Size and scope economies in water and wastewater services

An investigation into economies of size and scope associated with alternative structures for the Water Corporation's activities

Prepared for the Economic Regulation Authority

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Economics Policy Strategy

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Key points

- The literature is mixed as to size economies in water and wastewater utilities, but is generally indicative of modest size economies for smaller water supply utilities, but of limited economies, and even diseconomies, in wastewater.
- The literature also suggests there are few (if any) economies of scope in combining water and wastewater function, but that there are economies of vertical integration for water supply.
  - Trends towards greater use of wastewater as a source of water supply *may* support stronger supply/wastewater scope economies in the future.
- The structure of Water Corporation does not match well to most other utilities that have been subjected to detailed modelling, but basing size on number of connections and/or lengths of pipe would suggest that any economies at the margins of its current size and scope are very small – indicatively, well under 5 per cent potential savings.
- The average cost curve of the typical water/wastewater utility is best described as flat for output larger than 200ML/day. This suggests that provided there is no material reduction of customer density, the creation of smaller or more specialised entities is unlikely to sacrifice much efficiency.
  - Customer density and volume of water per customer are the strongest efficiency drivers. WA is characterised by relative low density and relatively high volumes per customer compared to most studies.
- The key issue for this Inquiry is not whether there are economies at the margin of current operations, but rather whether substantial diseconomies could flow from institutional change that produced some smaller entities, or entities with narrower scope.
  - This study suggests caution about creating very small supply entities; suggests any sustained diseconomies in entities of the order of a third to a half of the current size should still be quite modest; but recognises that the transition costs of unravelling current sunk investments in systems sized to the current entity need to be carefully managed.
  - Estimates of transition costs in relation to Melbourne water supply do suggest that these transition costs can probably be modest and largely one-off in nature – with limited impact on long-run costs.
- Evidence on multi-utilities (joint provision of gas/electricity/water) indicates that there are likely to be substantial efficiency gains relative to service provision via separate service providers across large areas with low population density.
- Low capacity utilisation is likely to be the single largest threat to efficiency, regardless of the size or scope of the organisation. For the large firm, low capital utilisation may arise through over-investment. For smaller firms created from the separation of a large firm, 'lumpy and uneven' capital allocation across firms may result in reduced utilisation if the firms cannot share the capital effectively.
  - There is no fundamental reason why separating out smaller entities, with appropriate commercial links and incentives, need threaten capacity utilisation.

Introductory comments

ACIL Tasman has been commissioned by the Economic Regulation Authority (ERA) to investigate economies of size and scope associated with different configurations of the Water Corporation's operations. The context within which the advice is being sought is the ERA's Inquiry into Competition in the Water and Waste Water Services Sector ("the Inquiry").

This brief is concerned with assessing the economic impact of economies of size/scope on various configurations of the Water Corporation's operations. The Water Corporation is a vertically integrated entity which provides water and wastewater services to the Perth metropolitan area and the majority of regional and remote centres. The underlying question driving the assessment is whether net social benefit could be increased by an industry configuration that is materially different from the present arrangement. Such improvement would be manifest as cost reductions (or opportunity to improve service standards at no extra cost) being achieved through increased efficiency and/or a reduction in the exercise of market power in output markets. From the perspective of the Inquiry, the proposed mechanism to achieve this is competition or at least the threat of competition and new entry.

In concept, this question is different from asking whether the present Water Corporation exhibits economies of size or scope within the usual interpretation of the term – whether *marginal growth* in the size or scope of operations would be delivered with a less than proportional growth in costs. The immediate policy questions – flagged in the ERA discussion paper for the Inquiry – relate to options to create new entities that would result in at least one of these entities being substantially smaller in scale; would separate functions resulting in a significantly reduced scope for each entity; or would merge existing regional operations with a non-water utility, delivering a substantial expansion in scope, but with a substantial reduction in size of water operations.

These options involve non-marginal changes – and in several cases involve unravelling larger operations, with sunk costs developed around those larger operations. This could well involve transitional and legacy costs that would not arise under an 'organic growth' approach to expanded size or scope. Comparing two established utilities of different size or scope (as is commonly done in the literature) is not the same as creating two utilities out of an existing utility.

It is important also to recognise that, from an engineering perspective, there will almost inevitably be theoretical opportunities to derive size and scope economies in any utilities business of any size. Of course there are real synergies in operations; scope for dealing with 'lumpy' inputs and for active cross fertilisation of ideas in relation to system planning etc; scope for negotiating 'bulk discounts' etc. Highly complex networked systems will inevitably be replete with such opportunities, but the principles apply across industrial activity. The fact is that there is a lot of evidence that, despite these real theoretical possibilities, actually captured economies can and do shrink as size and scope grow. Importantly, a point is eventually reached in many sectors where the complexities – of managing the larger system; of dealing with declining effectiveness of intra-firm communication; of dealing with a trend to longer decision times; of aligning incentives throughout the system with overall corporate incentives; and of encouraging, and responding appropriately to, innovation and opportunities for risk-taking – can deliver a loss of *dynamic efficiency* to the point where smaller firms can be more cost effective.

This is not just a theoretical argument – and is not just supported by theoretical studies. This reality has been shown many times in the way that competitive sectors organise in the face of changing technologies and advantages to innovation and risk-taking. The 1960s IBM-model of dominance of computer manufacture proved quite inadequate to the exploding opportunities of the 1980s.

In an environment such as water, especially in settings where climates and associated hydrology are changing and where technological options for both supply (eg, desalination and recycling plants) and demand management are also changing rapidly, these considerations of *innovation* and *dynamic efficiency* are almost certainly growing in importance compared to even a few years back. It is appropriate to challenge the dominance of economies based in the engineering possibilities alone – while it would be inappropriate to ignore these real possibilities.

Approach

We have looked at a number of ways to assist ERA in addressing these questions.

The first approach is to treat it as essentially empirical, and to review the available evidence from published studies. Economic theory provides arguments both for and against competition in industries considered to have significant elements of natural monopoly – with size or scope economies being one potential source of natural monopoly.

Arguments against competition or contestability appeal to perceived large economies of size and/or scope and the implied efficiency loss incurred by allowing more than one firm to operate in a particular market, or by breaking a large market into one or more smaller markets. Given the generally large sunk investment in the water transport and reticulation industry, this argument appears quite reasonable particularly for small, isolated markets. These arguments could well be further strengthened in the context of labour and skills shortages of the type now evident in Western Australia and much of Australia, and on the basis of the relatively low and disperse population of Western Australia in relation to area.

Advocates for competition argue that economies of size and scope are not substantial, if they exist at all – and that they will usually be less than the net social benefits deriving from the prices and service levels delivered through heightened competition. Where the incumbent's monopoly powers are already the subject of effective economic and pricing regulation, this argument is commonly less about competing down 'monopoly rents' and high profit margins, and more about using competition to find and implement strategies that deliver lower costs and/or cost effective improved customer service levels. A secondary argument is that at least the threat of competition is capable of extracting greater efficiency from incumbents. This argument is, however, dependent on the credibility of the threat.

One of the important conditions for deriving benefits from competition or contestability is that the markets are well-defined. Commonly, this design process involves identifying areas of strong 'natural monopoly' and separating these from other areas better suited to competition. Furthermore, recent developments in water supply, including in Western Australia, have challenged the traditional natural monopoly elements of some areas of water service supply – particularly the emergence of competitive desalination and reuse technologies, and emerging demands for competitive access to wastewater streams as a resource.

Our second approach to the question involves looking at other utility industries that have a number of features in common with water and which have been through a period of significant reform and disaggregation to see if there are any lessons for water. We have looked at the electricity industry most closely as it has been reformed significantly over the past 15 or more years in many countries. Typically, at the beginning of this process incumbent organisations claimed the existence of size and scope economies as a reason not to proceed. We look at some of the retrospective studies of this reform in a number of countries to determine what lessons, if any, there may be for WA water. Similarly, we briefly examine analogous lessons from the emergence of more competitive gas markets.

Finally, we have looked at the operations of the WA Water Corporation to look at the linkages that exist and the extent to which economies of scale or of vertical integration may exist. We also look at the drivers of costs in the water industry and the extent to which these costs may be amenable to reductions through competition, contestability or different institutional organisation.

The WA water and wastewater industry

The Water Corporation was established on 1 January 1996 following the recommendations of the Water Industry Restructure Implementation Group (WIRIG), which was formed to inquire into the operations and financing of the Western Australian Water Authority (WAWA). Among other things, WIRIG recommended the separation of WAWA's commercial, policy and regulatory functions.[1]

The Water Corporation serves almost two million customers spread across 2.5 million square kilometres and is responsible for providing water, wastewater, drainage and irrigation services.

The Water Corporation is large in relation to many other Australian water and wastewater service providers. In terms of the volume of water supplied, it is three times the average for other major urban Australian service providers. Sewerage collection is also substantially larger than the average and 15 times larger than the smallest sewerage collection utility.

Properties served per kilometre of water and sewerage mains, which provides an indication of customer density, is substantially below average, although in the Perth area, where the majority of customers reside, customer density is much higher.

The Water Corporation accounts for 94% of all potable water supplied in WA, only about 2% of non-potable water and nearly all of the wastewater and drainage assets.

Literature on economies of size and scope

There is a substantial body of literature reporting empirical studies on the magnitude of size/scope economies in the water industry. The earlier comment is highly relevant – much of this work involves comparing the economics of utilities that *happen to be* of different sizes or scope, and care is needed in drawing from these studies strong conclusions about the effect of *forcing a different size or scope* on an existing entity.

Some of this literature has recently been surveyed by the NSW Independent Pricing and Regulatory Tribunal (IPART)[2]. Appendix A of IPART's report provides a summary of the results suggesting that there is no general consensus on the question of whether there are increasing, constant or decreasing returns

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1 WA Treasury, *Progress Report: Implementing National Competition Policy in Western Australia*, Report to the national Competition Council, March 1999, p.35

2 IPART, *Literature Review, Underlying costs and industry structures of metropolitan water industries*, September 2007

to size/scope in providing water and wastewater services. This might be seen as rather unhelpful – but it does tend to highlight the reality that strong conclusions will generally be very context-specific.

IPART reported that most studies provide conditional support for economies of size, suggesting there is a finite (though varying) minimum efficient size (MES). Estimates of the MES for water supply suggest a range from 125,000 to 1 million serviced inhabitants. For wastewater, the MES is less clear as the studies surveyed either examine size economies of combined water and wastewater services or are interested mainly in testing for economies of scope between water and wastewater services. One study suggests an MES in wastewater of 100,000 serviced inhabitants.

IPART's review canvassed only five studies that examine economies of scope. Results can be categorised as economies of scope between: water production and distribution; and water-wastewater services. Two studies[3] report economies of scope from the vertical integration of water production and distribution. Two studies report economies of scope between water and sewerage services. Only one study reported diseconomies of scope.

ACIL Tasman's considerably more extensive literature review adds further insight into the likely magnitude of size and scope economies. In looking across the studies, it is apparent that there are three factors that impact on size economies:

1. Volume of water supplied
2. Number of connections served
3. Size of the area served

The magnitude of size economies appears to depend on the extent to which the volume of water supplied can be increased without incurring expansion costs in the other two factors. In a setting where there is pressure to reduce per capita consumption and where population and residential growth is strong, this opportunity appears likely to be quite constrained.

Another area of apparent consensus is that there are efficiencies to be derived from mergers among very small municipal water suppliers.

Few studies investigated economies of size in wastewater services, so conclusions are more tentative. The little research available suggests there are

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[3] Stone and Webster Consultants Ltd, I*nvestigation into evidence for economies of scale in the water and sewerage industry in England and Wales, Final Report*, for the Office of Water Services, January 2004; and
Hayes, K., "Cost structure of the water utility industry", *Applied economics*, 19(3), 1987, pp. 417-425

limited economies of size available. No explanation was provided in the studies considered, though we do discuss possible explanations below.

The question of economies of scope examined in the literature ranges across economies between:

1. water and wastewater services
2. retail (distribution) and wholesale (transmission/source) water supply
3. environmental services and water supply
4. quality of water and wastewater treatment
5. water delivered and water lost

The research suggests that there are few (if any) size efficiencies to be gained by combining water and wastewater utilities. It is worth noting that the increasing emphasis being given to wastewater as a potential source for fresh supply – through recycling schemes – *may* mean that stronger economies of scope are starting to emerge, but are unlikely to be clearly evident in the types of studies undertaken using historical data. If this is the case, it would seem appropriate to recognise that the same trends are delivering greater scope for innovation, which could in turn favour greater competition.

Economies of scope are found between retail and wholesale water supply, suggesting efficiency from vertical integration. Scope economies between water delivered and lost indicates that it can be economically efficient to choose not to rectify some level of water loss.

In addition to the scope economies identified within the literature concerned with analysing specialist water/wastewater utilities, one study analysing multi-utilities suggests there are substantial cost savings (up to 20%) for multi-utilities providing gas-electricity-water services. This finding raises questions with respect to why there would be economies of scope between these services and not between water and wastewater services – over and above the obvious synergies where the services are all metered etc.

While there is no explicit confirmation in the literature, it would appear that economies of scope are derived from economies of "shared common costs". Within relatively small utilities, the cost difference between maintaining separate organisations and a single combined entity represents a significant portion of unit cost. By contrast, the large urban water and wastewater utilities have grown far beyond the point at which the cost difference is likely to impacts significantly on unit cost. Indeed, it is more likely that other inefficiencies, such as increased bureaucracy, overwhelm any cost saving.

In addition, a factor that is particularly relevant to sparsely populated regions of Western Australia is the time spent on coordination savings between small utilities can be maximised if organised internally within a single utility.

Implications for water and wastewater industry configuration

The focus of much of the literature is on finding ways of achieving greater levels of efficiency. Economies of size and scope have been included in the efficiency measures to determine whether efficiency gains can be realised through changes in the scale and scope of operations. In this regard, the literature has recognised evidence in support of mergers between small water suppliers where it is sensible to do so – a conclusion of relatively limited direct application in WA, but that may be relevant to strategy in the event that a separation of regional operations is being considered. The evidence from the literature would tend to support reasonably large regional operations – and/or exploiting economies of scope with other regional utilities.

While there appears to be little (historical) support for combining water and wastewater services, the loss of efficiency, if any, appears to be relatively small. Hence, the relevant policy issue is whether creating or maintaining combined water and wastewater utilities implies material losses of efficiency. The tentative conclusion is that it depends on other benefits that may be derived. If those other benefits outweigh the implied efficiency losses, then it may be more appropriate to maintain combined water and wastewater services. However, if combined water and wastewater utilities are being entertained, then it may also be appropriate to consider whether there are benefits in creating multi-utilities that span water/wastewater and other services, such as electricity transmission and distribution. Given the remoteness of large parts of Western Australia, such utilities may be appropriate.

The trend towards wastewater being considered increasingly as a potential source of water supply (through indirect, and even direct, potable supply of recycled water) does flag the possibility of increasing scope economies in the future – that suggests some caution in seeking a separation based only on historical use patterns. However, joint ownership of the water and wastewater streams should not be essential to exploiting these growing synergies under institutional arrangements that embody sound procurement planning and, possibly, access arrangements. Care is needed – but not necessarily avoidance.

Overall our findings suggest that the magnitude of scale and scope economies is relatively modest in many cases. Whether they are sufficient to offset the benefits of specific forms of competition requires an assessment of such benefits – which is beyond the scope of this paper. However, if market structures can deliver a constructive competitive market, with incentives for innovation and competition through dynamic efficiency, then it is possible that the gains from competition would be sufficient to outweigh the (modest) loss of economies of scale and scope suggested in the literature. In addition, however, the transition costs involved in moving to a changed industry structure also need to be taken into account in the assessment.

Lessons from electricity

The following conclusions were brought together from review of electricity industry reforms.

A simple decision to reform the Electricity Supply Industry (ESI) has not necessarily resulted in improvements in efficiency, a lowering of prices or improvements in dynamic efficiency. The market mechanism must be developed with great care and the market structure (the number of competing generators) must be appropriate. A poor market mechanism and an uncompetitive structure will almost certainly give worse outcomes than the pre-reform situation. On the other hand, a well designed and competitive market can provide considerable price and service benefits for consumers.

In the Australian National Electricity Market (NEM) the main benefits of reform have included significant reductions in wholesale prices, lower industrial and commercial prices and lower prices for domestic consumers in recent years as Full Retail competition (FRC) has helped to develop a competitive retail market able to pass on gains from a highly competitive wholesale market.

The other main gain has been the much more efficient and disciplined investment process in new plant, resulting in lower reserve margins and higher capacity factors for existing power stations. Investors in new generation are not now able to pass on most of their risks to consumers. Power stations that have been privatised have in nearly all cases been refurbished and their capacity upgraded from pre-NEM levels, making better use of existing capital stock. In a quite fundamental way, the competition has encouraged a market that is quite differently structured, because of the improved *dynamic efficiency* and *system risk management* offered by this structure.

Transmission and distribution have been left as natural monopolies with access arrangements in place in nearly all reformed electricity industries. However, they have been left with the functions to operate and invest in their networks but *not the planning or system control functions*. In nearly all cases these are undertaken by independent bodies who do not own any assets.

Economies of vertical integration existed in the electricity industry as vertically integrated electricity commissions undertook new investment, operated both power stations and the transmission network and scheduled these assets to meet demand. However, it has emerged that the transition and transaction costs involved in separating out this function are not significant – and are substantially less than was originally envisaged. In the case of the NEM, they appear to be lower by an order of magnitude than the wholesale price reductions experienced shortly after the NEM commenced.

Other benefits are available from having an independent operator undertake close management of system assets and the network. The way the system is managed becomes much more transparent, allowing potential new investors to make better decisions about how assets are likely to be used and which assets would make the best new investments in coming years. Additions to the network, which the network owner will be able to include in their rate base, should be considered by the independent system operator as they will have the best informed and most objective view of the system's needs.

For the water sector there are some useful messages. Firstly, the benefits of reform will not only materialise in the form of lower prices. More efficient use of existing capital, more transparent and objective planning for the future, more transparent system operation and a more objective and independent procurement process may be possible. Of course, one of the major conclusions is that the benefits depend very much on the design of the new system, the governance of new market institutions and, in cases where a competitive market price setting process is needed, the number of players in the market and competitive structure.

Lessons from gas

In concept gas is more similar to water than electricity – with direct issues of storage in system, of pressure requirements and system balancing of a type that would be familiar to most water utilities. There are also important differences – gas has not generally been treated as an essential service; there has been commercial discretion as to whether individual towns and parts of towns are connected; and gas demand, while variable, is not characterised by the longer-term severe fluctuations in capacity relative to demand seen in water as a result of severe droughts and now the impacts of uncertain climate change impacts.

Nevertheless, there are some useful insights, particularly in the complete lack of concern regarding so-called economies of vertical integration. The industry also demonstrates the ability to manage and plan a fairly complex supply chain without a central control, planning or procurement role. The above comments on volatility differences between gas and water are almost certainly relevant here, but the experience does – as with electricity – urge caution in assessing these economies as being too high.

There appear to be relatively few concerns as to the level of transaction costs, efficiency of operation and investment in the gas setting – and some support for the view that system size economies have been accessed with a much less aggregated system than is typical of water – and, historically, of electricity.

Cost drivers for water

The cost drivers are complex for both water and sewerage services and include many factors other than average annual volumes supplied or collected. Moreover, as one moves down the distribution system towards the customer, peak factors become relatively more important, so that volumes *per se* carry less importance in the sizing of capacity.

Water resources

The operation and maintenance of several sources (as compared to a single source) is likely to involve some economies of scale. However, the contracting out of operation and maintenance activities might be expected to minimise the extent of any diseconomies involved in disaggregating ownership of sources.

The complexity of water resource planning, and the issues that need to be addressed regarding uncertainty and the flexibility of the system to adapt to new information on future inflows, suggest that a reasonably centralised approach may be required for efficient augmentation planning, at least for the time being. Continuation of centralised planning would not preclude competitive procurement of new supplies, as proposed by Water Corporation – though it is appropriate to consider alternative allocations of responsibility for the central procurement. This question is being addressed in more detail in a separate study commissioned by ERA.

The operation and maintenance of water sources is a distinct activity that is unlikely to share expertise or staffing with other elements of the supply chain and/or other services such as sewerage. However, the interaction between sources, treatment and distribution costs suggests that there *may* be some loss of economies of scope should the resource activity be totally separated from treatment and distribution activities. Choices as to which sources to use when has implications for treatment and distribution costs *and* for system source security.

Water treatment

Complex treatment facilities are thought to involve economies of scale with respect to plant size (in terms of volumes treated)[4]. The economies of scale applying to less complex treatment plant may be less extensive. Whether there are economies of scale in terms of operating a number of treatment plants (to serve different population centres) is less clear, although studies suggest that

[4] IPART, Sept 2007, Literature Review, underlying costs and industry structures of metropolitan water industries, p19

technical economies of scale may be exhausted at a relatively small scale – at around 400,000 connected properties).

Water Corporation has over double that number of connected properties and relatively high levels of per capita consumption, suggesting that it is well beyond the scale that size at which technical economies of scale are exhausted – though the great diversity of sources could partially offset this effect. Nearly 600,000 connected water properties are within Perth, with the other regions having well under 100,000 connected water properties each. If the Perth region were to be split into two suppliers (each serving just under 300,000 properties) on this basis it would probably involve only minimal loss of economies of scale – although this would be heavily dependent on the geographic configuration of the resultant suppliers and the spread of key assets between them.

Based on the literature, breaking Water Corporation up along regional lines could in theory result in diseconomies of scale in the regions. However, it is not clear to what extent the current configuration of regional supply enables economies of scale to be realised in the first place.

Distribution system

The distribution system for potable supply is generally seen as a natural monopoly. Given the high cost of building distribution capacity, and size economies in trenching and pipe diameter, distribution systems are built with significant 'excess' capacity, implying economies of scale over the short and medium term. Such systems are uneconomic to duplicate, giving rise to increased interest in the establishment of open access to distribution systems in Australia.

However, as demand continues to increase, and as distribution systems increase in length and hence volumes carried in central locations also increase, bottlenecks arise which require remedial work to increase main capacity. Such work is very expensive, and is likely to contribute to the findings in the literature that large water distribution systems can be subject to diseconomies of scale.

Sewer systems

The issues regarding economies of scale and scope for sewerage distribution systems are likely to be similar to those for water. The high cost of developing the sewer and drainage networks mean that there are significant economies of scale in the short and medium term (ie with respect to the use of existing capacity).

However, due to the greater reliance on gravity within the system, sewage treatment plant is often relatively local to the properties served. This means that sewerage systems tend to cover smaller geographic areas than water systems, and hence may exhaust economies of size more quickly. The same reasoning could contribute to the earlier evidence of little if any historical economies of scope between water and wastewater.

Wastewater treatment and disposal

Economies of scale arise with respect to the size of an individual treatment plant; however technological advances indicate that these economies of plant scale are diminishing. In addition, large treatment plants involve transporting the sewage further for treatment, suggesting that, as with water, there are potential trade-offs and economies of scope between treatment and distribution within the sewerage service.

Importantly, the increased introduction of water recycling creates the potential for further synergies and economies of scope between water and sewerage. Such economies may arise through the ability to delay an expensive water augmentation through increased recycling, and/or the ability to avoid additional sewerage treatment requirements that might flow from concerns for the environmental impact of heightened discharge rates. Any move to indirect potable re-use (including aquifer recharge) would significantly increase the size of such economies of scope – though we stress that joint ownership and operation may not be needed to exploit these opportunities. They will require increased ability to assess system, as opposed to individual project, economics in supply and discharge management – and the ability to align commercial incentives.

Findings

It is clear that economies of scale and scope exist in the water and wastewater industries and that these mainly relate to the natural monopoly elements of the supply chain relating to water pipeline and reticulation networks. Even factoring these elements in, the economies appear modest. The studies reviewed provide less support for economies of scope between water and wastewater, though trends towards recycling may alter this in the future.

Separation of planning

If the natural monopoly elements of the industry, comprising main water pipelines and local water reticulation, are maintained as an integrated unit, can an improvement in efficiency be achieved by separating other activities, such as bulk water supply, planning for future needs, procurement, system control and scheduling of water sources and retailing?

The lesson from the electricity industry is that separating out such functions did deliver efficiency improvements as well as gains arising from improved governance and transparency of industry planning and the scheduling of sources of supply. Electricity reform showed that if care is taken with market design and industry structure then significant benefits can be available in the form of lower costs, more transparent industry processes and a more appropriate allocation of risk between investors and consumers.

In the water industry in WA, the network costs of the water delivery system appear to be a high proportion of total costs so that the gains available from improved procurement and contestability of bulk water may not be as great as in electricity. Concerns for the environmental impact of sourcing and discharge strategies are also greater. Nevertheless, the separation of processes such as planning, procurement and system control away from the operation and maintenance of the water supply network could offer benefits in the quality and transparency of these processes.

Alternative configurations

The findings in this report have implications for the efficient configuration of water and wastewater service provision in Western Australia. Specifically, we considered: horizontal and vertical separation of metropolitan water and wastewater operations for the Perth metropolitan area; and reorganisation of the way these services are provided in regional Western Australia. We stress that our conclusions relate to what can be said about size and scope economies – not the gains from competition that might be the primary rationale for considering some changes.

Vertical separation

In relation to vertical separation in Perth, the evidence reviewed indicates that efficiency gains from vertical integration are likely to dissipate at approximately 2,400 ML/year. This is supported by experience with the separation of Melbourne Water into a wholesale business and three retail service providers, with analysis of before and after efficiency indicated significant improvements over the period 1993/94 (prior to reforms) and 2006/07. The Melbourne retailers also point to significant reductions in costs per property that have been achieved over the period.

Horizontal separation

While the studies of economies of scale were generally undertaken with vertically integrated businesses, we believe that the broad conclusions are likely to be applicable to the network part of the business. This suggests that horizontal disaggregation of Water Corporation's Perth distribution and retail activities would be unlikely to result in significant diseconomies of scale.

The Melbourne retailers agree that while there would be some economies of scale achieved by re-integrating the three, through operational savings, these would be relatively modest. Moreover they argue such savings would be offset by reduced incentives for dynamic efficiency (with the loss of incentives for innovation produced by the comparative competition regime in Melbourne) and possibly significant transition costs in re-integrating the three businesses.

In further support of horizontal separation, ACIL Tasman understands that the Water Corporation maintains largely separate north and south Perth divisions.

Separation of regional operations to combine with electricity

With respect to the regions, the reviewed evidence appears not to cut across considering separation of the Water Corporation's regional operations. Two options considered are:

- Horizon Power as a combined electricity, water and wastewater service provider.
- Amalgamation of various water suppliers in the south-west.

Both of these options seek to preserve the main economies of size and scope by ensuring that all suppliers are of a reasonably efficient size, allowing for possible dynamic efficiency gains as well as size economies. This enables sufficient control over resources to deliver essential services and spreads the fixed cost of operation over a sufficiently large customer base to minimize average cost. Of course, reversing the earlier argument, the merits of accessing any economies here would need to be weighed alongside an assessment of any detrimental threats to dynamic efficiency and the magnitude of transition costs.

Support for Horizon Power as a multi-utility operator – offering a possible offset for any loss of size economies in relation to regional water – is found in both the received literature on size and scope economies and experience in the Northern Territory. Advice received from Cardno BSD suggests there is scope for reducing duplicative costs. However, complete amalgamation of the country water business with the Horizon electricity business may only yield a marginal improvement in cost saving. The main test is whether the cost of separation of the centralised water function exceeds the savings in the amalgamation of the maintenance functions.

Amalgamation of South West suppliers

With regard to the amalgamation of south-west water suppliers, our analysis suggests that all of the operations are currently probably operating at less than the minimum efficient scale. Specific mergers considered are:

- Combined Aqwest-Water Corporation water operations in the greater Bunbury area and BWB-Water Corporation in Busselton.
- Creation of a three-way merger of Aqwest, BWB and the Water Corporation's south west business.
- A merger of Busselton Water Board and Aqwest.

The most likely areas of savings are associated with the elimination of duplicative costs in management, governance and technical operations. Other benefits include:

- The opportunity to build internal capability to adequately protect water quality and adequately arrange the planning and design of infrastructure while maintaining a policy of outsourcing service where appropriate.
- Enhanced ability to comply with public health standards and meet future security of supply concerns.

There are, however, risks involved in effecting the suggested reorganization, including community resistance to change and possible increase in per customer charges. The risk of cost increase depends crucially on transition costs, overall customer density and utilisation of capital. On balance, it appears likely that these risks can be avoided with careful implementation.

Finally, in relation to transition costs, there is limited evidence on the cost impacts. There may well be two components to these costs: those incurred in establishing new institutional arrangements to ensure the ongoing effective provision of water and wastewater services; and the direct costs of establishing new organisations. Anecdotal evidence from Victoria suggests the direct costs of transition were modest for the earlier disaggregation of the Melbourne suppliers, but may be greater for re-integration. In the UK many of the smaller water only companies have merged, suggesting that the transition costs were modest relative to the expected cost savings. However merger of the three Scottish water utilities into a (large) single entity appeared to involve significant transition costs. By induction, we surmise that separation (the reverse of a merger) would probably be relatively small.

1 Introduction

ACIL Tasman has been commissioned by the Economic Regulation Authority (ERA) to investigate economies of size and scope associated with different configurations of the Water Corporation's operations. The context within which the advice is being sought is the ERA's Inquiry into Competition in the Water and Waste Water Services Sector ("the Inquiry").

This study is concerned with assessing the economic impact of economies of size/scope on various configurations of the Water Corporation's operations. It is not intended to be a comprehensive review of all possible configuration options. Rather, it has evolved based on discussions with ERA to provide guidance on possible models that were emerging for consideration from other work being done for the Inquiry.

2 Size and scope economies

'Size economies' (sometimes referred to, sometimes but not always with a slight shift in meaning, as 'scale economies') refers to the scope for larger organisations to deliver products of services at lower average cost than smaller organisations. Where there are size economies, an expansion in output can be achieved with a less than proportionate expansion in costs. There can be numerous plausible drivers of such savings – including expanded scope for sharing overheads (especially 'lumpy' ones or ones requiring skills in short supply), technical efficiencies that flow from sizing in areas such as pipe diameter, and savings from the exercise of market power in sourcing inputs.

Size economies have traditionally been seen as one of the factors that can drive sector organisation towards 'natural monopolies' – if gains from merging can improve competitiveness. Reversing this, the presence of size economies may cut across a strategy to deliver gains through greater competition, where this requires smaller entities.

Size economies are not inevitable, at least past a minimum firm size (that will be highly dependent on technologies, nature of supply area etc). The economics literature recognises not only that the scope for achieving further size economies can decline to almost zero (supporting the concept of a 'minimum efficient size'), but also that a point can be reached where increase in size leads to actual *diseconomies*.

The term 'scope economies' applies to the ability for two or more service or products to achieve joint economies. For example, combined electricity and gas retail utilities are reasonably common – with scope for sharing costs of IT systems, meter reading and possibly aspects of infrastructure investment and maintenance (common trenching for services etc) suggesting possible economies from having the two services combined in the one service provider.

In the water sector, scope economies could arise across a range of products – with water, sewerage and drainage being the 'traditional' grouping. It is also possible to consider gains from water services being linked to other services, such as electricity and gas – and we address an example of this later.

It is important also to recognise that, from an engineering perspective, there will almost inevitably be *theoretical opportunities to derive further size and scope economies* in any utilities business of any size. Of course there are real synergies in operations; scope for dealing with 'lumpy' inputs and for active cross fertilisation of ideas in relation to system planning etc; scope for negotiating 'bulk discounts' etc. Highly complex networked systems will inevitably be replete with such opportunities, but the principles apply across industrial activity. The fact is that there is a lot of evidence that, despite these real theoretical possibilities, actually captured economies can and do shrink as size and scope grow. Importantly, a point is eventually reached in many sectors where the complexities – of managing the larger system; of dealing with declining effectiveness of intra-firm communication; of dealing with a trend to longer decision times; of aligning incentives throughout the system with overall corporate incentives; and of encouraging, and responding appropriately to, innovation and opportunities for risk-taking – can deliver a loss of *dynamic efficiency* to the point where smaller firms can be more cost effective.

This is not just a theoretical argument – and is not just supported by theoretical studies. This reality has been shown many times in the way that competitive sectors organise in the face of changing technologies and advantages to innovation and risk-taking. The 1960s IBM-model of dominance of computer manufacture proved quite inadequate to the exploding opportunities of the 1980s that flowed from the evolving technologies and consumer lifestyles.

In an environment such as water, especially in settings where climates and associated hydrology are changing and where technological options for both supply (eg, desalination and recycling plants) and demand management are also changing rapidly, these considerations of *innovation* and *dynamic efficiency* are almost certainly growing in importance compared to even a few years back. It is appropriate to challenge the dominance of economies based in the engineering possibilities alone – while it would be inappropriate to ignore these real possibilities.

It is also worth recognising that while the term 'minimum efficient size' emerges naturally from the consideration of size economies (and declining size economies), the term is defined by this context and should not be dissected further. The most efficient size for firms in a sector may well be at a size below the 'minimum efficient size' and this is not a contradiction in terms. In the context of the present enquiry, the distinction may prove crucial. It could emerge that the only way to access big gains from competition in a WA setting will require some of the utilities to be smaller than the 'minimum efficient size'. There is then no contradiction, but there is a trade-off – would the gains from competition outweigh the loss of gains from size economies? Could that loss be further defrayed by tapping into scope economies in relation to other services? These sorts of questions seem to be the ones that are central to the present Inquiry – all the more so given the key conclusions that have emerged from the present study, supporting the likelihood of some modest size economies in parts of the WA water sector.

3 Review of Western Australia's Water and Wastewater Services Industry

An informed assessment of the likely magnitude of size/scope economies in Western Australia must take account of the specific circumstances of the Western Australian water and wastewater services industry. A key aspect of this is an understanding of Water Corporation's current configuration and why it has evolved into its current structure. Clearly local circumstances, which include the nature of the available water sources as well as its economic and social objectives, have a bearing on Water Corporation's configuration. For example, it may well be that specific social objectives prevent the Water Corporation from maximizing the efficiency gains that might otherwise be available through exploiting economies of size/scope. Alternatively, the costs associated with its portfolio of source water may mean that a configuration that has been shown to be efficient in other jurisdictions would not lead to efficiency gain in Western Australia.

3.1 Water Corporation history and current configuration

The Water Corporation was established on 1 January 1996 following proclamation of the *Water Corporation Act 1995*.[5] This followed the recommendations of the Water Industry Restructure Implementation Group (WIRIG), which was formed to inquire into the operations and financing of the Western Australian Water Authority (WAWA). Among other things,

[5] The Water Corporation is owned by the Government of Western Australia

WIRIG recommended the separation of WAWA's commercial, policy and regulatory functions.[6]

The Water Corporation's functions are defined in section 27, Part 3 of the Water Corporation Act. Section 27.2 requires the Water Corporation to use its fixed assets for profit subject to providing its core functions as defined in section 27.1, which is primarily to provide water and wastewater services.

Size and scope of Water Corporation operations

According to its 2005-06 Annual Report the Water Corporation serves almost two million customers spread across 2.5 million square kilometres and is responsible for providing water, wastewater, drainage and irrigation services.[7]

Table 1 **Water Corporation size and scope**

Services	Units	2005-06
Water Services		
Annual volume of water supplied	ML	324,886
Number of properties served	nr	1,008,553
Number of properties connected	nr	868,983
Length of mains	km	31,760
Wastewater Services		
Average volume of wastewater treated daily	ML	386
Number of properties served	nr	793,697
Number of properties connected	nr	710885
Length of sewers	km	13,865
Drainage Services		
Number of properties served	nr	319,900
Length of drains	km	2,814
Irrigation Services		
Volume of water delivered	ML	357,277

Note: Unit definitions are: ML – megalitres; nr – number; km - kilometres

Data source: Water Corporation, Water for life, Report 2006, Five-year Statistical Summary, p.59

Table 1 provides an indication of the size and scope of Water Corporation's operations. Casual inspection indicates that the Water Corporation is a large

[6] WA Treasury, *Progress Report: Implementing National Competition Policy in Western Australia*, Report to the national Competition Council, March 1999, p.35

[7] Water Corporation, *Water for life,* Report 2006 [http://www.watercorporation.com.au/_files/WCReport2006.pdf]

organisation supplying water to more than one million properties and providing sewerage services to more than three quarters of a million properties.

Table 2 **Water Corporation against other Australian water and wastewater suppliers**

	Units	Water Corp	Other Australian major urban service providers			
			Min	Mean	Max	Std Dev
Residential water supplied	ML	157,814	9,508	51,994	320,509	72,528
Commercial and industrial water supplied	ML	49,925	0	21,092	146,937	31,657
Other water supplied	ML	23,759	0	10,107	60,814	14,620
Total urban water supplied	ML	244,158	12,891	120,338	528,260	161,344
Volume of bulk water exports	ML	12,660	0	86,794	526,414	187,853
Residential and non-trade waste sewage collected	ML	109,875	7,133	56,680	405,803	88,939
Trade waste collected	ML	6,100	319	6,875	26,739	7,372
Total sewage collected	ML	115,975	7,452	62,867	432,542	94,753
Length of water mains	km	12,267	407	4,027	20,752	4,567
Properties served per km of water main	nr/km	54	26	113	1,258	259
Length of sewerage mains and channels	km	10,273	387	4,094	23,404	5,200
Properties served per km of sewer main	nr/km	57	34	241	3,817	842
Population receiving water supply services (000s)	nr	1,501	101	790	4,267	1,141
Total connected properties – water supply (000s)	nr	665	46	336	1,706	473
Population receiving sewage services (000s)	nr	1,370	95	860	4,141	1,166
Total connected properties – sewage (000s)	nr	585	39	331	1,656	462

Note: Data is reported on an annual basis for 2005-06

Data source: National Water Commission, National Performance Report 2005-06 Major Urban Water Utilities, Water Services Association of Australia, ISSN: 1834-3899

Table 2 provides an indication of Water Corporation's Perth operations relative to other major urban water and wastewater service providers. In terms of the volume of water supplied, the Water Corporation supplies three times the average for the other major urban service providers. Sewerage collection is also substantially larger than the average and 15 times larger than the smallest sewage collection utility.

While the number of properties served for both water and sewerage services is relatively large, the total lengths of water and sewerage mains are, in relative terms, even larger. Consequently, properties served per kilometre of water and sewerage mains, which provides an indication of customer density, is substantially below average.

Market concentration

The Water Corporation accounts for[8]:

- 94% of potable water supplied in Western Australia;
- 2% of non-potable water supply; and
- the majority of the wastewater and drainage value chain.

The notable low share of the non-potable water market is due to 98% being self-sourced by customers.

Regional dimensions

Table 3 provides a break down of the Water Corporation across regions as defined in annual reports. Even with the regions disaggregated, properties per kilometre of water mains is well below the average of the eastern states water utilities. Indeed, four of the regions are well below the minimum shown in Table 2. Perth represents 75% of the total water services and receives 66% of the total water supply. Properties per kilometre of water mains measure for Perth is more than 12 times larger than the least dense region (Goldfields and Agricultural).

Table 3 **Water Corporation regional statistics 2005-06**

		Units	Perth	Goldfields & Ag	Great Southern	Mid West	North-West	South-West
Water	Services	nr	579,602	43,984	30,401	31,192	21,454	67,095
	Connected properties	nr	664,742	40,123	30,103	34,578	26,599	72,838
	Length of mains	km	12,267	9,450	3,716	2,492	1,342	2,493
	Properties per km of mains	prop/km	62.43	4.94	9.53	16.99	22.89	35.15
	Volume supplied	ML/day	622.94	74.9	35	56.99	80.13	69.45
Sewerage	Connected properties	nr	584,730	11,844	16,521	13,437	22,905	61,448
	Length of sewers	nr	10,273	379	488	458	450	1,817
	Properties per km of sewers	Prop/km	56.92	31.25	33.85	29.34	50.9	33.82
	Volume treated	ML/day	317.7	5.6	10.1	6.5	13.9	32.4
	Pumping stations	nr	573	38	48	61	57	217

Note: Goldfields & Ag is an abbreviation of Goldfields and Agricultural
Data source: Water Corporation 2005-06 annual report

8 Water Corporation, *Submission to the Economic Regulation Authority's Inquiry on Competition in the Water and Wastewater Services Sector*, 31 August 2007, pp. 28-29

3.2 Comparison with suppliers in England and Wales

Finally, it is useful to understand how Water Corporation compares in terms of size and customer base with the water and sewerage businesses in England and Wales, since many of the studies of scale and scope have been conducted using their data.

Number of properties served

Table 4 sets out the total number of connected water properties for the English and Welsh water businesses.

Table 4 **Number of water properties, UK**

	total connected water properties
Tendring Hundred	71,600
Folkestone	73,999
Dee Valley	118,792
Cambridge	124,854
Bournemouth & West Hampshire	194,240
Mid Kent	251,797
Sutton & East Surrey	273,002
Portsmouth	296,520
Bristol	497,512
Wessex	558,030
South Staffs	560,104
South East Water	604,870
South West	752,190
Southern	1,038,003
Three Valleys	1,246,775
Dwr Cymru	1,347,620
Northumbrian & Essex & Suffolk	1,924,862
Anglian & HPL	1,982,944
Yorkshire & York	2,156,664
United Utilities	3,135,645
Severn Trent	3,349,607
Thames	3,716,079

Data source: OFWAT, June Return 2006, Table 4

The equivalent information for Water Corporation is shown in Table 5, broken down by region. Comparison of the two tables shows that all of Water Corporation's country regions have substantially fewer connected properties than the smallest of the water only companies (WOCs) in England and Wales (with the exception of the South West which is only marginally smaller than the smallest WOC). Perth compares in size with a medium-sized water only company/small water and sewerage company.

Table 5 **Number of water properties, Water Corporation**

	total connected water properties
Goldfields and Agricultural	43,984
Great Southern	30,401
Mid-West	31,192
North-West	21,454
South-West	67,095
Total Perth	579,602
Total Water Corporation	773,728

Data source: NWI, 2007, National Performance Report 2005/6.

Table 6 compares the density of customers (measured in terms of population per km of water main) for the UK companies and Water Corporation's Perth business. The density of Water Corporation's customer base lies within the range of the UK companies, towards the lower end of the density spectrum. Note that water only companies all serve urban populations, while the WASCs serve a combination of urban and rural areas.

Table 6 **Comparison of customer density**

	Density (pop/km)	Average	Min	Max
Water Corporation - Perth	122.4			
WOCs		170.9	107.2	275.0
WASCs		150.1	98.4	256.3

Data source: Saal and Parker, 2005, Assessing the performance of water operations in the English and Welsh water industry, NWI, 2007 National Performance report 2005/6 and Water Corporation Annual Report 2005/6.

Table 7compares the size of the English and Welsh water businesses with Water Corporation.

Table 7 **Volume of water delivered**

	Total water delivered	Total water delivered
	ML/day	ML pa
Tendring Hundred	25.8	9,399
Folkestone	39.1	14,268
Dee Valley	61.5	22,455
Cambridge	64.8	23,667
Mid Kent	140.2	51,155
Bournemouth & West Hampshire	140.3	51,210
Sutton & East Surrey	144.0	52,549
Portsmouth	154.8	56,509
Bristol	241.2	88,053
South Staffs	274.2	100,079
Wessex	306.2	111,759
South East Water	330.1	120,476
South West	366.6	133,791
Essex & Suffolk	416.0	151,836
Southern	495.5	180,872
Northumbrian	588.3	214,737
Dwr Cymru	657.8	240,082
Three Valleys	768.8	280,594
Anglian & HPL	975.1	355,893
Yorkshire & York	1,012.7	369,621
United Utilities	1,491.9	544,536
Severn Trent	1,588.4	579,762
Thames	2,126.0	775,997
Water Corporation		
Perth	622.9	227,373
Goldfields and Ag	74.9	27,339
Great Southern	35.0	12,775
Mid West	57.0	20,805
North West	80.1	29,237
South West	69.5	25,368

Data source: OFWAT, June Return 2006, Table 10

Operating costs

Table 8 shows the breakdown of operating costs in each of these categories for the English and Welsh water businesses for 2005/6. Equivalent information for Water Corporation is not published.

Table 8 **Operating costs by activity (UK)**

	Potable water supply	Sewerage and drainage services
Resources and Treatment	29%	
Distribution	35%	
Sewage Collection		17%
Sewage treatment		32%
Sludge treatment and disposal		20%
Customer services	10%	11%
Scientific services	4%	2%
Other business services	1%	1%
Other	21%	16%
Total	100%	100%

Data source: OFWAT, 2006, Financial performance and expenditure of the water companies in England and Wales.

Capital expenditure

Table 9 sets out the balance of capital expenditure in each activity for 2005/6 for the English and Welsh businesses. Table 10 sets out the breakdown of capital expenditure by purpose (maintenance, maintaining the supply/demand balance and improved quality/standards of service).

Table 9 **Capital expenditure by activity (UK)**

	Water	Sewerage
Water resources	5%	
Water treatment	20%	
Water distribution	65%	
Water general	11%	
Sewerage collection		40%
Sewage treatment		51%
Sewerage general		9%
Total	100%	100%

Data source: OFWAT, 2006, Financial performance and expenditure of the water companies in England and Wales.

Table 10 sets out the equivalent information for Water Corporation (for the urban water and wastewater business only). This shows that Water Corporation was forecasting a very significant proportion of capital expenditure to be spent on securing the demand supply balance (for Perth's first desalination plant). This represented a substantial increase in demand/supply balance expenditure compared to prior years (when expenditure was more evenly spread or involved a preponderance of spend on quality/levels of service).

Table 10 **Capital expenditure by purpose (UK)**

	UK		Water Corporation
	Water	Sewerage	Water and sewerage
Maintenance	50%	28%	20%
Supply/demand balance	26%	5%	64%
Improved quality/levels of service	23%	40%	16%
Total	100%	100%	100%

Note: Water Corporation data is the forecast for year ended 2006, forecast as at November 2004. (Source Allens, March 2005, Review of Assets, Costs and cost allocation of Western Australian Urban Water and Wastewater Service Providers. UK data from OFWAT, 2006, Financial performance and expenditure of the water companies in England and Wales.

4 Lessons from the literature

Having established that the Water Corporation is a large, horizontally and vertically integrated organisation, we now consider the impact of changing its current configuration. The main impact that we are concerned with here is the potential gain or loss of net social benefit that results from any changes. On one hand, there may be benefits to enhancing contestability, if not actual competition. On the other hand, there is a risk of a loss of efficiency due to lost economies of size/scope.

On the latter point there is a substantial empirical literature focused on measuring the magnitude of size/scope in the water industry, some of which has been recently surveyed by the NSW Independent Pricing and Regulatory Tribunal (IPART)[9]. Appendix A of IPART's report provides a concise summary of the results of studies concerned with measuring economies of size/scope. Examination of IPART's summary suggests that there is no general consensus with respect to the question of whether there are increasing, constant or decreasing returns to size/scope in providing water and wastewater services.

Of the studies surveyed, IPART reported that most provide conditional support for economies of size suggesting there is a finite (though varying) minimum efficient size (MES). The discussion in Section 2 is important here – the most efficient size of a firm, factoring in the benefits of competition, might be less than the MES. However, the MES provides a basis for addressing whether a trade-off is involved or not.

Estimates of the MES for water supply suggest a range from 125,000 to 1 million serviced inhabitants. For wastewater, the MES is less clear as the studies surveyed either examine size economies of combined water and

[9] IPART, *Literature Review, Underlying costs and industry structures of metropolitan water industries*, September 2007

wastewater services or are interested mainly in testing for economies of scope between water and wastewater services. One study suggests an MES in wastewater of 100,000 serviced inhabitants.

IPART's review canvassed only five studies that examine economies of scope. Results can be categorised as economies of scope between: water production and distribution; and water-wastewater services. Two studies[10] report economies of scope from the vertical integration of water production and distribution. Two studies report economies of scope between water and sewerage services. Only one study reported diseconomies of scope.

4.1.1 Cross-country studies

Given the lack of general consensus regarding economies of size/scope in water and wastewater services, it is useful to analyse the factors that drive conflicting study results. Cross-country studies are a useful starting point as they compare similar size utilities across substantially different circumstances.

Table 11 reproduces results reported in Tynan and Kingdom (2005)[11]. Their study explicitly compared the performance of 270 water and sanitation utilities across 83 countries. The results suggest that there are economies of size in terms of the volume of water supplied for small water utilities. However, comparing across the number of connections or customers indicates inconsistent results. For large utilities (note the Water Corporation would be classed as large), the results suggest that in the majority of circumstances, size economies are exhausted. A short-coming of this study is that the authors do not describe their methodology beyond stating that a "…standard econometric model is used to estimate economies of size…"[12] A particular concern is that they do not say whether they control for customer density, service quality such as water standards, and efficiency variables such as the number of pipe breaks/leakages etc.

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[10] Stone and Webster Consultants Ltd, I*nvestigation into evidence for economies of scale in the water and sewerage industry in England and Wales, Final Report*, for the Office of Water Services, January 2004; and
Hayes, K., "Cost structure of the water utility industry", *Applied economics*, 19(3), 1987, pp. 417-425

[11] Tynan, N. and Kingdom B. (2005) "Optimal Size for Utilities?", P*ublic Policy for the Private Sector*, Note Number 283, The World Bank Group

[12] Tynan, N. and Kingdom B. (2005), *op. cit.*, p. 1

Table 11 **Increase in costs when small and large water utilities double in size**

Indicator of size and utility size class	Africa	Indonesia	Peru	United States	Vietnam
Volume of water produced					
Small	63	81	76	86	75
Large	118	89	98	97	75
Connections or customers					
Small	53	50	105	98	73
Large	99	113	109	104	98

Note: utilities are deemed small if serving a population of 125,000 or less and are otherwise deemed to be large. An increase in cost of less than 95 per cent suggests size economies, those with cost increase of more than 105 per cent suggests diseconomies of size.

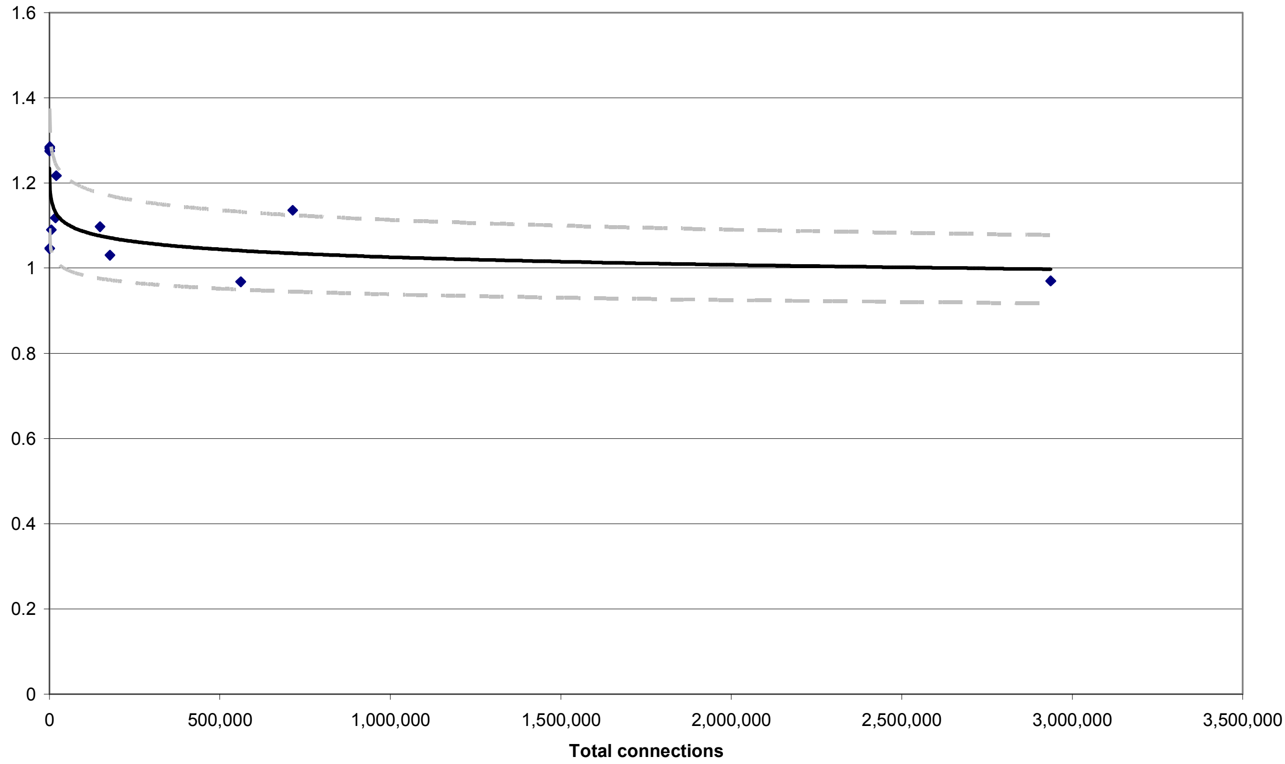
Data source: Tynan, N. and Kingdom B. (2005) "Optimal Size for Utilities?", *Public Policy for the Private Sector*, Note Number 283, The World Bank Group

A more recent cross-country study, Nauges and van den Berg (2007)[13], examine economies of size for water and wastewater firms across Brazil, Colombia, Moldova and Vietnam. As the authors point out, these four countries differ substantially in economic development, in the extent of network coverage and in the characteristics of the utilities. In their study, economies of size are measured while controlling for production and customer density. Production density relates to the volume of water and wastewater supply within the network.

For average sized water and wastewater suppliers, there are economies of size across all countries except Brazil. Looking at individual countries, the results show that there are constant economies of size for Brazilian utilities that service between 46,000 and 5 million connections. By contrast, Colombian water utilities exhibit economies of size across utilities servicing between 2,300 and 1.4 million connections. Size economies are apparently exhausted after 1,900 and 13,900 connections in Moldova and Vietnam, respectively. Figure 1 plots the combined results for the small, medium and large utilities across the four countries together with upper and lower bounds. Note that size economies are exhibited for those utilities in which the statistic is statistically larger than one. Size economies appear relatively modest.

13 Nauges, C. and van den Berg, C *How "natural" are natural monopolies in the water supply and sewerage sector? Case studies from developing and transition economies,* World Bank Policy Research Working Paper 4137, February 2007

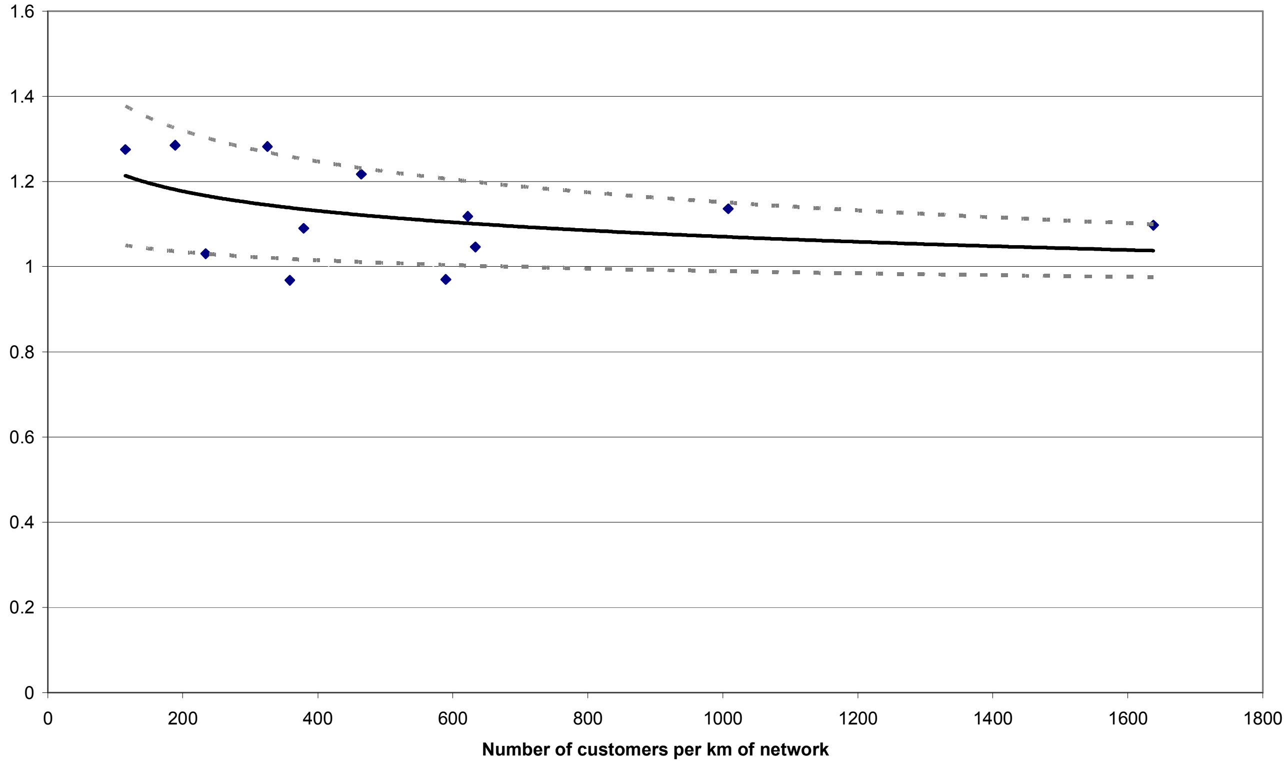
Figure 1 **Nauges and van den Berg (2007) – Economies of size in small and medium sized water and wastewater service providers against total connections**



Source: Nauges, C. and van den Berg, C *How "natural" are natural monopolies in the water supply and sewerage sector? Case studies from developing and transition economies*, World Bank Policy Research Working Paper 4137, February 2007

Plotting the results for size economies against customer density (as shown in Figure 2) suggests that size economies are present across a wide range of customer densities. Also, the likelihood that there are unrealised size economies appears to be higher for utilities with lower customer density. Taking the Water Corporation as one network in which there is a very low customer density suggests there may be size economies available. However, it would be better to compare Water Corporation data on a regional basis. For example, the customer density statistic for the Perth metropolitan area is likely to be substantially higher than for the total (metropolitan and non-metropolitan) network.

Figure 2 **Nauges and van den Berg (2007) – Economies of size in small and medium sized water and wastewater service providers against customer density**



Note:

Source: Nauges, C. and van den Berg, C (2007) *How "natural" are natural monopolies in the water supply and sewerage sector? Case studies from developing and transition economies*, World Bank Policy Research Working Paper 4137, February

4.1.2 Country-specific studies

The cross-country studies surveyed suggest that there is an optimal size for water and wastewater utilities, although there appears to be a lack of precision in the threshold size range. Given the variable results across countries, it is worthwhile considering analysis based on more detailed data to determine whether the stylised facts on the influence of institutional arrangements, network coverage and utility characteristics can be established.

England and Wales

The experience in England and Wales has yielded a set particularly useful set of studies for analysing size/scope economies in water and wastewater services. Indeed, Saal and Parker (2005)[14] offer considerable insight in the subject as

[14] Saal, D. and Parker, D. (2005) *Assessing the performance of water operations in the English and Welsh Water industry: A panel input distance function approach*, Aston Business School Working Paper RP0502

they estimate the magnitude of size economies across changing regulatory regimes while controlling for differences in technical efficiency, network density, number of pumping heads, water quality and company mergers. After controlling for these factors, the results show that for the average sized firm, that there are no size economies.

The results are most appropriate when comparing the water and sewerage companies against the Water Corporation. Note that the average number of connected properties is approximately twice the size of those reported by the Water Corporation.

Table 12 **Saal and Parker (2005) selected summary statistics**

		Mean	Std. Dev.	Min.	Max.
WoCs	Connected properties (000s)	296.3	270.5	37.2	1,226.7
	Water delivered (ML/day)	172.3	160.0	23.3	768.5
	Density	170.9	32.8	107.2	275.0
WaSCs	Connected properties (000s)	1,804.7	1,046.1	455.8	3,636.7
	Water delivered (ML/day)	1,022.8	573.9	288.9	2,115.6
	Density	150.1	41.6	98.4	256.3

Note: WoCs – water only companies;

Source: Saal, D. and Parker, D. (2005) *Assessing the performance of water operations in the English and Welsh Water industry: A panel input distance function approach*, Aston Business School Working Paper RP0502

The inclusion of variables that control for important differences between English and Welsh water and wastewater utilities means that the resulting estimated size economy measures are independent of the controls. In addition, the influence of customer density on measurement of size economies, which is likely to be a key difference between the Water Corporation and English and Welsh water and wastewater utilities has been removed. This allows a closer, albeit tentative, comparison of the Water Corporation to the utilities contained in the study.

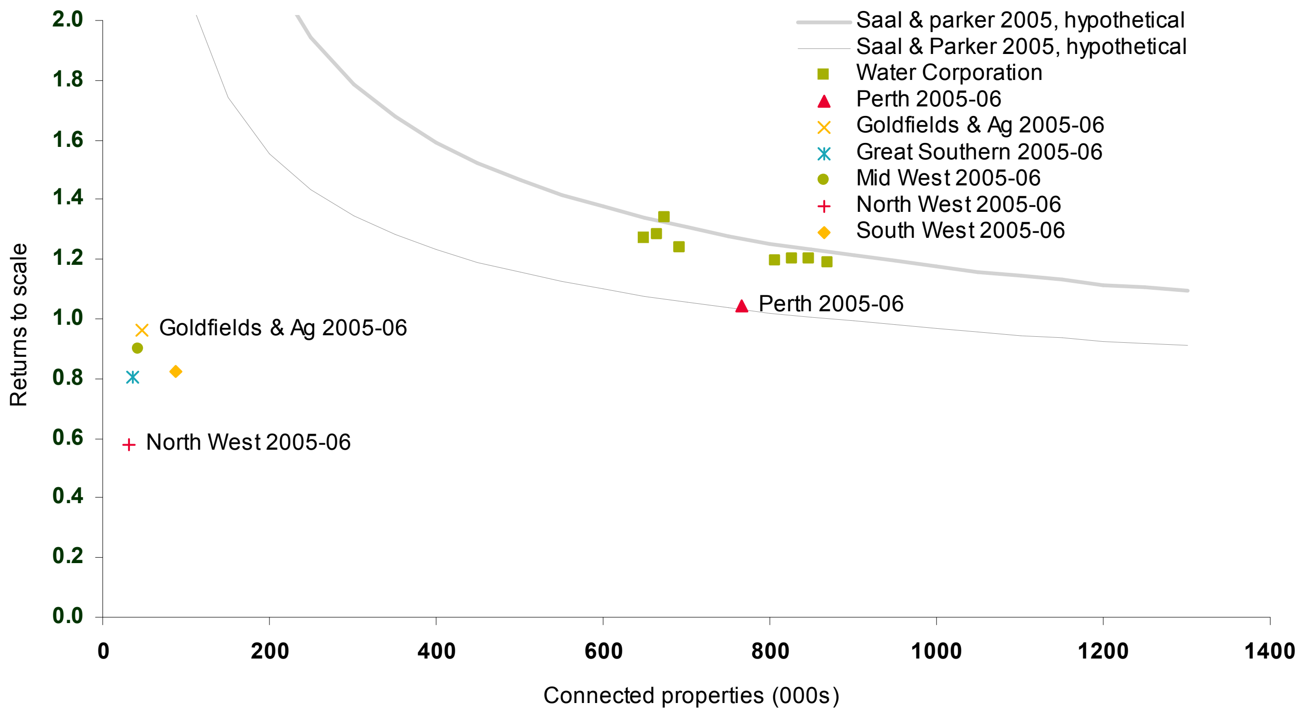
Figure 3 presents a cross-section view of the estimated size economies based on the water and sewerage model presented in Saal and Parker (2005) along with (tentatively) estimated size economies for the Water Corporation.[15] The grey-coloured downward sloping curved line shows the impact of varying the number of connected properties while holding the volume of delivered water constant (at the 2003 average for English and Welsh water and sewerage utilities). Note that the line extends the size economies function to as few as 200,000 connected properties, a point well below the minimum number of connected properties for water and sewerage companies reported in Table 12.

15 Size economies are referred to as 'returns to scale' in Saal and Parker 2005

The blue-coloured curve depicts the same curve, but with the volume of delivered water decreased to match Perth water supply as at 2005-06.

The chart suggests that the Water Corporation, as an aggregated entity, is located in the increasing size economies (greater than 1) portion of the curve. However, plotting Water Corporation's disaggregated regional observations for 2005-06 suggests that the regional operations are substantially below the feasible frontier implied by Saal and Parker (2005). The reason is that the curved line implies a substantially higher volume of water supplied than is realised by the Water Corporation. That is, if the Water Corporation were able to deliver substantially more water to its regional customers, it could potentially achieve substantial size economies.

Figure 3 **Size economies for Water Corporation based on Saal and Parker 2005**



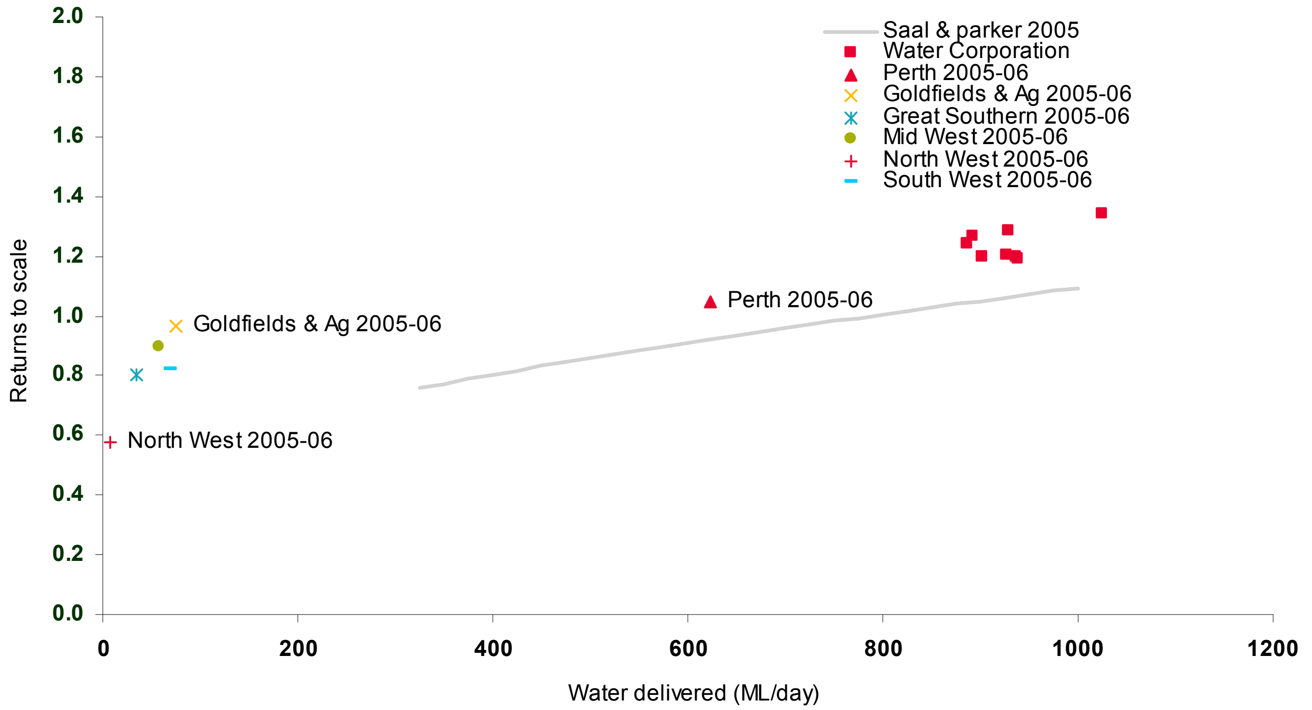
Note: Goldfields & Ag is an abbreviation of the Goldfields and Agriculture region as presented in Water Corporation annual reports

Source: Saal, D. and Parker, D. (2005) Assessing the performance of water operations in the English and Welsh Water industry: A panel input distance function approach, Aston Business School Working Paper RP0502 *and* Water Corporation Annual Reports

An important issue highlighted here is that the characteristics of the regional water market in regional Western Australia may be preventing the Water Corporation from achieving greater efficiency.

Figure 4 shows a different cross-section of the results presented in Figure 3, this time allowing the volume of delivered water to vary while holding connected properties constant at the observed number of connected properties in Perth for 2005-06. The model suggests that there are size economies associated with the volume of delivered water.

Figure 4 **Size economies for Water Corporation based on Saal and Parker 2005**



Note: Goldfields & Ag is an abbreviation of the Goldfields and Agriculture region as presented in Water Corporation annual reports

Source: Saal, D. and Parker, D. (2005) Assessing the performance of water operations in the English and Welsh Water industry: A panel input distance function approach, Aston Business School Working Paper RP0502 *and* Water Corporation Annual Reports

Figure 5 presents a hypothetical projection of Water Corporation's size economies as Perth's water supply is increased by up to 60% from the reported 2005-06 level while keeping the number of properties constant. As shown, hypothetical size economies increase with the volume of delivered water.

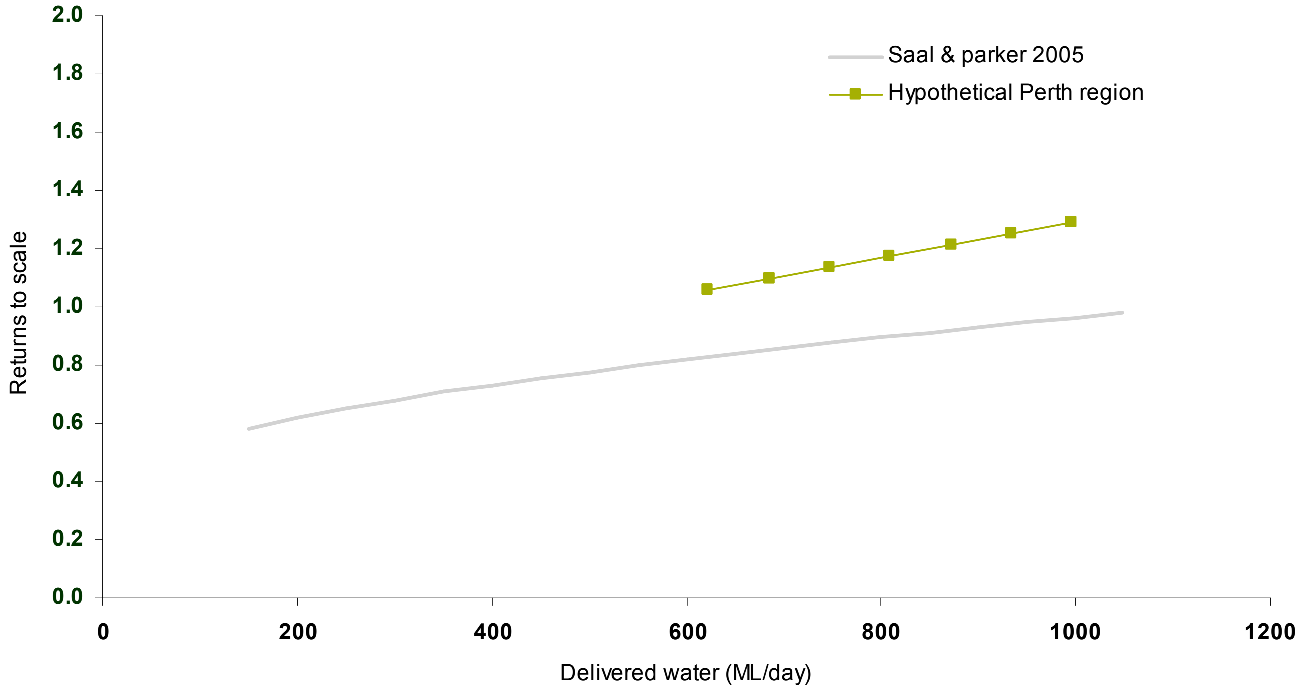
Of course, the comparison between the Water Corporation and the water and sewerage utilities analysed in Saal and Parker (2005) should not be pushed too far.[16] There are likely to be important differences between the Western Australian water system and elsewhere. The important point made here is that the same study that reported largely constant economies of size in the UK suggests there may be modest size economies in Water Corporation aggregate operations.

Moreover, a short-coming with Saal and Parker (2005) is that the model did not measure size economies in sewerage services. Neither did it model joint production of water and wastewater (sewerage) services. By contrast, Stone and

[16] Saal and Parker (2005), op. cit.

Webster Consultants (2004)[17] did model both water and sewerage services in a framework that permits the analysis of the cost impact of changing configurations. We now consider that paper in detail.

Figure 5 **Hypothetical expansion of water supplied to Perth customers**



Note: Calculations based on Saal, D. and Parker, D. (2005) *Assessing the performance of water operations in the English and Welsh Water industry: A panel input distance function approach*, Aston Business School Working Paper RP0502

The Stone and Webster Consultants study specifies 18 translog cost function models and one generalised quadratic cost function. The translog models are divided into short- and long-run specifications. Given the well documented problems with using a translog function to measure economies of scope in which at least one of the outputs approaches zero, an additional long-run cost function is estimated employing the generalised quadratic functional form.

The large number of estimated models allowed extensive testing for the most appropriate model specification. Crucially, several models included controls for differences in customer density, water and service quality, environmental standards and the operating environment across water and sewerage firms.

17 Stone and Webster Consultants Ltd (2004) *Investigation into the evidence for economies of scale in the water and sewerage industry in England and Wales*, *Final Report*, for the Office of Water Services, January

Unfortunately, the Stone and Webster Consultants study does not report summary statistics or model coefficients, so we are limited in being able to draw comparisons between the utilities analysed in this study and the Water Corporation. However, it is likely that the study employed a data set that is similar to that of Saal and Parker (2005). Thus, we know that the water and sewerage utilities are on average larger than the Water Corporation.

The results show that for English and Welsh water and sewerage companies, there are strong diseconomies of size.[18] For the preferred long-run specification, a 1% expansion in output implies a 1.5% increase in total cost. The reported positive capital elasticity measure implies inefficient investment. However, there does appear to be a trend toward more efficient capital investment with time.

With respect to economies of scope, the Stone and Webster Consultants study reports:

- Statistically significant economies of scope for the joint production of delivered water and equivalent population served.
- No scope economies between water and sewerage connections.
- No aggregate (volume of water delivered, population served and connections) scope economies between water and sewerage operations.

Thus, it would appear that for English and Welsh water and sewerage companies, there is no justification for a horizontally integrated structure spanning water and sewerage services.

On vertical integration, the Stone and Webster Consultants study reported economies of scope between water production and distribution. However, there is no evidence of a similar effect for wastewater collection and treatment/disposal. The implication is that there is merit in separating the business of treatment and disposal from wastewater collection.

Other UK studies

Other studies, such as Saal et. Al. (2004)[19], Saal and Parker (2001)[20], Saal and Parker (2000)[21], Ashton (1999)[22], Cubbin and Tzanidakis (1998)[23], Hunt and

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18 Stone and Webster Ltd (2004), op. cit., pp. 41-43.

19 Saal, D.S., Parker, D. and Weyman-Jones, T. (2004), *Determining the contribution of technical efficiency, and scale change to productivity growth in the privatized English and Welsh water and sewerage industry: 1985-2000*, Aston Business School Working Paper RP0433

20 Saal, D.S. and Parker, D. (2001), *The impact of privatization and regulation on the water and sewerage industry in England and Wales: a translog cost function model*, Aston Business School Working Paper RP0103

21 Saal, D.S. and Parker, D. (2000), "The impact of privatisation and regulation on the water and sewerage industry in England and Wales: a translog cost function model", *Managerial and Decision Economics* 21(6), pp. 253-268.

Lynk (1995)[24] and Lynk (1993)[25] present mixed results. Saal *et. al.* (2004), Saal and Parker (2001) and Saal and Parker (2000) consistently report diseconomies of size. Saal and Parker (2001) also test for and reject scope economies between water and sewerage services. However, they raise the possibility of quality-driven economies of scope in which the improvement in the quality of one output (presumably wastewater) decreases the cost of producing the other. Ashton (1999) also finds constant economies/diseconomies of size for water-only companies along with diseconomies of capital utilisation and low levels of capital utilisation.

Confining their examination to water distribution, Cubbin and Tzanidakis (1998) find economies of size. Hunt and Lynk (1995) test for economies of scope between volume of water delivered, volume of sewerage collected and environmental services. The interaction term corresponding to the joint production of water and sewerage suggests there may be diseconomies of scope between water and sewerage. In an earlier study, Lynk (1993) reports economies of scope between water and sewerage. The contradictory results are surprising given the studies analyse industry costs over the same period of time.

These studies vary in terms of the measurement methods employed and span several decades. The apparently contradictory results can be reconciled as the specifics of each study are examined. Differences in study focus explain some of the results. Cubbin and Tzanidakis are confined to water distribution as an industry subset and do not examine issues such as vertical and horizontal integration. This contrasts with the Stone and Webster Consultants study and the Saal and Parker series where analysis is concerned with significantly broader aspects of the industry. Differences in model specification may explain the differences between Hunt and Lynk (1995) and Lynk (1993). While neither study has an explicit control for capital, the Hunt and Lynk study includes lagged cost as an explanatory variable in their cost function which may capture some of the variation in capital. Lynk does not.[26]

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22 Ashton, J. (1999),*Economies of scale, economies of capital utilization and capital utilization in the English and Welsh water industry*, Bournemouth University, School of Finance and Law Working Paper Series, 17.

23 Cubin, J. and Tzanidakis, G. (1998), "Regression versus data envelopment analysis for efficiency measurement: an application to the England and Wales regulated water sector", *Utilities Policy* 7, pp. 75-85.

24 Hunt, L.C. and Lynk, E.L. (1995), "Privatisation and efficiency in the UK water industry: an empirical analysis", *Oxford Bulletin of Economics and Statistics* 57(3), pp. 371-388.

25 Lynk, E.L. (1993), "Privatisation, joint production and the comparative efficiencies of private and public ownership: the UK water industry case", *Fiscal Studies* 14(2), pp. 98-116.

26 There is a possibility that capital is used as the numeraire in the model, though this is not explicitly stated in either study.

The implications from the Ashton (1999) study together with the Stone and Webster Consultants (2004) study and the Saal and Parker series suggest an initially inefficient capital base which is gradually adjusting to more efficient use over time. As pointed out earlier, however, English and Welsh water and wastewater utilities are substantially larger on average than the Water Corporation. Consequently, findings of size diseconomies in that jurisdiction need to be treated with caution when considering the implications for Western Australia.

United States

In contrast to the UK, there appear to be relatively few recent studies on the economics of water and wastewater industries. Torres and Morrison Paul (2006)[27] ranks as one of the best available. Spanning across 255 utilities obtained from a 1996 survey conducted by the American Water Works Association, the estimated model measures economies of size while controlling for customer density and size of service area

According to Torres and Morrison Paul, the US water system is characterised by tens of thousands of water community systems. As at 2002, 83% (43,314) serve populations below 3,300 persons. Thus, the US experience in supplying water to small populations across large service areas is particularly relevant for drawing out the efficiency implications of supplying water to Western Australia's regions. Another attractive feature of the study is that the model specifies water supplied to final consumers as an endogenous variable. This allows for the year to year uncertainty associated with how much water will need to be supplied given variation in weather.

A significant point of difference between Torres and Morrison Paul and the Nauges and van den Berg (2007)/ Saal and Parker studies is the measurement of customers per square mile rather than customers (properties) per kilometre of pipeline. This adds a sharper spatial dimension to the measurement of size and scope economies. They also crystallise concepts of the economies of vertical and horizontal network expansion. Economies of vertical network expansion (customer density) measures the simultaneous expansion of volume and customer numbers while holding demand per customer constant. Economies of horizontal expansion (spatial density) arise from the simultaneous expansion of delivered volume and customer service area.

Size economies are then defined as the simultaneous increase in volume delivered, customer numbers and service area size. The decomposition of size

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27 Torres, M. and Morrison Paul, C.J. (2006), "Driving forces for consolidation or fragmentation of the US water utility industry: a cost function approach with endogenous output", *Journal of Urban Economics* 59, pp. 104-120.

economies into these three components helps to reconcile why some achieve economies of size and others do not.

Table 13 reproduces the results presented in Torres and Morrison Paul (2006). Note that in comparison to the Water Corporation, these suppliers are small. The average large water supplier is only 14% of the size of the Water Corporation in terms of volume of delivered water. The Perth region is double the size of the average large water supplier analysed by Torres and Morrison Paul. The North West and Goldfields and Agricultural regions are 30% and 21% larger, respectively, than the average medium-large water suppliers. The South West is within 12% of the average medium-large water supplier. The Great Southern is somewhere between medium and medium-large.

Table 13 **Economies of size, scope and density**

	Sample mean	Small	Medium	Medium-large	Large
Water delivered (mean) (ML/day)	91	7	18.6	61.8	306.9
Cost elasticity measures					
Volume	0.58	0.33	0.46	0.53	0.61
Scope	0.45	0.75	0.59	0.52	0.57
Service area size	0.16	0.16	0.17	0.15	0.3
Customer numbers	0.49	0.49	0.53	0.51	0.54
Spatial density	0.74	0.49	0.63	0.68	0.91
Customer density	1.07	0.82	0.99	1.04	1.15
Size	1.23	0.98	1.16	1.2	1.45
Economies of size	**0.81**	**1.02**	**0.86**	**0.83**	**0.69**

Data source: Torres, M. and Morrison Paul, C.J. (2006), "Driving forces for consolidation or fragmentation of the US water utility industry: a cost function approach with endogenous output", *Journal of Urban Economics* 59, pp. 104-120.

The cost elasticity measures in Table 13 are as reported in Torres and Morrison Paul (2006).[28] The size economies measure is the reciprocal of the elasticity of cost with respect to size (Size). An elasticity measure that is statistically less than one implies increasing economies. For example, a 1% increase in the volume of water (holding customer numbers and size of service area constant) implies 0.58% increase in cost for the average water supplier in the sample. Since the increase in cost is less than the increase in volume, there are quite strong returns to volume.

Reading the table suggests there are increasing returns to volume, service area size and customer numbers. However, increasing these three factors simultaneously (reflected in the Size measure) suggests diseconomies. There are apparent increasing returns to spatial density. That implies that US water suppliers could realise efficiency gains from proportionally increasing

[28] Torres and Morrison Paul (2006), op. cit., p. 115

customers and service area. The results also imply that efficiency gains sought by the simultaneous increase in the volume of delivered water and number of customers would not be realised.

The scope measure shows the percent difference between separate production of retail and wholesale water and joint production, thus capturing the cost savings accruing to water utilities that offer water for both wholesale and retail customers. The expectation is that there are likely to be scope economies since retail and wholesale share the same source, pumps, treatment facilities and transmission lines. The results indicate that small water utilities can realise a 75% reduction in cost through joint production of retail and wholesale water provision. Even large firms on average realise a 58% reduction in cost.

The key insight derived from decomposing economies of size into volume of delivered water, number of customers and size of service area is that getting bigger is not necessarily better in terms of efficiency of water delivery. What matters is the way in which the expansion occurs. This implies an MES in each of the three dimensions of size economies. Unfortunately, the applicability of the study to Western Australia is limited because Torres and Morrison Paul do not present summary statistics on customer numbers and size of service area. Thus, we cannot readily compare the US experience with Western Australia's. In addition, the study is concerned with water-only utilities, rather than combined water and sewerage.

Torres and Morrison Paul do, however, provide some useful insight in their conclusion. First, they point out that "…smaller water utilities that incur lower expansion costs tend to be characterised by low output per customer and per square mile as well as a high service area per customer…"[29] For larger utilities, "…expansion is costly unless it can be accomplished without accompanying increases in the network…". The scope economies are perhaps the most telling. There are significant efficiencies to be gained for water retailers to expand into the wholesale water market.

Garcia, Moreaux and Reynaud (2004)[30] provide another useful study of US water suppliers. The motivation for their study is to measure the effect of vertical integration in the Wisconsin water industry. They find size economies for vertically integrated utilities. However, they find only gains to vertical integration for small utilities.

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[29] Torres and Morrison Paul, op. cit. p. 118.

[30] Garcia, Moreaux, M. and Reynaud, A., *Measuring Economies of Vertical Integration in Network Industries: An Application to the Water Sector*, 2004.

Other notable US studies are Bhattacharya *et al* (1994)[31] and Hayes (1987)[32]. Bhattacharya *et al* (1994) reports an elasticity of cost with respect to output for both public and private water suppliers of 0.85 and 0.86, respectively. This implies large size economies for the typical US utility. However, the study does not control for customer numbers, size of service area, quality or any form of density.

Hayes (1987) measures size economies and scope economies for joint production of retail and wholesale water suppliers. Hayes finds evidence of both size and scope economies. Size economies are reported across almost all output ranges:

- 1,000 to 25,000 million gallons per year for retail (approximately 10.4 to 259.3 ML/day)
- 250 to 10,000 million gallons per year for wholesale (approximately 2.6 to 103.7 ML/day)

As one would expect, there appears to be an inverse relationship between the magnitude of size economies and volume of water supplied.

Scope economies measures indicate substantial economies between small retail-wholesale suppliers. The efficiencies decline as retail and wholesale increase proportionately. However, Hayes also conducts a formal test for subadditivity (natural monopoly) and finds that subadditivity is rejected for outputs of 5,000 million gallons in both retail and wholesale for his 1976 sample of water utilities. This means that industry cost can be reduced by allowing mergers between firms up to, but not exceeding the threshold joint production of 52 ML/day of retail and wholesale water supply. As with Bhattacharya *et al*, Hayes does not control for customer numbers, size of service area, quality or density.

Italy

Fraquelli and Moiso (2005)[33] analyse the cost structure of 18 Italian water suppliers over a period of thirty years. They report that the Italian water system suffers from service fragmentation, low efficiency, small scale of operations, insufficient water supply, low quality of water and customer service standards

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31 Bhattacharya, A. Parker, E. and Raffiee (1994), "An examination of the effect of ownership on the relative efficiency of public and private water utilities", *Land Economics* 70(2), pp. 197-209.

32 Hayes, K. "Cost structure of the water utility industry", *Applied Economics* 19, 1987, pp. 417-425.

33 Fraquelli, G. and Moiso, V. *Cost efficiency and economies of scale in the Italian water industry*, presented at Pavia University, 15-16 September 2005.

and tariffs that are insufficient to cover costs. To rectify this, the Italian government has assigned the right to manage water supply via a competitive tender process.

Fraquelli and Moiso (2005) report that earlier studies show that size economies of water supply in Italy disappear as the number of customers served grows beyond 150,000 to 200,000 customers.

Table 14 presents Fraquelli and Moiso (2005) main results. Economies of output density is measured as the inverse of the elasticity of cost with respect to output. They also calculate the elasticity of cost with respect to network length. The reported size economies is the inverse of the sum of these two elasticities.

Table 14 **Size economies across water suppliers**

Water delivered	Economies of output density	Size economies
(ML/year)		
25,306	18.53	2.18
31,658	9.9	1.77
34,685	8.32	1.64
38,830	6.95	1.5
43,000	6.05	1.4
50,891	4.98	1.26
52,213	4.85	1.24
62,148	4.12	1.12
97,811	2.96	0.91
250,000	1.87	0.65

Data source: Fraquelli, G. and Moiso, V. *Cost efficiency and economies of scale in the Italian water industry*, presented at Pavia University, 15-16 September 2005.

As shown in the table, there are strong size economies for small water suppliers (25,306 ML/year). The size economies measure implies that a 1% increase in inputs yields a 2.18% increase in output. Diseconomies of size appear for water suppliers delivering more than 63,000 ML/year. For example, increasing inputs by 1% for a water supplier delivering 97,811 ML/year yields 0.91% in outputs.

Note, however, that if an increase in delivered water can be achieved without increasing network size, then a 1% increase in inputs yields a 2.96% increase in water delivered.

A key difference between the Fraquelli and Moiso (2005) study and earlier studies of the Italian water industry is that, in Fraquelli and Moiso (2005), only vertically integrated companies are examined. Earlier studies looked at disaggregated water suppliers. Hence, comparing the stronger size economies results reported in Fraquelli and Moiso (2005) suggests there are efficiency gains available via vertical integration of these relatively small water suppliers.

Portugal

Martins, Coelho and Fortunato (2006)[34] studied 218 municipal water and wastewater utilities in Portugal using 2002 data. Motivation for the study is to determine if there are advantages in merging neighbouring local water utilities within a single water operator and, measure the consequences of the production of water losses jointly with other outputs: water delivered to residential and non-residential consumers. They control for network length; customer density (computed as the ratio of the number of network connections by squared kilometres); the proportion of raw water acquired to other utilities; the type of utility management; and whether the utility faces an economic regulation environment.

The authors report that there are size economies and recommend that small water utilities merge where it is possible. The minimum efficient scale is calculated to be 15.6 ML/day. They also find that there is an optimal level of water loss. That is, it is cost efficient to choose not to fix all leaks.

Germany

Sauer (2005)[35] examines the cost structure of rural water suppliers in Germany. He studies very small water suppliers that serve towns and villages that appear to be similar to the size of Western Australian towns. Sauer's primary focus is to determine the optimal size for a water supplier, which is calculated by minimising average cost with respect to water output, total network pipeline length and total number of connections. The results are reproduced in Table 15.

Table 15 **'Optimum' firm size for water supply in rural Germany**

	Optimal size
Water output (1,000m^3/year)	3,592
Network length (km)	808.8
Number of connections	18,453

Note: This table is reproduced from Table 6 in Sauer (2005)

Data source: Sauer, J. "Economies of scale and firm size optimum in rural water supply", *Water Resources Research*, 41, 2005, pp1-13

34 Martins, R., Coelho, F. and Fortunato, A. *Evaluating Cost Structure of Portuguese Water Utilities: Economies of Scale and Water Losses*, presented at the XVI International Reser Conference, Lisbon, September, 28-30, 2006

35 Sauer, J. "Economies of scale and firm size optimum in rural water supply", *Water Resources Research*, 41, 2005, pp. 1-13

Sauer states that, given the results in Table 15, the optimal number of supplied inhabitants is approximately 66,000 per firm delivering a total of 3,590 ML per year. That equates to approximately 0.05ML/person/year, which appears to be substantially lower than the Australian average.

By way of comparison, the Perth portion of the Water Corporation's operations is 63 times larger in terms of water output, 15 times larger with respect to total kilometres of mains and 41 times the number of connections. The Great Southern is 4, 5 and 2 times the optimum size with respect to water delivered, mains kilometres and connected properties.

However, the optimal size for rural Germany implies a customer density of 23 connections per kilometre. Perth (62 properties/km) and the South West (35 properties/km) exceed the optimum while the North West matches it and the Goldfields, Great Southern and Mid West are below the optimum density measure.

The notion of an optimum size in terms of the number of customers per kilometre implies that the cost per customer per kilometre is non-linear and possibly "U"-shaped. This would suggest that beyond some threshold, diseconomies of density set in.[36] The point of minimum average cost is likely to be dependent on the design of the network. For example, the diameter of pipes installed, the topology of the local terrain, the number of pumping stations etc.

Diseconomies of density may result if a network requires substantial remediation/capacity expansion in order to accommodate more customers within a fixed operating area.

France

Garcia and Thomas (2001)[37] investigate the cost structure of 55 water utilities in Bordeaux, France. An interesting aspect of their study is that they model water network losses as an output that is "produced" jointly with water delivered to customers. This provides an explicit control for inefficiency across municipal suppliers. Water loss is likely to be a function of the pressure applied to maintain water throughput. Garcia and Thomas (2001) point out that there is a peak/off-peak relationship between pressure and leaks. As customer demand for water decreases, water pressure increases leading to increased leakage.

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36 Note that Torres and Morrison Paul (2006) also indicate an optimal customer density, suggesting that an incremental expansion of network size had a lower impact on cost than an incremental increase in the number of customers for a network of fixed size.

37 Garcia, S. and Thomas, A. "The Structure of Municipal Water Supply Costs: Application to a Panel of French Local Communities", *Journal of Productivity Analysis*, 16, 2001, pp.5-29

The decision to repair network leakages is a function of its cost. A manager may choose not to repair leaks when it is less costly to respond to increasing demand by simply increasing water pressure. Hence, they measure the cost impact of leakage via economies of scope with delivered water.

Like other relatively recent studies, Garcia and Thomas (2001) also control for network density and quality variables. They find short-run size economies while in the long-run there are constant (no) size economies.

Japan

Mizutani and Urakami (2001)[38] examine Japanese water suppliers. To ensure that their conclusions are robust to differences in functional form of their model, they measure size economies using the log-linear cost function, the translog cost function and the translog cost function with controls for differences in network density and quality across water utilities. They report that there are slight diseconomies of size at the sample mean point. They also report that the optimal size of a water supply organization would be one supplying a population of approximately 766,000 people. They conclude that there are economies of network density, but no scale economies in Japanese water supply firms.

Canada

Renzetti (1999) reports economies of size for both water and sewerage services. Based on a sample of 77 Ontario municipal water supply utilities and sewerage treatment facilities, Renzetti reports that size economies for residential water supply of 1.25, 1.46 for non-residential supply and 1.36 for sewerage services. These measures are substantial. Importantly, he reports that controls for population density have a negative coefficient, but is statistically insignificant. Another important anecdote from this study is that the marginal cost is higher than comparable US studies, which is partly attributed to lower customer density in Ontario. Unfortunately, Renzetti does not report summary statistics, so we are unable to determine the size of the utilities.

South Korea

Kim and Lee (1998) model 42 municipal urban water supply companies drawing water from the Han River in South Korea. Employment density (1,000 workers/km) and population density (1,000 persons/km) are included as key determinants of water production costs. They find size economies for the average sized utility. Breaking up the results by city, they report that four

38 Mizutani, F. and Urakami, T. "Identifying network density and scale economies for Japanese water supply organizations", *Regional Science*, volume 80, 2001, pp. 211–230

utilities show diseconomies of size, 12 show constant (no) size economies and 12 show size economies.

Based on the results, the authors argue that it is possible to realise increased efficiency through cooperative development (construction, operation, and management) based on utility spatial and economic attributes. That is, mergers make sense if it requires relatively little in terms of adjustment/transactions costs.

4.1.3 Economies of vertical integration

Several overseas studies included in our review show that there are efficiency gains in vertical integration up to some finite, though possibly imprecise size. For example, Torres and Morrison Paul (2006)[39] cite efficiencies between retail and wholesale due to sharing of source water resources, pumps, treatment facilities and transmission lines. In their study, "…estimated scope economies between production of water for retail and wholesale are fairly high and particularly significant for smaller utilities…" This has implications for utilities delivering up to 300-310 ML/day.

At the other end of the size range, Stone and Webster Consultants (2004) also reported gains in vertical integration "…from the integration of water production and distribution..."[40]

These efficiencies are related to the technology embedded in water networks. However, as Garcia, Moreaux and Reynaud (2004) point out there are also potential gains from vertical integration due to transaction costs and market imperfections.[41]

Some examples of the economies from technical relationships have already been cited. In addition to those, the authors offer coordination economies from unanticipated events as another example of cost economies arising from technical relationships. A vertically integrated firm may have better information than separated firms. Such economies are most evident where optimal production or distribution capacity arises from a joint decision with respect to plant and transmission system size. Economies arising from technical relationships can often be readily recognised where there is potential for unnecessary duplication of fixed costs.

Transaction costs arise when there are difficulties with contracting between buyers and sellers of intermediate products. If it is not possible or too costly to completely specify a contract then vertical integration may be more efficient.

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39 Torres and Morrison Paul, op. cit. p. 116

40 Stone and Webster Consultants, op. cit., p. 47

41 Garcia, S., Moreaux, M. and Reynaud, A., op. cit., p. 4

Issues of cost shifting from one contracting party to another often arise when transaction costs are significant.[42]

Significant size economies in the upstream portion of the industry may allow the exercise of monopoly power in the intermediate market. Alternatively, an upstream firm may be able to extend its monopoly power into another market by blocking access to an essential part of the production process.

For example, market imperfections can distort the allocation of downstream inputs, resulting in cost increases. Garcia, Moreaux and Reynaud also acknowledge that there are potential gains from disintegration. For example, they draw an analogy between the production stages of water and the gas/electricity industry. They argue that water production (bulk water) appears to be a natural point for competition. They also suggest that, as has been proven in gas and electricity, the natural monopoly network of water pipes does not necessarily preclude competition.

Garcia, Moreaux and Reynaud's (2004) estimates of marginal variable cost and average variable cost for Wisconsin (USA) vertically integrated and vertically disintegrated water utilities are reproduced in Table 16. Several factors are evident in these data. First, the sum total marginal variable cost of non-vertically integrated production and distribution utilities is greater than the marginal variable cost of the vertically integrated firm. The authors attribute the difference to the purchase cost of water for the non-vertically integrated distribution utilities. Second the fact that average variable cost is greater than marginal variable cost for the vertically integrated utilities suggests the presence of size economies. However, the authors report that the average size of the vertically integrated utility is smaller than the average non-vertically integrated utility. This suggests that the vertically integrated firms are higher up the average cost curve and have not yet fully exploited potential size economies.

[42] Note that economic regulation may reduce the transaction costs associated with contracting

Table 16 **Estimates of marginal and average cost of vertically integrated and non-vertically integrated water utilities**

		Average utility	Minimum	Maximum
NVI Production utility	MVC	0.2064 (0.0349)	0.0887	0.9924
	AVC	0.1959 (0.0250)	0.1111	1.354
NVI Distribution utility	MVC	1.0248 (0.0394)	0.6862	2.404
	AVC	1.1188 (0.0102)	0.7608	2.4358
VI utility	MVC	0.7589 (0.0594)	0.0317	2.4985
	AVC	1.2021 (0.0448)	0.0645	3.8196

Note: NVI – non-vertically integrated firm, VI – vertically integrated, MVC – marginal variable cost, AVC – average variable cost. Values in parentheses are standard errors. MVC and AVC are in US dollars per thousand gallons of water

Data source: Reproduced from Garcia, Moreaux, M. and Reynaud, A., *Measuring Economies of Vertical Integration in Network Industries: An Application to the Water Sector*, 2004.

Garcia, Moreaux and Reynaud (2004) take the analysis further by simulating the total cost of supplying equivalent volumes of water across vertically integrated and non-integrated utilities based on their estimated cost functions. The difference in cost is referred to as the GVI (global vertical integration) index and is analogous to a test for natural monopoly. They show that the gains to vertical integration dissipate near 627 million gallons (approximately 2,373 ML per year), which is less than 1% of the Water Corporation's output. At 717.25 million gallons (2,715 ML/year), the production cost for the vertically integrated water supplier is 56% higher than the non-vertically integrated utility.

In looking exclusively at the technological economies of vertical integration, the authors report that efficiencies due to *technological economies* disappear at 200 million gallons (757 ML/year). That difference between the overall economies of vertical integration and the technological economies suggests the balance is due to transaction costs and market imperfections.

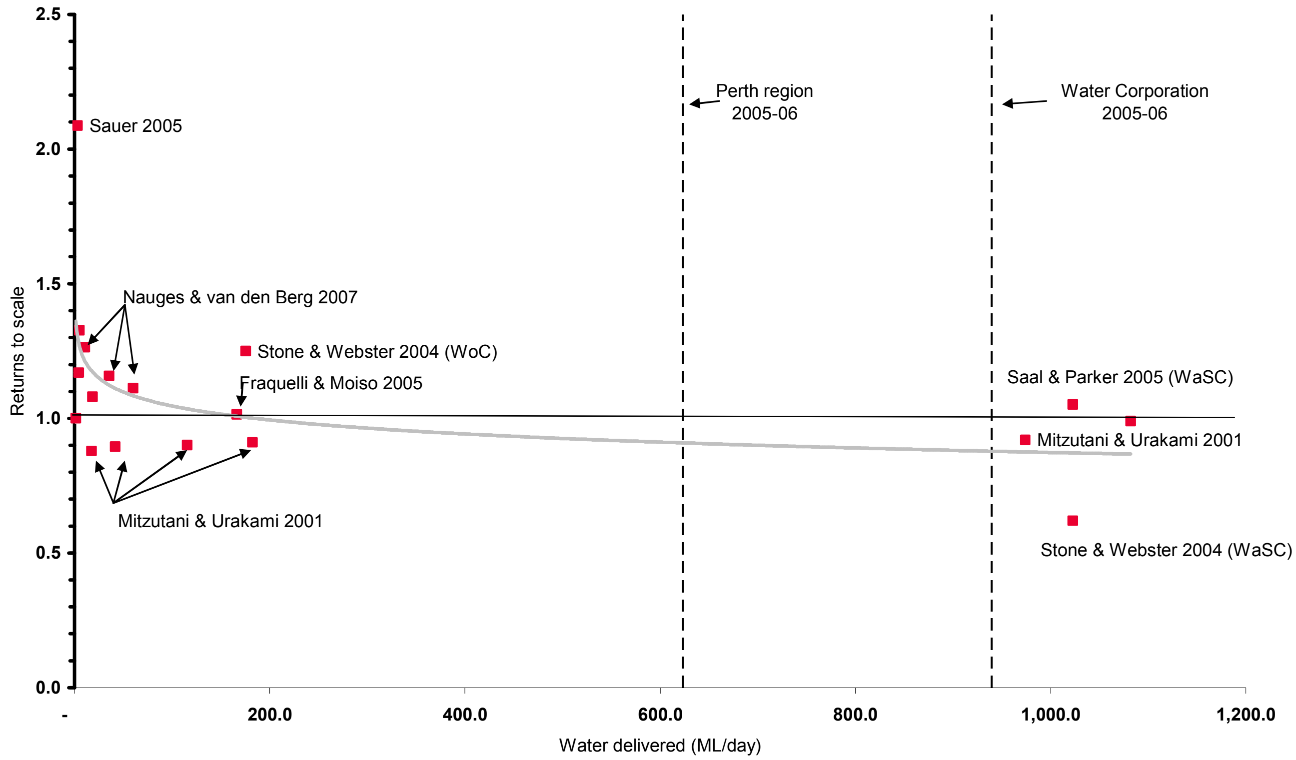
In total, we have reviewed three papers reporting economies of vertical integration: Garcia, Moreaux and Reynaud (2004), Stone and Webster Consultants (2004) and Torres and Morrison Paul (2006). All three studies show that there are economies of vertical integration. As discussed, Garcia, Moreaux and Reynaud (2004) report that total economies of vertical integration dissipate at 2,300 to 2,400 ML/year and suggest that strong diseconomies of vertical integration are present at approximately 2,700 ML/year. On the other hand, Stone and Webster Consultants (2004) report finding economies of vertical integration among substantially larger water suppliers. If we base our expectations on the Garcia, Moreaux and Reynaud (2004) study, we should see diseconomies of vertical integration in the Stone and Webster Consultants (2004) study. In reconciling the apparent contradiction, it suggests that the threshold output at which economies of vertical integration dissipate may be imprecise and specific to the economic and environmental circumstances in which the water suppliers are operating. This is not in itself surprising.

4.1.4 Summary

In drawing together the conclusions of the studies surveyed, it is clear that there are mixed results with regard to size economies and scope in the water and wastewater industry. Differences between the studies are summarised in Appendix A.

Figure 6 provides an overview of measured size economies against daily water output for selected studies. The studies included are those that are considered broadly comparable and where summary statistics reported in the studies allow comparison.

Figure 6 **Returns to scale based on selected studies**



Note: WoC is an abbreviation for Water only Companies. WaSC is an abbreviation for Water and Sewerage Companies. The sample is selected from studies that are considered to be broadly comparable and where summary statistics permitted comparison.

Data source: Drawn from referenced studies and Water Corporation annual reports

As shown, the majority of studies consider water utilities that are substantially smaller than the Water Corporation. In addition, there is a large gap in scale between the small and very large utilities.

The grey line of best fit suggests that water utilities delivering between 200ML/day and 1,000 ML/day are unlikely to show size economies. However, it is important to note that few studies have examined very large water and wastewater utilities, so the results should be considered as tentative. Moreover, no Australian studies were found, which limits the degree to which we can draw inferences.

In looking across the studies, it is apparent that there are three key factors that impact on size economies:

1. Volume of water supplied
2. Number of connections served
3. Size of the area served

The magnitude of size economies appear to depend on the extent to which volume of water supplied can be increased without incurring expansion costs in the other two factors.

Another area of apparent consensus is that there are efficiencies to be derived from mergers among small municipal water suppliers.

Few studies investigated economies of size in wastewater services, so conclusions are tentative. The little research available suggests there are limited economies of size available. No explanation was provided.

The question of economies of scope examined in the literature ranges across economies between:

1. water and wastewater services
2. retail (distribution) and wholesale (transmission/source) water supply
3. environmental services and water supply
4. quality of water and wastewater treatment
5. water delivered and water lost

The research suggests that there are few (if any) scope efficiencies to be gained by combining water and wastewater utilities. However, economies of scope are found between retail and wholesale water supply, suggesting efficiency from vertical integration. Scope economies between water delivered and lost indicates that it can be economically efficient to choose not to rectify some level of water loss.

Implications for water and wastewater industry configuration

The focus of much of the literature is on finding ways of achieving greater levels of efficiency. Economies of size and scope have been included in the efficiency measures to determine whether efficiency gains can be realised through changes in the scale and scope of operations. In this regard, the clear policy recommendation is to encourage mergers between small water suppliers where it is sensible to do so.

While there appears to be little support for combining water and wastewater services, the loss of efficiency appears to be relatively small. Hence, the relevant policy issue is whether creating or maintaining combined water and wastewater utilities implies material losses of efficiency. The tentative conclusion is that it depends on other benefits that may be derived. If those other benefits outweigh the implied efficiency losses, then it may be appropriate to allow combined water and wastewater services. However, if combined water and wastewater utilities are being entertained, then it may also be appropriate to consider whether there are benefits in creating multi-utilities that span water/wastewater and other services, such as electricity transmission and distribution. Given the remoteness of large parts of Western Australia, such utilities may be appropriate.

Indeed, a study by Piacenza and Vannoni (2004)[43] discussed in section 5.2 report cost saving due to economies of scope in the order of 16-22% via joint production of all three outputs. This stands in stark contrast to the finding of diseconomies of scope between waste and wastewater services. While there is no explicit confirmation in the literature, it would appear that economies of scope are derived from economies of "shared common costs". Within relatively small utilities, the cost difference between maintaining separate organisations and a single combined entity represents a significant portion of unit cost. By contrast, the large urban water and wastewater utilities have grown far beyond the point at which the cost difference impacts on unit cost. Indeed, it is likely that other inefficiencies such as increased bureaucracy overwhelm any cost saving.

In addition, a factor that is particularly relevant to sparsely populated regions of Western Australia is the time spent on coordination savings between small utilities can be maximised if organised internally within a single utility.

Overall our findings suggest that the magnitude of scale and scope economies is relatively modest in many cases. Whether they are sufficient to offset the benefits of specific forms of competition requires an assessment of such benefits – which is beyond the scope of this paper. However if market structures can deliver a constructive competitive market, with incentives for innovation and competition through dynamic efficiency, then it is possible that the gains from competition would be sufficient to outweigh the (modest) loss of economies of scale and scope suggested in the literature. In addition,

[43] Piacenza, M. and Vannoni, D. "Choosing among alternative cost function specifications: an application to Italian multi-utilities" *Economics Letters* 82, 2004, pp. 415-422

however, the transition costs involved in moving to a changed industry structure also need to be taken into account in the assessment.

5 Reconfiguration of WA's water and wastewater industry

The preceding section demonstrates that there are size economies in water and wastewater supply, as well as cost savings available via various types of scope economies. There is also some suggestion, as one would expect, of natural monopoly elements. However, these are likely to be output-specific and finite rather than being global and overwhelming.

Given the likely limits to natural monopoly, a key policy question is whether the Western Australian water and wastewater industry can be made more efficient through some form of reorganisation. Examples of other efficiencies that may be realised are:

- Improved dynamic efficiency, through
  - Enhanced utilisation of capital and
  - Innovation in services and nature of service provision
- Reduction of x-inefficiency – the efficiency with which output is derived from fixed inputs.

This section discusses the merits of various strategies designed to extract greater efficiency while preserving (or exploiting) economies of size and scope.

Given that the Water Corporation is relatively large and the state is geographically expansive, it may be appropriate to consider horizontal and/or vertical disaggregation. Horizontal disaggregation may involve separation of:

- water and wastewater services;
- geographic separation
  - for vertically integrated businesses or the distribution/retail component only

Similarly, vertical disaggregation could involve separation of:

- resources, treatment, trunk transmission, distribution and retail functions for water supply
  - resources, treatment and trunk transmission usually remain vertically integrated within a disaggregated structure
  - similarly retail and distribution functions have typically remained together in water
- network and treatment/disposal functions in respect of sewerage services.

The separation of planning and procurement functions, possibly with a separate system manager, is the subject of a separate briefing paper. The purpose of the discussion below is to consider what guidance the literature provides on the institutional structures of most interest for WA. The options considered are:

1. Vertically separating bulk water functions (resources, treatment and transmission) from distribution/retail
2. Further horizontally disaggregating distribution and retail in the Perth region
3. Separating remote services and combining them with electricity
4. Aggregating suppliers in the South West.

The following discussion draws on the conclusions of the available literature. Ideally we should undertake a detailed cost study of Water Corporation itself. In the absence of this we are relying on drawing inferences from the studies conducted elsewhere.

5.1 Vertical separation of bulk water and distribution

Section 4.1.3 above discussed the findings of several studies on the extent of economies of scope in vertical integration. While there are likely to be important differences between Western Australia and Wisconsin, the study by Garcia, Moreaux and Reynaud (2004) does suggest that the gains to vertical integration in water supply may be substantially less than some believe. Notably, Garcia, Moreaux and Reynaud (2004) compare their results to studies analysing the gains to vertical integration in electricity. They suggest that the magnitude of the gains to coordination across production stages (vertical integration) are substantially less than in the electricity industry, which has been exposed to successful vertical separation.

The fact that both Torres and Morrison Paul (2006) and Stone and Webster Consultants (2004) report vertical economies for water suppliers that are larger than those studied by Garcia, Moreaux and Reynaud (2004) suggests caution with regard the precise threshold at which economies of vertical integration dissipate. Torres and Morrison Paul (2006) show that a firm producing at approximately one third of Water Corporation's output can realise cost savings of 57% through vertical integration.[44] We can note from Table 19 in the Stone and Webster Consultants (2004) report, however, that a 1% increase in water output would have delivered a 0.3% cost saving due to economies of scope at the size of the average water-only utility (approximately 20% of Water Corporation's current production).[45] [46] The estimates of the implied savings

[44] Torres and Morrison Paul, *op. cit.* Table 2, p. 115

[45] Stone and Webster Consultants, *op. cit.*, p.48

[46] Stone and Webster Consultants, *op. cit.*, Table 4 p. 31 shows water-only companies produced on average 200ML/day of delivered water in 2003.

from economies of vertical integration are taken from the water only utilities (and not the water and sewerage utilities) since they are of a similar scale to Water Corporation North and South separated entities.

While there is substantial variation across these three studies, we note that as discussed in Garcia, Moreaux and Reynaud (2004) a large part of the economies of vertical integration may be due to market imperfections and transaction costs. This suggests that a well-designed and regulated intermediate water market would preserve a large part of the efficiencies associated with vertical integration.

Vertical separation of this type has been undertaken in both Melbourne and Sydney. (In the case of Melbourne vertical disaggregation was accompanied by horizontal disaggregation of the distribution/retail function which is discussed further in Section 5.2). In both cases, the benefits of vertical disaggregation in terms of improved focus and incentives must have been regarded as more than outweighing the loss of economies of vertical integration and the transaction costs involved. For Sydney, a key driver was to ensure adequate attention to public health risks in relation to water source management, following a cryptosporidium scare – not cost reduction as such.

Advice from Cardno BSD suggests that there are economies from retaining integration between water treatment and water storage. This does not, of course, preclude arrangements such as a water treatment plant being provided under a build, own, operate contract (as has been done, for example, with the Prospect Treatment Plant in Sydney) – but it does imply tight technical links are needed between source operation and treatment operation and this will generally need to be reflected in the nature of the contract for treatment.

However Cardno BSD considered that, even though water production from a variety of sources and its distribution to consumers is highly integrated, it may be feasible to 'separate' the source outlets from the mains network. In efficiency terms, separation at the source outlet provides the potential for competition between source providers with an associated on-going competitive pressure to extract greater efficiency from the system.

5.2 Horizontal separation of Perth services into North and South

A further option for re-structuring Water Corporation's operations would be to build on the vertical separation of bulk and distribution/retail activities by horizontally separating the latter in the Perth region (i.e. North and South).

Our examination of the literature above suggests that such disaggregation need not involve significant aggregate loss of efficiency – with the possible exception of transition costs – in the distribution/retail function, given the scale of Water Corporation's activities in Perth.[47] The greatest risk appears to be uncertainty as the actual magnitude of economies of vertical integration. While most of the studies cited have considered vertically integrated businesses, much of the conclusions regarding economies of scale appear to be driven by considerations regarding network services, and hence are applicable to the distribution side of water Corporation's business.

As discussed earlier in Section 4.1.3, the crucial factors to consider are: the transaction costs associated with coordinating demand and supply of water in the intermediate market; and market imperfections. The influence of factors depends crucially on institutional arrangements; e.g. the existence and effectiveness of an economic regulator.

5.2.1 Experience from Melbourne

The metropolitan water industry in Melbourne was disaggregated in 1995 into a bulk water and sewerage service provider and three geographically distinct retailers. Melbourne Water undertakes the wholesale function, comprising:

- Harvesting and storage of raw water
- Treatment of raw water
- Transport of treated water to the boundary of the retailers' distribution systems
- Operation of the bulk sewerage network
- The majority of sewage treatment.

The retailers' functions are:

- Operating the distribution systems for water and sewerage to/from customers premises
- Operating a number of small sewage treatment plants, including the provision of recycled water to local customers
- Retail functions including meter reading, billing, call centre enquiries, new connections and complaints
- Trade waste services to commercial and industrial customers.

The original objectives of the reform were to introduce commercial measures, improve customer services and improve accountabilities. In particular, there was concern that as an integrated supplier of both public and private goods, Melbourne Water had potentially confused accountabilities. A government

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[47] Note from Figure 6 that for the size of Water Corporation, size diseconomies if WC were to be halved would be at most 10% and are likely to be close to zero. In addition, with a well designed intermediate market for water, economies of vertical integration are also close to zero.

review concluded that the industry would function better if new entities were formed to focus on their core functions, develop a commercial outlook and reduce operating costs. Thus the establishment of the three retailers was intended to provide:

- A clear focus on core activities, with customer's closer to regional management
- Improved performance via competition by comparison between three regionally based water and sewerage businesses
- Introduction of operating licences to specify clearly the obligations the water suppliers were expected to deliver.

In their submissions to the current review of the retail industry structure by VCEC, the three retailers have argued that these reforms brought significant benefits, with:

- Significant improvements in customer service
- A cultural shift towards continuous improvement and innovation and
- Substantial productivity gains.

KPIs published by the retailers show significant improvements over the period 93/94 (prior to reforms) and 2006/7. For example, SE reports improvements on 19% in overall customer satisfaction, with water quality complaints improving by 55% and sewer blocks per 100km of main improving by 59%.

Following the reforms, the retailers implemented a range of improved work practices, including outsource partnering, improved systems, improved asset management processes, competitive tendering and process reengineering. In its 2005 review of the structure of the water industry in NSW, IPART concluded that the process of restructuring the Melbourne Water industry

> Revealed many opportunities for improving productive efficiency and introduced a more productive workplace culture.[48]

The retailers also point to significant reductions in costs per property that have been achieved over the period[49]. They also cite a recent study by Coelli and Walding, which concluded that the Melbourne businesses were on the efficiency frontier using total factor productivity measures[50].

In its submission to the VCEC Inquiry, Melbourne Water notes that

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48 IPART (2007), Literature Review: Underlying costs and industry structures of metropolitan water industries, page 36.

49 South East Water, 2007, initial submission to VCEC review, p25

50 Coelli and Walding, june 2005, Performance Measurement in the Australian water supply Industry, quoted in city West Water, 2007, Submission to VCEC Inquiry into reform of the metropolitan retail water sector.

> Between 1995/96 and 2001/02 operating costs for the Melbourne industry declined at a faster rate than the Australian Industry Average

And that

> Customer service, as measured by service reliability and customer complaints about water quality, improved at a greater rate in the early years following disaggregation[51].

However, Melbourne Water is of the view that its capacity of the disaggregated structure to provide further significant gains is limited.

The Melbourne retailers agree that there would be some economies of scale achieved by re-integrating the three, through operational savings, but consider that these would be relatively modest. Moreover they argue such savings would be offset by reduced incentives for dynamic efficiency (with the loss of the drive for innovation produced by the comparative competition undertaken in Melbourne). Melbourne Water suggested that the operational savings could be of the order of $35m to $45m per year (compared to a total turnover of $990 for the three retailers in 2005/6).

5.2.2 Implications for Perth

The improvements in levels of service and productivity that were achieved in Melbourne suggest that disaggregation of wholesale from distribution and horizontal disaggregation of the retail/distribution function did provide dynamic efficiency gains. Moreover, the economies of scale in distribution/retail functions that would be achieved by re-integrating the business would appear modest (at most 4.5% of turnover).

In further consideration of a possible north-south split, ACIL Tasman understands that the Water Corporation created separated north and south entities in pursuit of greater efficiency some years ago.[52] This was apparently partially reversed some years later. Discussion with Cardno BSD indicated that at the operational level, north and south are still largely separate organisations, sharing only senior management. This anecdote suggests that there are indeed efficiencies to be gained from independent operation.

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51 Melbourne Water, 200, Submission to the VCEC Inquiry into reform of the metropolitan retail water sector, page 8.

52 This anecdote is based on discussions with Water Corporation.

5.3 Water and wastewater services in remote Western Australia – Horizon Power as a combined electricity, water and wastewater service provider

A key rationale for reconfiguring the provision of essential services in remote parts of Western Australia is that a utility management team is likely to be focused on areas of potential growth or where the bulk of the market is located. Issues associated with small markets that are distant from head office may be difficult to deal with, time consuming and expensive.

At the same time, it is crucial that remote areas receive adequate attention and resources. A utility with small, remote markets as its "core business" may be better placed to realise economies of scope by addressing similar problems and needs across many small communities.

Quantitative support for the multi-utility concept can be found in Piacenza and Vannoni (2004)[53] who test for economies of scale and scope across 90 Italian public utilities. Among these, 39 specialise in one of the outputs (19 firms provide gas only, 16 provide water and four provide electricity), 37 two-output firms (31 gas-water, one gas-electricity and five water-electricity combinations) and 14 three-output utilities (electricity-gas-water). They report cost saving due to economies of scope in the order of 16-22% via joint production of all three outputs.

Further support can be found for the presence of economies of scope in the experience of multi-utility providers in the Northern Territory and in the UK.

5.3.1 Northern Territory Power and Water utility

Power and Water is the Northern Territory's main provider of electricity, water and sewerage services. According to their website[54] Power and Water has more than 70,000 customers, including:

- 55,000 domestic consumers;
- 10,000 businesses (120 major customers); and
- nearly 7,000 customers in remote Aboriginal communities.

Power and Water manage their remote operations jointly for water and electricity, and consider that there are a number of economies in doing so. PWC trains and manages Essential Service Operators (ESO), who are personnel located in communities and typically employed by local councils or

[53] Piacenza, M. and Vannoni, D. "Choosing among alternative cost function specifications: an application to Italian multi-utilities" *Economics Letters* 82, 2004, pp. 415-422

[54] http://www.powerwater.com.au/powerwater/aboutus/index.html

the communities themselves. The ESO is responsible for monitoring both water and electricity services, and are supported by specialists as necessary.

Areas where economies of scope are claimed to arise in running the two services jointly include operation and maintenance and minor works.

5.3.2 United Utilities, England

United Utilities was formed by the merger of a regional water and sewerage authority (North West Water) with its local electricity distribution and retail company (Norweb) in 1995. By 2002 they served 2.9 million water properties and 2.2 electricity properties (with the water service covering a slightly larger geographic area) and had a total turnover for the business of £1.9bn.

In 2002, United Utilities had estimated five-year cumulative cost savings from its multi-utility operations to be £480m. These savings were expected to be derived from:

- IT systems
  - Through adoption of common platforms and integrated systems
    - Asset management system
    - Investment prioritisation system
    - Geographic information system
    - Customer service system
- Manpower
  - Merging teams (including field management and management)
- Property
  - Using multi-utility sites, and selling or letting unused sites to make operational and capital savings
  - Before the merger there were 24 sites (12 each for water and electricity). After merger this was reduced to 11 multi-utility sites.

5.3.3 Scope for synergies between Horizon Power and Water Corporation remote operations

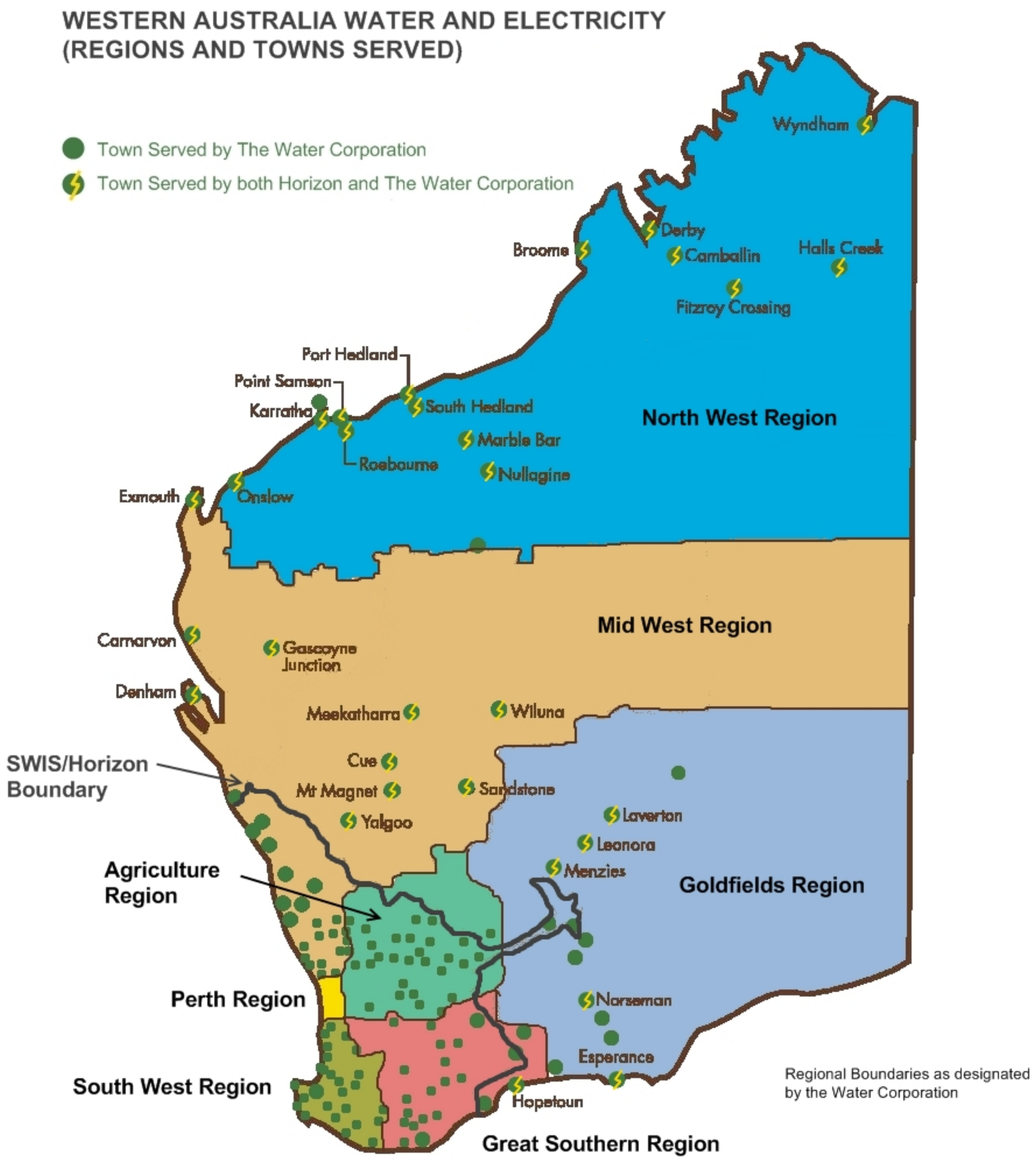
The preceding discussion on the experience with multi-utilities elsewhere suggests there is merit in the idea. However, success in terms of long-run net social benefit in Western Australia depends crucially on the extent to which unnecessary duplication exists in Water Corporation and Horizon Power remote area operations and the transition costs associated with reconfiguration.

An indication of the extent of overlap between the two organisations can be gleaned from Figure 7 and Figure 8. As shown, the respective 'footprint' of both organisations shows there are numerous towns and communities in common.

Figure 7 **Horizon Power Supply Areas**

Data source: Cardno BSD

Figure 8 **Regions and towns served by both Horizon Power and the Water Corporation**



Data source: Cardno BSD

Preliminary advice was also sought from Cardno BSD with regard to the practicalities involved. Cardno BSD advises that:

- Water Corporation operates country water and wastewater schemes from regional offices located in Karratha, Geraldton, Northam, Kalgoorlie, Bunbury and Albany. However, an array of services are provided centrally in Perth including scheme planning, engineering design, asset management, system control, customer billing and corporate services.

- Horizon Power service about 36,000 customers located outside the South West Integrated System (SWIS) and are based in Karratha.

Cardno BSD also advise that given the overlap in operations, the Water Corporation Karratha office and Horizon Power are already in discussion to identify how they can work together to reduce costs.

With respect to possible cost reduction strategies, Cardno BSD advises that there appear to opportunities for cost reduction due to:

- The need for both organisations to employ local maintenance staff in isolated areas maintaining all services and including meter reading. If these staff are currently under-utilised and are willing, there may be scope for sharing their services across both organisations.
- Combining responsibilities in one organisation may yield productivity improvements through better coordination. For example, time spent on travel to reach productive worksites may be reduced.
- Reduction in fixed cost through sharing of local depots and offices.
- Sharing management of billing information. This could also extend to Local Authority billing information.
- Combining management functions in country offices.
- The possibility of increased specialisation in some staff for tasks with overlapping skill sets such as trenching for underground power and pipe excavation.

Improvements in customer service might also be realised by:

- Providing a single point of contact for land developers and builders.
- Maintaining a larger pool of service personnel available to respond to faults and emergencies. A larger internally trained workforce may also help provide a substitute for low quality outsourced labour services in some remote locations.

However, key differences in the providing water and electricity services mean that scheme planning and engineering expertise have little associated efficiency attached. In addition, specific details with respect to operational changes need to be carefully considered such as:

- The cost effectiveness of transferring the centralised water and wastewater functions for remote areas to Karratha from Perth. Difficulties in attracting and retaining specialised staff in Karratha may offset perceived cost savings in other areas. Any change must be handled carefully to avoid losing staff in isolated areas where replacement is difficult. For example, the proposed introduction of reverse osmosis water treatment plants to the Murchison

District drew threats of early retirement from incumbent water supply operators afraid of the new technology.

- The cost impact of billing changes for remote area customers. For instance, would the increase in per customer billing for water and wastewater services be offset by combining with Horizon Power billing?
- Training cost associated with multi-skilling local maintenance staff.

These possible improvements need to be assessed against current outsourcing practices. Organisations providing high quality services to both Horizon Power and the Water Corporation may already be utilising the same trained labour force to maintain all/both the utilities services. For example a local water/gas/electrician/fitter in a remote town would contract for repair and maintenance of both electrical, water and sewer assets. The Water Corporation already makes use of this style of 'custodian' arrangement for water and wastewater services. Since construction and asset upgrades are already predominantly performed by contractors for any major work so it is not likely that a consolidated multi-disciplinary group would reduce costs in this area.

Specific issues related to service quality will also need to be carefully considered, such as:

- A reduction in specific knowledge regarding associated with water, wastewater or electricity operation could reduce the effectiveness of operation and maintenance.

Boundary issues also need to be considered with regard to their impact on cost and operational responsiveness. For example, the Horizon Power boundary cuts across the Water Corporation's Mid-West, Agricultural and Goldfields and Great Southern regions (see Figure 8).

Some boundary issues may be easily resolved by establishing agreed rules. For example if a pipeline connects two towns with separate electrical maintenance depots, the required water and sewer maintenance would have to be split at a given point. However, if the rules are not defined carefully then there is a risk that quality of service delivery may suffer near this boundary.

Conclusion

There do appear to be opportunities in the businesses working together to share resources for the maintenance of isolated towns. However, complete amalgamation of the country water business with the Horizon electricity business may only yield a marginal improvement in cost saving. The main test is whether the cost of separation of the centralised water function exceeds the savings in the amalgamation of the maintenance functions.

5.4 Rationalising South West water and wastewater utilities

In light of the key conclusion drawn from the literature review of size and scope economies in water and wastewater supply, it is useful to consider whether efficiency improvements can be realised by facilitating mergers between utilities operating in the South West region. Currently there are three utilities providing water services in the south west region:

- Aqwest provides water supply in Bunbury, except for Dalyellup, Eaton and Australind.
- Busselton Water Board (BWB) provides water supply in the town of Busselton, Port Geographe, Siesta Park and Wonnerup.[55].
- The Water Corporation provides water supply to all other towns.

The Water Corporation provides all of the wastewater services in the South West. The Water Corporation's south west business, which is the largest of the three utilities, has:

- A regional administration office in Bunbury.
- Major operational depots in Mandurah, Bunbury, and Busselton.
- A number of smaller operational depots within the south west region.

Aqwest has a combined administration and operational facility in Bunbury and the BWB has administration and depot facilities in Busselton. In addition, the Water Corporation's South West business is significantly larger than Aqwest and Busselton Water Board both in terms of staff numbers, revenue and customers served. An indication of the absolute and relative scale is provided in Table 17. The volume supplied statistics suggest that all three water suppliers may be within the size economies region, suggesting possible efficiency gains are available by increasing size of operation – though as noted earlier it can be efficient, in a wider market setting, to have entities operating below the point that maximises size economies.

Table 17 **Summary statistics of Aqwest, BWB and the Water Corporation**

	Units	Aqwest	BWB	Water Corporation (South West)
Services	nr	14,097	n.a.	67,095
Connected properties	nr	14,739	9,020	72,838
Length of mains	km	339	236	2,493
Properties per km of mains	prop/km	4,348	n.a.	35.2
Volume supplied	ML/day	16	11.2	69.4

Note: n.a. means "not available"

Data source: Annual reports and ERA web site

55 Busselton Water Board, Annual Report 2005/06, p.7

In relation to cost efficiency, ERA provided the comparable statistics for Aqwest and the Water Corporation's Australind-Eaton operations. These are as follows:

- Operating expenditure per kilolitre (kL) for Aqwest is $0.75 while the Water Corporation is $0.33.
- Gross cost per kL: Aqwest $1.37; Water Corporation $1.00
- Net cost per kL (i.e. excluding special agreement revenue and developer contributions): Aqwest: $1.16; Water Corporation $0.69

These statistics suggest Aqwest is a relatively higher cost operation than the Water Corporation, possibly reflecting Aqwest's relatively higher fixed to total cost due to its small scale.

With regard to potential opportunities for efficiency improvements, Cardno BSD advises that there are areas of duplication in management (both administrative and technical), staff numbers as well as some parts of their respective operations which could be reduced via mergers. In relation to management duplication, Cardno BSD advises that Aqwest and BWB have separate Boards and senior management teams. The relatively small scale of both organisations also means that the ratio of customer service, ratings staff and operations/technical staff to total volume of water produced are relatively high.

Technical aspects incurring potentially unnecessary duplication across the organisations include:

- Water treatment (including water quality, fluoridation, disinfection)
- Hydraulic analysis and planning
- Instrumentation and process control

However, since both organisations are likely to procure these skills on an "as needs basis", a formal audit of both organisations would be required to determine the extent of any potential cost savings.

Other service areas, even if procured from external organisations, may still involve duplication in cost. These involve development of standards, policies, production of annual reports, operating licence audits, asset management effectiveness reviews, board meetings and other administrative tasks, which is essentially duplicative. There may also be significant potential inefficiency in the development of water sources and water treatment facilities.

Specific merger options that may yield greater efficiency are:

1. Combine Aqwest-Water Corporation water operations in the greater Bunbury area and BWB-Water Corporation in Busselton.
2. Create a three-way merger of Aqwest, BWB and Water Corporation's south west business.
3. Busselton Water Board and Aqwest

In relation to Option 1, Aqwest is currently only providing potable water to Bunbury. The neighbouring towns or localities of Eaton, Australind and Dalyellup are provided with potable water by Water Corporation. Water Corporation's assets, groundwater allocations and operating licences for these areas could be transferred to Aqwest.

Busselton Water Board's operating area could be increased by transferring Water Corporation's assets, groundwater allocation and operating licence for Dunsborough to Busselton Water Board.

Option 2, the three-way merger would create one large service stretching across the entire South West region. There would be numerous options for the final boundary of an amalgamated "south west water utility" and it need not necessarily follow the current boundary of the Water Corporation's South West region.

A combined Busselton Water Board and Aqwest (Option 3) would increase the 'critical mass' of both BWB and Aqwest by combining their water-only operations. Alternatively, the combined Aqwest-BWB could assume control of Water Corporation's wastewater operations in Busselton and Bunbury.

In evaluating these options, it must be kept in mind that there appears to be no compelling imperative to change the structure of the water industry in the South West. All operations are perceived to be highly successful and enjoy the confidence of the communities they serve.

However there is much duplication of effort and duplication of facilities between these 3 organisations within the south west area of Western Australia.

Apart from reduction in duplication and its associated cost, important benefits of any of the amalgamation options would include:

- The opportunity to build internal capability to adequately protect water quality and adequately arrange the planning and design of infrastructure while maintaining a policy of outsourcing service where appropriate.
- Enhanced ability to comply with public health standards such as fluoridation.

There are a number of issues which have the potential to detract from modifying the water industry structure in the South West. These include:

- Perceived strong community support for Aqwest and BWB as stand alone operations.
- Possible increase in per customer charges. This would depend crucially on transition costs, overall customer density and utilisation of capital.
- Potential for reduced efficiency through increased size of the administration. However, it would seem that the combined utility would remain within the efficient size range.

Any modification to the water industry within the south west area should look to achieve the following:

- To build on the existing cultures of the water utilities in the south west, particularly within the smaller water utilities of Aqwest and BWB
- Provide a degree of economy of scale to allow increased efficiencies. The size economies would likely be derived from reduced duplication of facilities and effort, particularly within the town sites of Bunbury and Busselton.
- Maintenance of current service standards with a reduced cost structure.
- Improved responsiveness in planning and development of new water sources.
- Reduced risk of non-compliance with water and wastewater levels of service.

Transition costs of effecting reorganisation

A crucial element in the pursuit of improved efficiency is the transition cost of achieving the desired structure. If these costs are significant, then the perceived benefits may be outweighed and society would be better off without change. On this point, we have relatively little evidence. Analysis of Victoria's experience in separating its retail operations into three organisations suggests the costs are small in proportion to the gains. The costs of re-integration may be greater, although there would be choices as to the extent and speed with which the processes and systems of merged entity would need to converge.

Similarly in the UK many of the smaller water only companies have merged, suggesting that the transition costs were modest relative to the expected cost savings. On the other hand, the integration of three Scottish water suppliers into a single (large) entity, Scottish Water, appeared to involve significant transition costs.

Indirect support is provided in Stone and Webster Consultants (2004) study of the cost structure of the UK water and wastewater industry.[56] The study tested the statistical difference in the cost structure of merged and separate entities.

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[56] Stone and Webster Consultants, op. cit. pp. 48-50

They concluded that while the mergers yielded a cost saving, it was small and statistically indistinguishable from zero.

By induction we surmise that, at least for a utility the size of Water Corporation, the reverse of mergers (separation) may be small. This result may not hold for small utilities. Moreover, actual execution depends on local circumstances.

6 Economies of scale in the electricity supply industry

6.1 The drivers of electricity reform

Before 1994 in Australia almost all electricity was supplied through government owned vertically integrated electricity commissions. The electricity commissions were monopoly suppliers in their own states and could legally refuse access to third parties to their networks or their power stations.

The COAG reforms of the late 1980s and early 1990s turned attention to the performance of state-owned entities and the electricity supply industry (ESI) came under close scrutiny.

In 1991 the (then) Industry Commission released a report on the electricity and gas sectors. The report, *Energy Generation and Distribution*, noted that

> The electricity and gas sectors have not been performing to their full potential… Poor investment decisions leading to excess capacity and gross over staffing during the 1980s provide the most striking evidence that electricity and gas have not been supplied at least cost.[57]

The report went on to identify a number of specific inefficiencies in the electricity industry, including the following;[58]

- Capital utilisation, as measured by reserve margins, ranged between 40 and 70% over the mid to late 1980s across Australia, compared with an international benchmark of between 20 and 25%.
- There were substantial disparities between the cost of electricity supply and prices charged, with commercial and industrial consumers paying substantially more than the cost of supply.

The very high reserve margins were causing capacity factors to be generally low, resulting in poor use of capital. New power stations, whether needed or not, were also being completed and brought into the tariff base. The electricity commissions carried none of the risk of poor investment decisions as these costs were passed directly through to consumers.

The report also found a degree of political involvement in tariff setting and investment decision making that tended to increase costs and reduce efficiency.

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[57] Industry Commission, 1991, *Energy Generation and Distribution Volume I*, Commonwealth Government Printer, Canberra

[58] Industry Commission, 1991, *Energy Generation and Distribution Volume II*, Commonwealth Government Printer, Canberra

Residential tariffs rarely represented the full cost of supply while tariffs to industry and commercial users tended to be higher than the costs of supply.

The Industry Commission report recommended corporatisation and structural separation of electricity utilities as well as a network access regime. With the assistance of the financial pressures supporting National Competition Policy, most states managed to implement at least some of these recommendations over the subsequent 5 years. All states structurally separated generation from transmission and distribution (although WA came late to these reforms and the NT has not yet undertaken separation) and an access regime was introduced in the form of the National Electricity Code, which later became the National Electricity Law.

The principles of reform were agreed by the Council of Australian Governments (COAG) in December 1992;

> COAG confirms 'their commitment to the principle of separate generation and transmission elements in the electricity sector'. The work of the NGMC in overseeing the development is noted.[59] (

Subsequently, COAG made a number of significant decisions concerning the industry, including;

- Structural changes to be put in place to allow the competitive market from 1 July 1995.
- Confirming the commitment to an interstate transmission network.
- Confirming the objective of competitive generation.[60]

These reforms were not implemented from a platform of industry-wide consensus. The state electricity commissions in the first half of the 1990s (Pacific Power, the State Electricity Commission of Victoria (SECV), Queensland Electricity Commission and Electricity Trust of South Australia) opposed each of the reforms and brought to bear their considerable resources in doing so. The heads of Pacific Power and SECV gave frequent public addresses referring to the "Balkanisation" of the electricity industry and the severe problems likely to result.

One of the arguments used was that economies of scale would be lost if the industry was disaggregated. In particular, it was argued that the economies of vertical integration would be lost and the electricity industry's highly complex plant scheduling and network control could only be done effectively and safely through a central control room. This control centre needed to be able to control both the network and the output from all the power stations on the

[59] COAG Communiqué, Perth, 7 December 1992

[60] COAG, Communiqué, Melbourne, 8-9 June 1993

system. Without this the system frequency could not be maintained and the industry could not guarantee there would not be load shedding (blackouts).

In proceeding with the disaggregation of the ESI it was necessary to ensure that the efficient management of the physical assets on the electricity network would not be jeopardised. Those managing the reform process at the time (the National Grid Management Council, or NGMC, which reported to COAG) needed to be sure that the close management and real time scheduling of the ESI's assets, both generation and transmission, would continue under a reformed model in a system driven by economic incentives for the dispatch of plant and provided sensible price signals for new investment. It was important that the transaction costs incurred in doing so did not exceed the savings won through the introduction of competitive generation and, eventually, retailing.

6.2 The loss of economies of vertical integration

In the electricity industry the claim most frequently stated, as is frequently claimed now for the water industry, was that there were significant economies of vertical integration present in the integrated electricity commissions. The main sources of economies of vertical integration in the electricity sector arise because of important technical interdependencies between stages and the fact that there are transaction costs that could be significant in a disaggregated market structure. Technically, an electricity supply system needs to function as a whole, allowing changes in levels of demand to be met in real time by changes in generation and coordination in the management of the transmission and distribution networks. If the owners of one part of an electricity system did not take into account the effects of their actions on others then significant externalities in the form of technical problems would arise, probably making large electricity networks technically unviable.

In a competitive ESI the physical management of the industry's assets is carried out by an independent market operator. In the case of the NEM this is the National Electricity Market Management Company (NEMMCO). NEMMCO is a not-for-profit independent company whose main role is to manage the electricity market and schedule generators. NEMMCO manages the dispatch of power stations to meet instantaneous demand using the price-quantity offers each unit has lodged. Units are "dispatched" (there generation output is accepted onto the network) according to a least cost algorithm that dispatches the whole of the NEM while minimising the total cost of generation and ancillary services within the constraints of the transmission network.

Separating this function away from a vertically integrated ESI has brought about some significant non price benefits. The algorithm used for plant dispatch is now transparent and all market participants (and governments and other interested parties) can see how it operates. NEMMCO has no assets of its own and remains independent from all the market participants. NEMMCO independently contracts for system support and ancillary services and these now tend to be undertaken at much lower cost than was incurred previously.

It appears highly unlikely that the most obvious transaction cost associated with this approach, which is NEMMCO's annual operating budget, is higher than the cost of plant scheduling as it was previously undertaken by the electricity commissions. The expenditure by the electricity commissions on this activity is aggregated in with their many other activities and cannot be separately identified. However, costs to consumers for this activity are currently relatively low and it is difficult to believe that they would exceed the costs of plant scheduling of the 5 electricity commissions whose areas now comprise the NEM. NEMMCO's annual budget is currently about $83 million and is collected by levies from market participants and overseen by the Australian Energy Regulator. The fee comprises less than 1% of the wholesale value of energy sold through the market to final consumers. In 2007-08 it will amount to about 0.85% of the $9 to $10 billion worth of wholesale electricity it will manage.

Since it was formed it has also been the logical home for a number of other roles which are now seen as much better carried out by a body which is independent of any market participant. These additional roles include an annual study into the adequacy of the transmission system, the development of systems for the introduction of full retail contestability, the annual Statement of Opportunities and ensuring system security by contracting for reserve if necessary. There appear to be significant governance and efficiency benefits in separating these roles. For example, it is now very difficult to envisage the annual transmission study, which is a major undertaking and must balance off new regulated investments in transmission and commercial investments in new generation, being done by any other body but one that is completely independent of both generators and transmission companies. .

6.3 Electricity reform in other parts of the world

One of the important studies undertaken during the mid 1990s was by Joskow[61], who developed a set of conditions concerning the technology of a typical ESI and its underlying cost structure which could be tested in empirical studies. These conditions can be summarised as follows;

4. In the generation stage, there is an exhaustion of scale economies related to market size, making competition among generators possible.

[61] Joskow, P.L., 1996. *Introducing Competition into Regulated Network Industries: from Hierarchies to Markets in Electricity*. MIT Press, Cambridge.

5. There are no major economies of vertical integration between stages, that is, integration does not lead to significant cost savings, so these can be offset by improvements in efficiency arising from market competition.
6. The network characteristics of transmission and distribution make these activities a natural monopoly and they should continue to be regulated. These activities are the key component for competition as they must guarantee access to the network without any form of discrimination. Additionally, transmission must ensure the physical balance of the system and reliability of supply.
7. Metering, billing and retailing can be separated from distribution. These activities do not have the characteristics of natural monopoly and their deregulation can be one way of passing on efficiency gains arising from competition in generation to the final consumer.

Since the introduction of electricity industry reform and disaggregation of the industry's vertically integrated monopolies in jurisdictions around the world, a number of other studies have been undertaken on the loss of economies of scale. Most have used cost functions to attempt to test whether scale economies exist and whether the loss of the economies of vertical integration cause a significant increase in costs. A study undertaken by Ramos-Real[62] reviewed a number of studies aimed at developing cost functions and testing for subadditivity to determine whether natural monopoly characteristics were present.

The following conclusions were able to be drawn from this review of industry studies:

1. Competition is possible in generation because economies of scale are exhausted for moderate size firms.
2. There would be efficiency losses if individual customers were served by more than one utility. This implies that transmission and distribution grids are natural monopolies and it would not make sense to duplicate them.
3. The multiproduct framework provides the opportunity for a fuller analysis of economies of vertical integration in the electric utility. The works that have been done in the context of the traditional integrated model mainly suggest the existence of economies of vertical integration.
4. From the works that have evaluated savings arising from the reform and disaggregation process, improvements are observed in rectifying allocative inefficiencies observed in the framework of traditional regulation, along with technical inefficiencies that could be corrected on introducing competition. Improvements in productivity have been observed in many cases after reforms have been implemented.

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[62] Ramos-Real F.J., *Cost functions and the electric utility industry. A contribution to the debate on deregulation.* Energy Policy 33 (2005) 69-87.

5. Certain problems in the way electricity markets work have made it difficult in some cases to pass on all productivity gains to prices for final consumers.

These results confirmed the initial arguments in favour of disaggregation and industry reform. Although on the difficult question of the savings arising from economies of vertical integration the study was not able to be unequivocal. The existence of economies of vertical integration is not incompatible with vertical disaggregation of the sector as long as the market allows for effective competition. The costs of disaggregation mainly arise from powerful technical interdependencies between the different stages of supply. In the competitive model, the problem of technical interdependencies can be resolved with an independent system operator in the transmission stage that has certain authority over individual producers as well as over the network. The independent system operator usually charges a levy on market participants in order to cover the costs of its market management role. In Australia's case, as we have noted above, this cost is small compared to the current average wholesale price of electricity and small compared to the reductions in wholesale prices following the commencement of the market.

One of the important studies on the effects of electricity industry disaggregation and reform was undertaken by the OECD and published in 2000[63]. In this paper one of the primary empirical findings is that the unbundling of generation and transmission, expansion of third party access, and introduction of electricity markets reduces both industrial end-user electricity prices and the ratio of industrial to residential prices. The unbundling of generation and transmission and the private ownership of generation each serve to improve the utilisation of capacity in electricity generators.

In cases where the benefits of reform had been marginal it was found that there were usually faults either in the market design or in the market structure. These faults are important and can prevent the benefits of a major reform program being realised. Examples of a fault in the market design might be the case of California or Peru.

In California the wholesale market was designed so that the ability of generators to contract with retailers was limited and their exposure to spot price outcomes was very high. When this was combined with a poor market structure (there were only 3 large generators) and a shortage of capacity after hydro failed and no new building had been allowed for some years, wholesale prices reached very high levels. Retailers were selling their energy at regulated prices and, being caught between an unregulated and very high priced

[63] Steiner F., 2000. *Regulation, industry structure and performance in the Electricity Supply Industry*. OECD Economics Department, Working Paper no 238

wholesale market and a regulated low price retail market, a number of them were forced to file for bankruptcy.

In Peru the market was established under a number of restrictions on what generators were allowed to bid. Each power station is only allowed to bid their marginal costs and these costs are subject to audit by the market regulator. New entrants are tightly controlled by the regulator and only allowed to enter when the regulator believes new capacity is needed and in the sequence decided by the regulator. These rules were designed to limit price volatility and achieve a better match between supply and demand. In fact they have achieved the opposite. Market prices in Peru are highly volatile and rarely relate to supply and demand fundamentals. Being denied any flexibility in price setting and no ability to increase prices in a scarcity situation, generators tend to create their own scarcity. The level of forced outage is very high and generators appear to be using outages to constantly game the system to increase prices. New entry plans, which need to be given a stamp of approval by the regulator, are repeatedly changed. Periods which were supposed to be operated under an adequate reserve margin become tight supply periods as new entrants suddenly put back their plant commissioning by 6 to 12 months, allowing their existing plant to enjoy higher prices.

The original England/Wales market introduced in about 1990 also proved a failure in some respects. The market mechanism was recognised as sophisticated and transparent way of running a market, which, under competitive conditions, would produce efficient prices. In many of the countries that used the England/Wales model as a basis for their own pool design (Australia, New Zealand, Singapore) this turned out to be the case. In England/Wales, however, the market was largely a failure because of poor market structure; two generators, Powergen and National Power, dominated the market and could set prices wherever they pleased. Prices stayed above long run marginal cost for most of the 1990s as these two generators produced significant rent for themselves and any other generators lucky enough to be in the market and getting a free ride on their price setting approach.

Undertaking electricity market reform does not automatically result in lower prices and more efficient use of capital. The outcome can and has been worse than the vertically integrated structure it replaces, highlighting the importance of good market design, good governance of market institutions and competitive market structure.

6.4 Competition at the retail level

Electricity reform has more recently moved on to the retail market and the development of retail competition, termed Full Retail Contestability (FRC) in the Australian context.

Electricity distribution (the ownership and management of the wires and poles used to distribute electricity to final consumers) is generally viewed as a natural monopoly and consideration has been given to the extent to which existing distribution companies should be disaggregated or privatised ones allowed to amalgamate.

Mergers among distribution companies and efforts at retail competition have nonetheless altered the operation of the distribution stage. One of the more recent and most useful studies in this area was undertaken by Kwoka[64] The research looked at US electric utilities and used a much larger data base than had been previously available to examine the scale properties of distribution with respect to output, distance, customer numbers and for different functions within distribution. It found significant economies at low output levels, holding system size and customer density constant, but the cost gradient estimated was modest. It also found that geographic size and customer numbers are important and that economies are significantly stronger for the infrastructure or "wires and poles" business than for the marketing function performed by distribution utilities.

These results support the approach taken in FRC whereby the distribution system is seen as a natural monopoly network and an access regime allows retail competition. It is less supportive of the benefits of merging distribution networks, indicating that the particular characteristics of each (in terms of size, customer numbers and density) would need to be addressed before an estimate of benefits might be made.

6.5 Conclusions

Reviewing the above for conclusions that will be useful in the restructuring of the water industry, the following have been brought together.

- A simple decision to reform the ESI has not necessarily resulted in improvements in efficiency, a lowering of prices or improvements in dynamic efficiency. The market mechanism must be developed with great care and the market structure (the number of competing generators) must be appropriate. A poor market mechanism and an uncompetitive structure will almost certainly give worse outcomes than the pre-reform situation.

[64] John E. Kwoka, *Electric power distribution: economies of scale, mergers, and restructuring.* Applied Economics, 2005, vol. 37, issue 20, pages 2373-2386

On the other hand, a well designed and competitive market can provide considerable price and service benefits for consumers.

- In the Australian NEM the main benefits of reform have included significant reductions in wholesale prices, lower industrial and commercial prices and lower prices for domestic consumers in recent years as FRC has helped to develop a competitive retail market able to pass on gains from a highly competitive wholesale market.
- The other main gain has been the much more efficient and disciplined investment process in new plant, resulting in lower reserve margins and higher capacity factors for existing power stations. Investors in new generation are not now able to pass on most of their risks to consumers. Power stations that have been privatised have in nearly all cases been refurbished and their capacity upgraded from pre NEM levels, making better use of existing capital stock.
- Transmission and distribution have been left as natural monopolies with access arrangements in place in nearly all reformed electricity industries. However, they have been left with the functions to operate and invest in their networks but neither planning nor system control. In nearly all cases these are undertaken by independent bodies who do not own any assets.
- Economies of vertical integration existed in the electricity industry as vertically integrated electricity commissions undertook new investment, operated both power stations and the transmission network and scheduled these assets to meet demand. However, it now appears that the transaction costs in separating out this function are not significant. In the case of the NEM, they appear to be lower by an order of magnitude than the wholesale price reductions experienced shortly after the NEM commenced.
- Other benefits are available from having an independent operator undertake close management of system assets and the network. The way the system is managed becomes much more transparent, allowing potential new investors to make better decisions about how assets are likely to be used and which assets would make the best new investments in coming years. Additions to the network, which the network owner will be able to include in their rate base, should be considered by the independent system operator from its system perspective.

For the water sector there are some useful messages. Firstly, the benefits of reform will not only materialise in the form of lower prices. More efficient use of existing capital, more transparent and objective planning for the future, more transparent system operation and a more objective and independent procurement process may be possible. Of course, one of the major conclusions is that the benefits depend very much on the design of the new system, the governance of new market institutions and, in cases where a competitive market price setting process is needed, the number of players in the market and competitive structure.

7 Lessons from the gas sector

7.1 Background

Historically, the gas market in Australia was dominated by state-based structures in which monopolies operated in all sectors of the value chain. The monopoly entities were a mixture of government owned and private utilities. In New South Wales, for example, the privately owned Australian Gas Light Company (AGL) controlled the retail market, the distribution system and the only transmission pipeline system from the Cooper Basin. In Victoria, South Australia and Western Australia transmission, distribution and retailing were controlled by state-owned utilities.

During the 1990s structural reforms were introduced to encourage a more competitive market on a nationwide basis. A third party access regime for natural gas was developed by the Council of Australian Governments in 1994, and a National Third Party Access Code based largely on the COAG regime was signed by the Commonwealth Government in 1997. Competition principles were established through the Commonwealth *Competition Policy Reform Act* of 1995 and various related agreements among the states. Key principles adopted at the national level include the following:

- Interstate access by producer and consumers
- Right of access on reasonable terms and conditions
- Establishment of reference tariffs
- Public access to information on tariff methodology
- Ring fencing of transmission, distribution and marketing entities and elimination of competitive advantages to state-owned businesses
- Establishment and empowerment of independent regulators
- Introduction of retail contestability.

The reform principles established in Australia have included the sorts of changes typical in liberalisation of gas markets around the world. Individual state governments have implemented these principles in their own legislation. The government-owned entities have been privatised or corporatised, and to varying degrees disaggregated. Competitive responses to the changes have to some extent emerged in all sectors of the business.

Nevertheless, gas markets in Australia have not been transformed into fully competitive commodity markets along the lines of the markets in the U.S. or the U.K. The market in Australia has some of the features necessary for the development of a commodity market. Market reform has provided open access to pipeline transmission and distribution systems and opened the door to new retail market participants and more direct contracting between producers and large end-users. The number of major retailers is still relatively small, but there is now a sufficient number of buyers to support a more competitive market.

The transmission pipeline system in Australia is in a process of evolution from single purpose "point to point" pipelines, which tended to have different ownership and different operating specifications, to an interconnected network which will provide greater access to all of the major market centres from the existing producing basins and potential future supply sources. New pipelines connecting the Cooper Basin to Victoria and the Gippsland Basin to New South Wales were completed in 1998 and 2000 respectively, and more recently pipeline connections between Victoria and Tasmania and between Victoria and South Australia have been built.

The Eastern Australian market has historically relied on two sources of natural gas for over 90% of its supply. The Esso/BHP joint venture in the Gippsland Basin offshore Victoria provided almost all of the gas supply to the Victorian market and a small portion of the supply to the NSW market. The rest of the gas supply to NSW and all of the South Australia supply came from Santos-operated fields in the Cooper/Eromanga Basin in the north east of South Australia and southwest Queensland.

More recently, there has been considerable diversification of supply in Eastern Australia, with the establishment of new supply sources in the East Gippsland, Otway and Bass Basins, and rapid growth of coal seam gas (CSG) production in Queensland and, to a lesser extent, New South Wales. However these new projects have also gone ahead on the basis of long-term take-or-pay contracts – a prerequisite for the major capital investment in production and transportation infrastructure needed to bring these new supply sources into play.

In Western Australia, most gas supply comes from the North West Shelf project in the Carnarvon Basin (primarily an LNG producer but also the main source of gas for the domestic market). Additional supply comes from other producers in the Carnarvon Basin, and from the onshore Perth Basin, but the NWS producers continue to dominate the domestic market.

Existing gas supply arrangements throughout Australia are predominantly long-term contracts, generally with take-or-pay provisions and prices indexed to inflation, with periodic price reviews. As is typical of gas contracting practice in less mature markets around the world, prices in these contracts are negotiated to levels that provide acceptable returns to producers while meeting the competitive requirements of buyers.

Short-term markets have not yet developed to a significant degree. There is an 'on system' market in Victoria operated by the independent market operator, VENCorp. The VENCorp market is intended primarily as a mechanism for daily market-based scheduling and balancing. Since most of the gas traded in this market is purchased under long-term contracts from the Esso/BHPB joint venture, the market generally trades at prices very close to these contract prices.

In recent times, the Victorian market has shown some price diversity as more alternative production has entered the market, but with one dominant producer whose contracts typically give buyers reasonable flexibility in their off-take requirements, there is little possibility of a significant surplus developing and driving prices down, even temporarily. On the other hand, upward spikes do occur during peak demand periods when the system becomes constrained by limited production capacity and transmission network factors.

7.2 Lessons for water

Currently, with the exception of Victoria, the market operates strictly as a bilateral contract market where information on price and volumes traded is rarely disclosed. There are plans to introduce a short term market to cater for contract imbalances and shortages but this is taking some time. The fact that a short term market has not developed outside of the managed version in Victoria may be an indicator that the participants do not see a need for a spot market.

There are some similarities between the provision of water and gas that make the comparison useful. The number of sources of supply for each major city in Australia is similar (usually between 1 and 4 for gas) and one or more longer trunk pipelines are required to bring gas to a "city gate" where the pressure is reduced and gas enters a local reticulation system The well head cost of the gas in the final price to consumers can be fairly low, usually less than 20% for domestic and small commercial consumers but much more for larger consumers who take high pressure gas direct from a mains trunk pipeline or high pressure lateral.

Despite the physical similarities, the organisation of the two industries is now quite different. It is now quite common in most of Australia for the gas producer, the pipeliner, the reticulator and the retailer to be different companies. The natural monopoly elements, such as the pipeline and the reticulation network, are usually covered by an access code but in a number of cases, where the National Competition Council has judged that alternative infrastructure exists, pipelines are uncovered.

As with water, the industry must be managed within a number of technical constraints. The pressure in both the trunk pipelines and the reticulation system must be maintained if gas is to keep flowing, so communication is needed between gas producers, pipeliners and reticulators. Gas is also placed into storage at various parts of the system in readiness for seasonal peaks.

These activities are managed by different companies under gas supply and shipping contracts which set out the obligations of each of the parties in the supply chain. There is no industry pressure for vertical integration so that the infrastructure can be better managed. Integration, when it occurs, appears to take place for commercial reasons. The returns at each step of the supply chain tend to be somewhat different and they consequently attract different types of companies with different appetites for risk. However, companies appear at times to find it useful to own at a strategic part of their upstream or downstream counterparts. This appears to help them manage their risks of either acquiring and transporting sufficient gas to meet their market or else placing the gas they have into the market.

There are no major transaction costs in managing the gas supply network or in scheduling contracts. Except in Victoria, where the role is undertaken by VENcorp, there is no major role involving system planning and procurement. It is up to retailers to source the supplies of gas they will need to meet their demand and to ensure they can ship it from the gas field to the consumer. Those involved at each step of the production chain make decisions about the adequacy of their production capacity to meet the contracts they enter into.

Differences from water are important also. Gas demand can be volatile, and certainly exhibits seasonal variation – but the sustained volatility in supply-demand balance that has long been a characteristic of water as a result of occasional extreme and prolonged droughts is not generally present. The relative immaturity of spot market activity – and limited demand to develop such markets – is evidence of this. This is in stark contrast to the active use of restrictions in water as an alternative to spot market activities to deal with volatility in the supply-demand balance.

In many ways the gas industry is fortunate in not being viewed in its initial development years as an essential service. Upstream gas fields have been developed on a commercial and opportunistic basis. Investments have been made in gas pipelines often initially involving governments but later sold to the private sector. The industry has also evolved without being required to serve all who want gas. There are many small communities where gas supply has been judged to be uneconomic and the investment has not been made. This, of course, has not been an option in the case of water.

Nevertheless, there are some useful lessons, particularly in the complete lack of concern regarding so-called economies of vertical integration. The industry also demonstrates the ability to manage and plan a fairly complex supply chain without a central control, planning or procurement role.

There appear to be relatively few concerns as to the level of transaction costs, efficiency of operation and investment in this setting – and some support for the view that system size economies have been accessed with a much less aggregated system than is typical of water – and, historically, of electricity.

8 Water Corporation: structure of activities and costs

Water Corporation's key services comprise potable water supplies, sewerage and drainage services and irrigation supplies. The provision of potable water and irrigation supplies involves the activities of resources, treatment and distribution. For sewerage and drainage services, the relevant functions are collection, treatment and disposal. In addition, there are activities of customer service (billings and enquiries/complaints), scientific services and other business activities.

8.1 Description of activities and associated structure of costs

Water resources

Description

In the Perth metropolitan area, Water Corporation operates the integrated water supply system (IWSS). A majority of Perth's water is sourced from groundwater: 52% of gross output in 2005/6 was sourced from groundwater, 44% from dams and 5% from other hills sources. With the completion of the Kwinana desalination plant, an additional 45 GL pa of supply is being made available (representing an additional 17% of input into the IWSS). A second desalination plant at Binningup is planned to provide the capacity for a further 50GL pa. Water Corporation operates these different sources conjunctively.

Operating costs for dam sources are relatively low. Future maintenance costs may be significant, given the dam safety requirements identified by Water Corporation (although much of this expenditure is capital in nature). Maintenance costs will tend to be fixed in nature, relating to the age of assets rather than volumes supplied.

The extraction of groundwater involves pumping costs, which will depend on the depth of the aquifer and the volumes extracted. Operation of desalination plant involves significantly higher operating costs, particularly in terms of power, and these costs will be directly related to volumes supplied. Desalination maintenance costs will comprise a mixture of fixed and variable elements.

An individual source will generally experience economies of scale with respect to volume. Thus large dams will generally involve a lower cost per volume of capacity than smaller dams. However, lumpiness in capacity serves to raise the total cost involved in supply, due to mismatches between demand and supply. The cost of constructing a new dam will generally be higher than previous dams, since the best sites will have been used first, implying that over the long term dam-based resources are subject to diseconomies of scale.

New "water factory" technologies have enabled water suppliers to diversify sources away from traditional dam and groundwater sources, both of which are climate dependent (albeit with long lags in the case of groundwater). Increased use of such technologies might be expected to increase the extent of economies of scope between water resources and treatment – given the similarity of the technologies and ability to share technical skills. Economies of scale are likely to be similar to those involved in water treatment –discussed further below.

The use of different sources will carry implications for the level of costs incurred in other parts of the supply chain. In particular, groundwater is generally of higher quality than surface water sources, and hence requires minimal treatment. However groundwater pumping costs (to link into the IWSS) will be higher than dam based sources, which can rely on gravity to feed supply. In addition there are trade-offs between expenditure on resources/treatment and distribution, whereby additional expenditure on leakage control can delay the need for resource augmentation.

The procurement of new water sources by Water Corporation is undertaken through a centralised, whole-of system, planning framework which seeks to identify the least cost investment and timing required to meet an acceptable level of water restrictions given forecasts of hydrological inflows and demand.

Implication for economies of scale and scope

The operation and maintenance of several sources (as compared to a single source) is likely to involve some economies of scale. However, the contracting out of operation and maintenance activities might be expected to minimise the extent of any diseconomies involved in disaggregating ownership of sources.

The complexity of water resource planning, and the issues that need to be addressed regarding uncertainty and the flexibility of the system to adapt to new information on future inflows, suggest that a centralised approach may be required for augmentation planning at least for the time being. Continuation of centralised planning would not preclude competitive procurement of new supplies, as proposed by Water Corporation (or by the Department of Water or designated planning body).

The operation and maintenance of water sources is a distinct activity that is unlikely to share expertise or staffing with other elements of the supply chain and/or other services such as sewerage. However, the interaction between sources and treatment and distribution costs suggests that there may be some loss of economies of scope should the resource activity be separated from treatment and distribution activities.

Water treatment

Description

Operating costs for water treatment plant depend on the volume of water treated and the standard of treatment. More complex levels of treatment can cost significantly more to deliver a given volume of water. Higher standards may be required as a result of the type of water source and/or higher drinking water quality standards.

Given Water Corporation's heavy use of relatively high quality groundwater sources, the majority of treatment plants involve low levels of treatment. Thus out of 31 plants, 22 provide disinfection only, 3 provide some further treatment and 6 undertake full treatment. Currently Water Corporation is up-grading the water treatment facilities in Perth and at a number of regional towns, including desalination facilities to improve water quality in the Murchison and Goldfields.

Implication for economies of scale and scope

Complex treatment facilities are thought to involve economies of scale with respect to plant size (in terms of volumes treated)[65]. The economies of scale applying to less complex treatment plant may be less extensive. Whether there are economies of scale in terms of operating a number of treatment plants (to serve different population centres) is less clear. Unpublished work undertaken for OFWAT[66] suggests that technical economies of scale are exhausted at about 400,000 connected properties.

Water Corporation has over double that number of connected properties, suggesting that it is well beyond the scale that size at which technical economies of scale are exhausted. Nearly 600,000 connected water properties are within Perth, with the other regions having well under 100,000 connected water properties each. If the Perth region were to be split into two suppliers (each serving just under 300,000 properties) on this basis it probably involve only minimal loss of economies of scale – although this would be heavily dependent on the geographic configuration of the resultant suppliers and the spread of key assets between them.

Based on the literature, breaking water corporation up along regional lines could in theory result in diseconomies of scale in the regions. However it is not clear to what extent the current configuration of regional supply enables economies of scale to be realised in the first place.

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65 IPART, Sept 2007, Literature Review, underlying costs and industry structures of metropolitan water industries, p19

66 Cited in Stone and Webster Consultants, 2004, p24, 2002 report by Strategic Management Consultants.

Water Distribution

Description

Distribution activities include the construction, operation and maintenance of trunk water mains and distribution pipes. In Australia, local reticulation mains are generally built by the developer, and then handed to Water Corporation to be maintained.

The cost of building the distribution system depends on the length of mains, topology (which influences the need for pumping stations), the volume of peak hour demand and requirements for firefighting (both of which influence the sizing of capacity of local mains). Density is a major influence on the relative cost of distribution services – both in terms of assets required and operating and maintenance costs. The rate of growth in new developments also contributes to infrastructure requirements.

Operating and maintenance costs are influenced by topology (with hilly terrain requiring more pumping), service standards (which can influence asset renewal policies), and geology and weather conditions (as non uniform ground movement leads to increased bursts and leaks).

Table 18 shows the number of properties served by Water Corporation, broken down by region.

Table 18 **Number of water properties, Water Corporation**

	total connected water properties
Goldfields and Agricultural	43,984
Great Southern	30,401
Mid-West	31,192
North-West	21,454
South-West	67,095
Total Perth	579,602
Total Water Corporation	773,728

Data source: NWI, 2007, National Performance Report 2005/6.

Implication for economies of scale and scope

The distribution system is generally acknowledged to be a natural monopoly. Given the high cost of building distribution capacity, distributions system are built with significant excess capacity, implying economies of scale over the short and medium term. Such systems are uneconomic to duplicate, giving rise to increased interest in the establishment of open access to distribution systems in the Australia (and an established access regime in the UK).

However as demand continues to increase, and as distribution systems increase in length and hence volumes carried in central locations, bottlenecks arise which require remedial work to increase main capacity. Such work is very expensive, and is likely to contribute to the observation that large water distribution system are subject to diseconomies of scale.

Sewage collection

Description

Sewage collection involves the removal of wastewater flows through local and trunk mains for treatment at sewerage treatment plant. In WA, developers generally build the local sewerage reticulation system, which when complete is handed to Water Corporation for operation and maintenance.

Water Corporation provides drainage services to around one third of the Perth area, plus some areas within the Great Southern and South West regions. This involves the removal of stormwater and excess groundwater.

Table 19 **Number of sewerage properties, Water Corporation**

	total connected wastewater properties	Drainage properties serviced
Goldfields and Agricultural	11,844	
Great Southern	16,521	Na
Mid-West	13,437	
North-West	22,905	
South-West	61,448	Na
Total Perth	584,730	319,900
Total Water Corporation	710,885	319,900

Water Corporation Annual Report 2005/6.

The sizing of sewer capacity is based on annual average and peak foul flows. However infiltration and (in some systems) combined drains mean that peak wet weather flows also influence required sewer capacity. Distance, soil type and topography also influence the total cost of installing sewer and drainage systems.

Operating and maintenance costs are influenced by pollution load (with higher loads imposing greater damage on pipes). Hilly terrain may require pumping. Asset age is also a driver of condition, influencing maintenance spend.

Implications for economies of scale and scope

The issues regarding economies of scale and scope for sewerage are likely to be similar to those for water. The high cost of developing the sewer and drainage networks mean that there are significant economies of scale in the short and medium term (ie with respect to the use of existing capacity).

However, due to greater reliance on gravity within the system, sewerage treatment plant is often relatively local to the properties served. This means that sewer systems tend to cover smaller geographic areas than water distribution systems and hence may exhaust economies of scale more quickly.

Sewage treatment and sludge treatment and disposal

Description

The key drivers of sewage treatment plant are volumes (including stormwater flows) and pollution loads. Treated wastewater is released through ocean outfalls, or in some case re-used in horticulture and recreational irrigation. Treatment can be to primary, secondary or tertiary levels, with requirements typically depending on the receiving waters.

Table 20 shows the number of sewerage treatment plant operated by WC.

Table 20 **Number of treatment plant – UK versus WC**

Water Corporation	
	Number of treatment plant
Goldfields and Agricultural	19
Great Southern	15
Mid-West	18
North-West	15
South-West	25
Total Perth	9
Total	101

Data source: Water Corporation annual report 2005/6

Perth has three major treatment plants, so that treatment is relatively centralised.

Sludge treatment and disposal involves the extraction of bio-solids for disposal. Disposal is typically via land fill or further processing into compost.

Implications for economies of scale and scope

Economies of scale arise with respect to the scale of an individual treatment plant, however technological advances indicate that these economies of plant scale are diminishing[67]. In addition, large treatment plants involve transporting the sewage further for treatment, suggesting that as with water, there are potential trade-offs and economies of scope between treatment and distribution within the sewerage service.

Importantly, the increased introduction of water recycling creates the potential for further synergies and economies of scope between water and sewerage. Such economies may arise through the ability to delay an expensive water augmentation through increased recycling, and/or the ability to avoid additional sewerage treatment requirements that might follow from increased discharge standards. Any introduction of indirect potable re-use would significantly increase the size of such economies of scope.

[67] Tasman Asia Pacific, Sep 1997, third party access in the water industry – an assessment of the extent to which services provided by water facilities meet the criteria for declaration of access.

The extent to which such economies of scope would be lost should water and sewerage services be separated is not clear. In theory contractual arrangements could be put in place to enable recycling. However, planning for an integrated water cycle would become more difficult. In addition, any arrangements for third party access (for example to sewers) would need to be effective.

Customer service

Billing services are often quoted as an activity subject to economies of scale, and scope in terms of joint billing of water and sewerage. Economies of scale would seem likely, with the use of a billing system able to handle increased numbers of customers relatively easily.

In England, a number of water only companies provide water services alongside a WASC supplier of sewerage services. Billing is done jointly, with the water only company contracted to include sewerage on the bills sent to customers. In this manner, the loss of economies of scope through separate provision of services is minimised.

Much of the cost involved in customer service is involved in answering and responding to customer queries. The ability to contract call centre services suggests that disaggregation of the industry would involve only minimal loss of economies of scale. Technical responses to service problems are unlikely to involve significant economies of scale and scope, as the work load will relate to the number of customers (and possibly the age of infrastructure).

Organisational capacity

Finally, a number of studies have suggested that diseconomies of scale can arise in organisational management[68].

[68] Noll, Shirley and Cowan, June 200, Reforming urban water systems in developing countries.

A Overview of reviewed literature

Study	Size economies (Y/N)	Economies of scope (Y/N)	Data	Country	Dependent variable	Functional form/model	Outputs	Estimation method	Scale elasticity	Controls
Ashton (2003)	N	NA	Pooled, 20 firms, 1991-96	UK	Variable cost	Translog	Single product, water volume supplied to households	GLS, SUR estimator	0.9633 (Statistically significant scale diseconomies)	Total number of households divided by the total length of water mains
Fabbri and Fraquelli (2000)	Y (at small volumes of water delivered)	NA	Cross section of 173 Italian water companies in 1991	Italy	Total cost	Translog	Water volume supplied	seemingly unrelated regressions (SUR)	Scale elasticity = 0.99 at mean	Number of customers, density proxy as ratio of population served and the length of water pipe lines, cost of water inputs purchased, treatment costs as a percentage of total costs
Fraquelli and Giandrone (2003)	Y (for smaller plants)	Y (through vertical integration)	103 wastewater treatment plants in Italy in 1996	Italy	Total cost	Cobb-Douglas	Volume of wastewater treated	Restricted least squares	Scale elasticity >1 (for smaller structures)	Technical dummy variables, quality characteristics
Fraquelli and Moiso (2005)	Y (up to 62,000 ML per day) N for larger volumes	NA	18 utilities over 30 years, 407 observations	Italy	Total cost	Translog	Single product, water volume supplied	MLE	2.18 (25,000 ML/day), 1.12 (62,000 ML/day), 0.65 (250,000 ML/day)	Network length, level of losses, and time trend denoting technological progress
Garcia, Moreaux and Reynaud (2004)	Y	Y (scope economies between distribution and wholesale for small utilities)	Pooled, 171 vertically integrated firms, 17 non-vertically integrated water production firms & 16 non-	USA	Variable cost	Translog	Multi product, water delivered to consumers and water sold to distribution companies	GMM	1.04 to 1.55 for vertically integrated water utilities	Customer density, capacity and power

Study	Size economies (Y/N)	Economies of scope (Y/N)	Data	Country	Dependent variable	Functional form/model	Outputs	Estimation method	Scale elasticity	Controls
			vertically integrated distribution firms							
Garcia and Thomas (2001)	N	Y (scope economies between delivered water and leaks)	Pooled, 55 firms 1995-97	France	Variable cost	Translog	Multi product, water delivered to consumers and water lost due to leaks	GMM	Statistically indistinguishable from 1	Customer density, capacity, power, number of municipalities provided, leaks
Hayes (1987)	NA	Y (but fall over time for larger firms)	475 water utilities (1960, 1970 and 1976)	US	Total cost	Generalised quadratic	Wholesale and residential water supplied	OLS	Economies of scope > 0	None stated
Hunt and Lynk (1995)	NA	Y (cost complementarities between water supply and environmental services) N (no economies of scope between water and wastewater. and environmental services)	10 RWAs (1979/80 to 1987/88)	UK	Total cost	Dynamic specification with interaction terms	Multi product, water supplied, wastewater treated and environmental services	OLS	Economies of scope < 0	Serial correlation and technological change
Kim and Clarke (1988)	N (on average), Y for small utilities	Y	Cross section,60 firms, 1973	US	Total cost	Translog	Multi product, Residential and Non residential water supplied	MLE	Small 1.64, Average 0.99, Large 0.88	Service distance, capacity utilisation
Kim and Lee (1998)	Y (at the average firm size and for 12	NA	Data from 1989 to 1995 for 42 municipal	South Korea	Total cost	Translog	Total water supplied	Seemingly unrelated regressions (SUR)	Average ranges from 1.24 to 1.26 (1989 to 1994)	Worker and population density

Study	Size economies (Y/N)	Economies of scope (Y/N)	Data	Country	Dependent variable	Functional form/model	Outputs	Estimation method	Scale elasticity	Controls
	firms) N (four showed diseconomies of scale and 12 showed constant size economies)		water firms							
Martins, Coelho and Fortunato (2006)	Y (for small and average production scales), N (for large utilities)	Y (for small and average utilities)	218 utilities, cross section 2002	Portugal	Total cost	Quadratic	Multi product, Residential and Non residential water supplied	OLS	Small 2.21, Average 1.23, Large 0.94 (Economies of Scope: small and average > 0, Large <0)	Network length, customer density (ratio of number of connections by squared kilometres), Proportion of water acquired from other utilities, dummy variables for corporate management and if subject to regulation
Mizutani and Urakami (2001)	N	NA	112 water supply organisations for the year 1994	Japan	Total cost	Translog	Water volume supplied	seemingly unrelated regressions (SUR)	Diseconomies of scale at the sample mean (not large)	Network density, utilisation rate, Quality measures
Nauges and van den Berg (2007)	Y (for Moldova, Colombia and Vietnam)	NA	27 Brazilian and 41 Moldovan utilities between 1996 and 2004, 228 Colombian utilities surveyed in 2003 and 2004, 67 Vietnamese utilities covering period from	Brazil, Colombia, Moldova and Vietnam	Total cost	Translog	Multiproduct, Total water supplied and wastewater collected	seemingly unrelated regressions (SUR)	Moldova 1.26, Vietnam 1.16, Colombia 1.11, Brazil 0.99	Length of water distribution network, average duration of supply, total volume sold over total volume produced, percentage of metered connections, number of towns serviced by the utility, number of pipe breaks that occurred, total population served,

Study	Size economies (Y/N)	Economies of scope (Y/N)	Data	Country	Dependent variable	Functional form/model	Outputs	Estimation method	Scale elasticity	Controls
			1997 to 2000							proportion of water volume sold to residential customers
Saal and Parker (2001)	N	Y (due to quality)	10 privatised companies over the period 1985-89	UK	Total cost	Translog	Multiproduct, Total water supplied and wastewater collected	Not stated	Scale elasticity = 0.83 to 0.88	Water quality, Time
Saal and Parker (2005)	Y	NA	UK utilities from 1993-2003	UK	Total cost	Stochastic frontier analysis/ Translog input distance function	Multiproduct, Total water supplied and wastewater collected	Not stated	Scale elasticity >1	Customer density, Quality, Time
Sauer (2005)	Y (for both short run and long run)	NA	Cross section of water firms in rural areas of Germany in 2000/01	Germany	Total Cost	Symmetric Generalised McFadden (SGM)	Total water supplied	Seemingly unrelated regressions (SUR)	Scale elasticity of 2.08	Network length, groundwater intake, number of supplied connections
Shih, Harrington, Pizer and Gillingham (2004)	Y	NA	1980 water systems in 1995, 1,246 in 2000	US	Total cost	Log-linear	Multi-product, Ground water, surface water and purchased water	OLS	Scale elasticity >1	Type of water source, private versus publicly owned system
Stone and Webster Consultants (2004)	N (SR), N (LR)	Y	38 firms, sample 1992-93 to 2002-03, Unbalanced panel, 290 observations	UK	Total cost, Variable cost	Translog, Generalised quadratic	Multi product, water and wastewater	Not stated	0.67 (SR, water and sewerage companies), 1.04 (water companies only) (not significantly different from 1)	Drinking water quality requirements, environmental standards, service quality, operating environment differences
Renzetti (1999)	Y (for water and sewerage)	NA	Municipal water supply and sewerage	Canada	Total cost	Translog	residential and non-residential water	Not stated	1.25 for residential, 1.47 for non-residential,	Population density per municipality, dummy variables for type of

Study	Size economies (Y/N)	Economies of scope (Y/N)	Data	Country	Dependent variable	Functional form/model	Outputs	Estimation method	Scale elasticity	Controls
			treatment plants in Ontario, Canada				supplied, sewerage collected		1.36 or sewerage	treatment process employed.
Torres and Morrison Paul (2006)	Y (for small utilities)	Y	255 observations from 1996 survey of AWWA	US	Variable cost	Leontief quadratic function	Multi product, Wholesale and retail, quantity of water supplied	Full information MLE	Scale elasticity >1	Service area (square miles), Number of customers, Percentage of water from groundwater sources

B Natural monopoly and subadditivity in cost

B.1 Subadditivity

The literature focused on measuring economies of scale and scope is concerned with determining the industry configuration that is the most efficient, least cost industry possible. Given this motivation, it is surprising that there are few studies that explicitly test the conditions under which the water industry is a natural monopoly.

In defining a natural monopoly, Baumol (1977) linked the mathematical concept of subadditivity to industry cost.[69] As Baumol states "…subadditivity means that it is always cheaper to have a single firm produce whatever combination of outputs is supplied to the market…"[70] As a special case, Baumol (1977) cited the possibility of subadditivity over a finite range of output.

The main results provided by Baumol (1977) are as follows:

- Scale economies are neither necessary nor sufficient for subadditivity.
- For the single output firm, evidence of scale economies is always sufficient but not necessary to prove subadditivity.
- Proof of subadditivity requires a global description of the shape of the entire cost function from the origin up to the output level in question.
- Sufficient conditions for subadditivity must include production complementarity between the different outputs of the industry.
- It is possible that for some output combinations, an industry will be a natural monopoly while in other combinations it will not. This is referred to as output-specific subadditivity.

That scale economies is not a necessary condition for subadditivity may be perplexing. However, Baumol (1977) shows that the requirement of natural monopoly is much too demanding a test of natural monopoly. Note that one of the key issues with economies of scale is that, by definition, it measures the equi-proportionate increase in output given an equi-proportionate increase in inputs. This is in contradistinction to an increase in outputs given an increase in inputs along the least-cost expansion path. This means that measuring economies of scale does not necessarily say anything about the observable behaviour of a natural monopoly industry.

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[69] Baumol, W.J. "On the proper cost tests for natural monopoly in a multiproduct industry", *The American Economic Review* 67(5), pp. 809-822

[70] Baumol, op. cit., p. 810

In contrast to economies of scale, Baumol tests for ray cost concavity. This determines whether the marginal cost of specific output combinations are declining as the scale of outputs increase in fixed proportions. Importantly, the test allows input quantities to follow the least-cost expansion path. If the cost curve is concave, then the cost function is strictly ray subadditive.

To complement ray concavity, Baumol (1977) also developed the test for trans-ray convexity. This test is closely related to economies of scope. Trans-ray convexity determines whether total cost declines when output proportions change.

The combination of strict ray concavity and trans-ray convexity implies natural monopoly in all possible output combinations. Strict ray concavity without trans-ray convexity implies a limited output-specific natural monopoly. That is, the industry is only a natural monopoly for specific output combinations.

Trans-ray convexity and ray concavity can be evaluated simultaneously using a subadditivity test:

$$C\left(\sum q_i\right) \leq C_1(\boldsymbol{\varphi}'\mathbf{q}) + C_2(\boldsymbol{\theta}'\mathbf{q})$$

where $C\left(\sum q_i\right)$ represents the combined cost of producing the output (q_i) within a single firm (i.e. the incumbent), $C_1(\boldsymbol{\varphi}'\mathbf{q})$ is the cost of producing some portion of the incumbent's output in one hypothetical firm and $C_2(\boldsymbol{\theta}'\mathbf{q})$ represents the cost of producing the remainder of the incumbent's output in another firm. A wide variety of possible industry configurations can be evaluated with indicative estimates of the cost impact associated with each configuration.

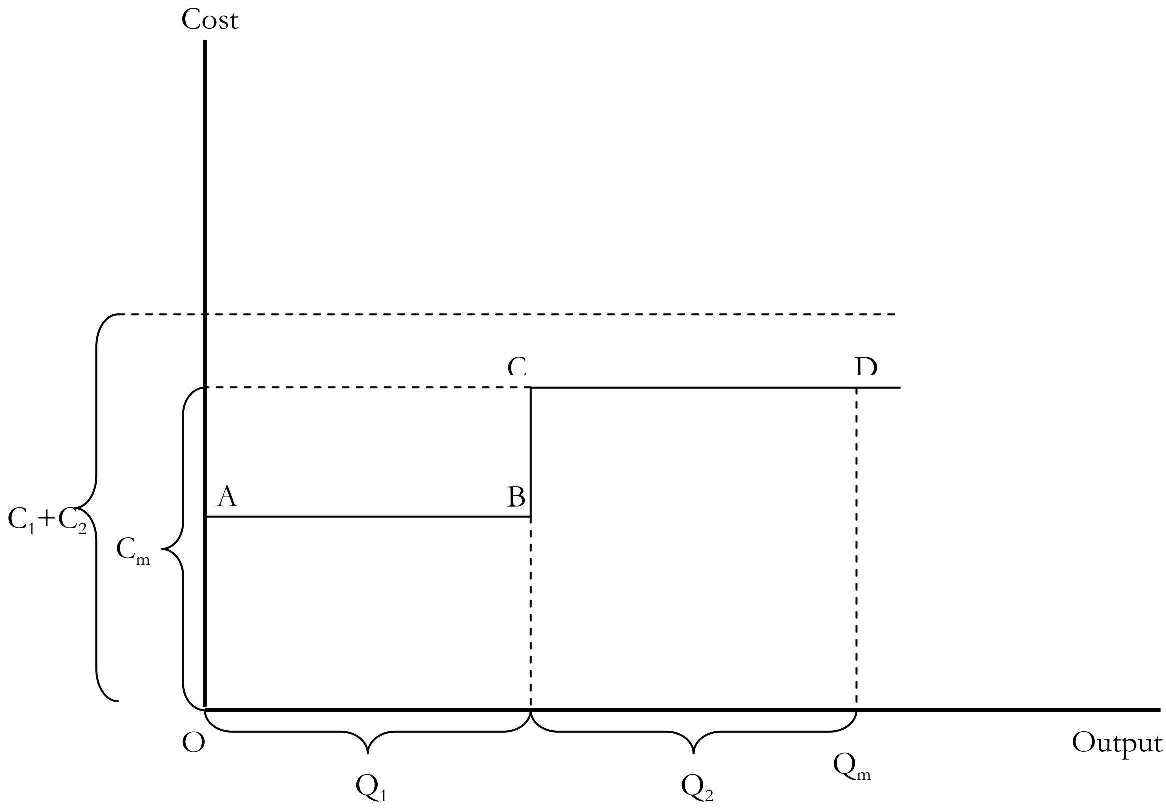
B.2 Illustrations of cost subadditivity

When considering how cost subadditivity is possible, it is helpful to have concrete examples. The following discrete examples are provided for illustrative purposes only. Note that cost subadditivity is concerned with the aggregate behaviour of cost, which may include many costs that act to offset the subadditivity implied by the following examples.

Example 1

The following diagram provides an example in which there is a choice between allowing an incumbent to build a new water storage facility or a new entrant.

Figure 9 **Water storage example of subadditivity in cost**

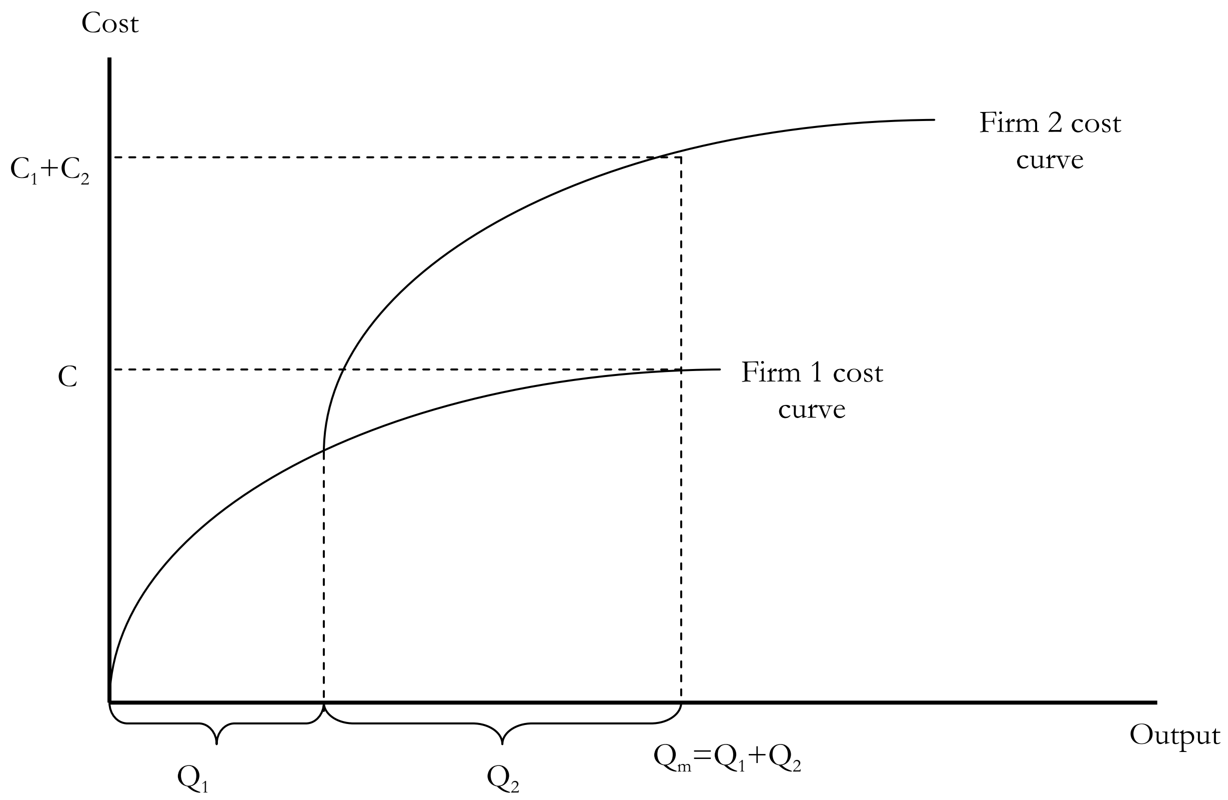


As shown in the above diagram, a step increase in fixed cost with zero marginal cost of expansion between Q_1 and Q_m induces subadditivity in cost. This situation could arise if two competing firms choose to duplicate (or are unable to share) water storage (e.g. dams) capacity. In this example, the first firm incurs a fixed cost which is depicted as the vertical line segment OA. Now suppose we need to increase water storage beyond Q_1, requiring the construction of a new water storage facility. In this example, if a second firm (a new entrant) provides the storage facility, the fixed cost OA is incurred again, doubling industry cost. However, if firm 1 expands capacity at its storage facility, then the additional fixed cost is smaller (depicted as line segment BC). This smaller incremental cost of expansion might occur if firm 1 is able to avoid certain one-off costs, which the second firm cannot avoid. Thus, monopoly cost is less than the combined cost of firm 1 and firm 2.

Example 2

Figure 10 provides an example in which fixed cost is zero while marginal (incremental) cost is consistently declining. In this case, the addition of a second firm always leads to a higher industry cost than monopoly expansion. This situation might arise when expansion implies increasing customer density.

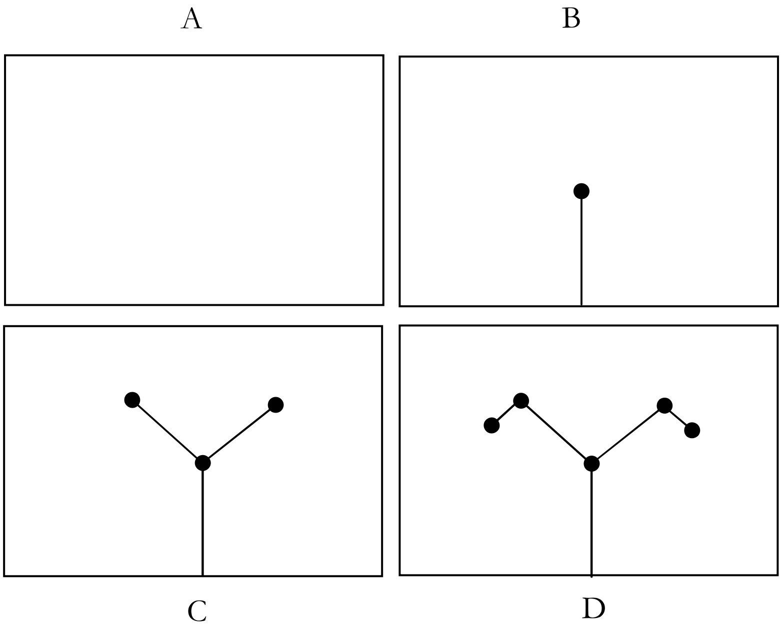
Figure 10 **Subadditivity due to consistently declining marginal cost**



A.3 Illustration of the impact of customer density

The diagram below illustrates the economics of customer density. Each rectangle represents the identical fixed cost of servicing a customer service area of a given size. In panel A, there are no customers and so total cost is the fixed cost represented by the rectangle. Assuming the cost of connecting customers to the network is directly proportional to the length of additional pipeline, panel B shows the impact of one customer. That is, there is an incremental cost of connecting the first customer which is in addition to the fixed cost of the customer service area.

Figure 11 **Customer density example**

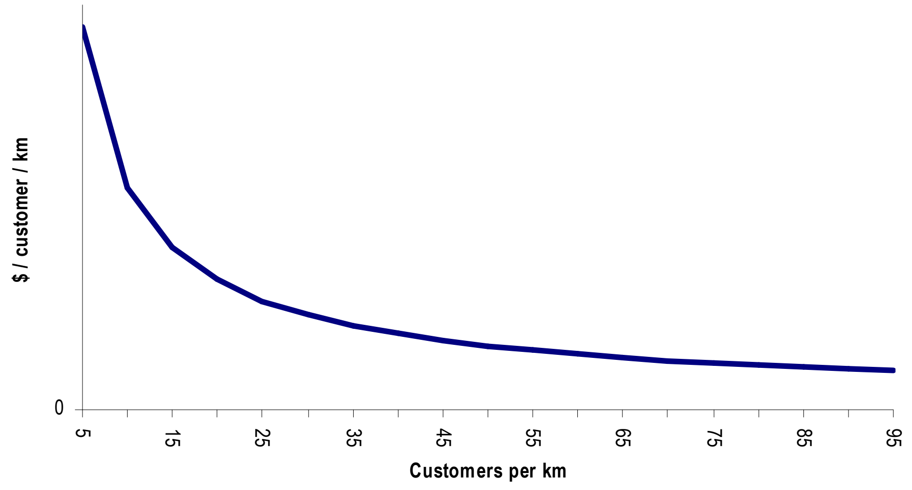


In panel C, an additional two customers are added. Note that the pipeline increments connecting the second and third customers are shorter than the pipeline connecting the first customer. This implies that the incremental cost of connecting the second and third customers to the pipeline is less than the cost of connecting the first customer. For simplicity, assume that the third customer is connected for the same cost as the second. Note that average cost (total cost divided by the number of customers) is lower than the average cost represented in Panel B.

Extending the analysis further, Panel D shows that the identical incremental cost of connecting the fourth and fifth customers is less than the cost of connecting the second and third customers. Again, average cost has decreased. In this case, there are economies of customer density and consequently, total cost is subadditive.

An example of the impact of customer density on average cost is shown in Figure 12

Figure 12 **Cost/customer/km**



Note: Based on Fraquelli, G and V Moiso (2005), *Cost Efficiency and Economies of Scale in the Italian Water Industry*, presented at Pavia University, 15 - 16 September.

A.4 Illustration of the impact of increasing pipe diameter[71]

The volume of a pipe of length 'L' and radius 'r' is given by $V = \pi r^2 L$ while the surface area of the pipe is given by $SA = 2\pi r L$. Doubling the diameter of a pipe increases the volume by $\pi(2r)^2 L = 4\pi r^2 L = 4V$. That is, the volume increases by a factor 4. However, the surface area of the pipe only increases by a factor of two, i.e. $2\pi 2rL = 2SA$.

Hence, larger pipes have a smaller surface area per unit of volume than smaller diameter pipes. This implies less flow resistance per cubic metre of water and for the same pumping power, there is a larger throughput. A cost minimising water supplier will therefore choose the optimal pipe diameter and pump size to provide a given volume of water per unit of time.

Now, in order to deliver a given volume of water, compare the cost of building two relatively pipelines side-by-side against the cost of building one large one. If V is the volume of water required, then two pipelines implies that each one would transport $\frac{1}{2}V$. In turn, this implies a radius of

$$r = \left(\frac{\frac{1}{2}V}{\pi L}\right)^{\frac{1}{2}}$$

Substituting this into the formula for surface area produces

[71] This example is provided by Church, J. and Ware, R. *Industrial Organization: A Strategic Approach*, Ontario, Canada, Irwin McGraw-Hill, 2000, p 54

$$SA_2 = 2\pi\left(\frac{\frac{1}{2}V}{\pi L}\right)^{\frac{1}{2}} L$$

That is

$$SA_2 = \frac{2}{\sqrt{2}}(\pi LV)^{\frac{1}{2}}$$

Two pipelines requires two times the surface area or

$$SA_2 = \frac{4}{\sqrt{2}}(\pi LV)^{\frac{1}{2}}$$

The ratio of the surface area to volume is thus

$$\frac{SA_2}{V} = \frac{4}{\sqrt{2}}\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}$$

For the single pipeline option, the solution is

$$\frac{SA_1}{V} = 2\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}$$

Comparing the two alternatives,

$$\frac{SA_2}{V} \Big/ \frac{SA_1}{V} = \frac{\frac{4}{\sqrt{2}}\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}}{2\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}} = \frac{2}{\sqrt{2}} \frac{2\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}}{2\left(\frac{\pi L}{V}\right)^{\frac{1}{2}}} = \frac{2}{\sqrt{2}} = \sqrt{2}$$

Hence, assuming the square metre price of steel pipelines is the same across the alternatives, the two-pipeline alternative will always be 1.4 times more expensive than the single pipeline option.

A.5 Illustration of economies of spatial scope

In a recent paper, Basso and Jara-Díaz (2005)[72] developed the concept of economies of scope arising when there are cost savings to be derived by combining spatially distinct and separate networks. The following diagram provides an example in which there are two distinct networks. There is a choice of connecting a separate transmission line and maintaining separate distribution networks (labelled A). Alternatively, a considerably shorter

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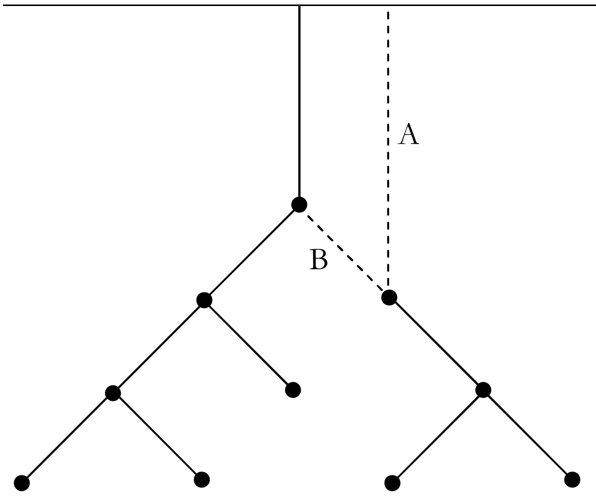
[72] Jara-Díaz, S. and C. Cortés "On The Calculation Of Scale Economies From Transport Cost Functions". *Journal of Transport Economics and Policy*, 30, 1996, pp. 157-170

connecting pipe (labelled B) would effectively combine the two networks as one. If the incremental cost of building and operating the additional pipe is directly proportional to its length, then there may be economies of spatial scope in combining the two networks.

Figure 13 **Example of economies of spatial scope**



This idea would be seen by many economists to be economies of scale in another guise as both networks produce the same output, namely water supplied to connected customers. However, it is helpful to distinguish the example described in Figure 13 (which is concerned with the incremental cost of combining two networks) with an increase in volume supplied within one of the networks.