. Ofwat analyses operating expenditure (*opex*) and capital expenditure (*capex*) separately. Operating expenditure is subject to an efficiency challenge which is decomposed into an industry efficiency challenge for continuing efficiency improvement (technical change) and a catch-up factor to the frontier company. The catch-up factor is determined through a suite of econometric and unit cost models which are used to calculate the company's relative efficiency. Based upon these efficiency scores firms are banded and given an efficiency challenge to catch-up 60% of the difference from the benchmark company[4]. Firms are further incentivised to improve efficiency between the five-year price reviews, if companies outperform their efficiency challenge the benefits can be kept for the five years. Capital expenditure was evaluated through the use of yardstick competition, using econometric models and unit costs. In the 2009 price review *capex* was analysed through the use of menu regulation which encourages firms to submit realistic and well evidenced capital planning schemes. Ofwat determines an independent baseline, and provides incentives for firms to outperform. The companies have the incentive to outperform their efficiency target through a symmetric efficiency incentive on the level of over and under spend. The incentive rate is based upon the ratio of Ofwat's baseline and the company's business plan. Opex is recovered within the period; however *capex* is added to the Regulatory Capital Value (RCV)[5] which earns a return based upon Ofwat's assumptions of the cost of capital. A fair return on capital is required to attract investment within the industry.

The 2014 price review to set prices for 2015–2020 is partly designed around eliminating the presence of the perceived *capex bias*. Ofwat [27] defines the *capex bias* as the view that companies within the industry have an inappropriate preference for expenditure on capital assets over day-to-day operational expenditure. [8] state that the bias is believed to exist for three reasons. Firstly, there are the different financial incentives created by examining *capex* and *opex* separately. Secondly, the presence of what is termed as the *Averch–Johnson effect*; which arises if the allowed rate of return is higher than the true cost of capital [3]. Thirdly, the culture of the sector is one that is focused on *capex* solutions and infrastructure to meet future demand.

3. Literature review

The privatisation and regulation of the water and sewerage industry in England and Wales has spawned a large literature on estimating productivity and cost efficiency. Ashton [2] analyses firm-specific cost efficiency conditions of WaSCs using a translog variable cost function over the period 1987–1997.The paper reports a moderate level of dispersion of inefficiency which may be due to the performance or the operating environment within the sector.

Saal and Parker [30] estimate a cost function to evaluate the impact of privatisation and regulation on productivity. The impact of changes in quality regulations were taken into account through a quality-adjusted measure of output. The model highlights the importance of adjusting for changes in quality standards through the impact on the interaction term between water and sewerage activities, finding an improvement in the quality of one output may reduce the cost of producing the other. Productivity was examined over the period in which the null hypothesis of no productivity change was rejected. Individual parameter estimates reveal that the productivity change was led by improvements after the 1994 price review and were not due to privatisation. Saal et al [33] examine technical efficiency through an SFA (Stochastic Frontier Analysis) input distance function and find that productivity growth was not statistically different after privatisation and the 1994 price review. The impact of privatisation and regulation resulted in technological improvements rather than efficiency improvements. The average efficiency was lower in 2000 than at privatisation; however the price cap has influenced the relatively inefficient firms by substantially improving the minimum efficiency score.

Similarly, Bottasso and Conti [4] examine efficiency for water activities estimating an SFA translog cost function with quasi-fixed capital and confirm that operating inefficiency decreased for the period 1995–2001. Bottasso and Conti [5] examine economies of scale and technical change for the WoCs using a variable cost function for 1995–2005. Their results on total factor productivity indicate that the rate of technical change is much higher after the 1999 price review in comparison to the rate after the 1994 price review which was close to zero. Productivity improvements have been a result of labour saving technological progress.

Saal and Reid [34] analyse *opex* productivity growth of the WaSCs from 1993 to 2003 through the use of a quasi-fixed capital translog cost function. The paper examines the impact of the

[3] The first price-cap in 1989 was set for 10 years with an opportunity for the regulator to hold an interim determination after five years, which the regulator implemented.

[4] Ofwat [26].

[5] The RCV is the value placed on companies 100 days after privatisation and is rolled forwards based on the amount of capital expenditure for each period less the level of depreciation.

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