3 QUALITY AND REGULATORY DESIGN

Price is only one dimension of value for money; consumers are also affected by the quality of products and services. Managers may pursue quality initiatives for their cost implications: costs associated with responding to complaints and rectifying damage. Firms in a competitive market-place may also pursue quality to retain satisfied customers and win over others. Improved quality may also increase the size of the market — customers may be encouraged to consume more. However, in utility industries domestic consumers have typically been offered a very restricted range of service levels, with no choice at all in services such as water supply. In the absence of competition, consumers face two problems. First, it is not clear what level of service it is reasonable to expect at any particular price level. Second, there is no direct power to influence the industry's level of quality by changing supplier, or to gain personal redress when things go wrong.

3.1 Theoretical background to quality

The economics literature relating to quality has generally focussed on the impact of imperfect information and the use of the hedonic method to adjust price and output indexes for quality change (BTCE, 1992, p. 7).

Lancaster's extension of the conventional theory of consumer demand incorporated product characteristics as a central component of demand theory for the first time (Lancaster 1966). It provides a framework for analysing the concept of service quality.

Under Lancaster's approach, a product is viewed as a bundle of characteristics. Consumers derive utility from the characteristics embodied in the product rather than from the product per se. Utility orderings are assumed to rank collections of characteristics and only to rank products indirectly through the characteristics that the products possess.

Each product potentially possesses a large number of characteristics but the operational use of Lancaster's model depends on the ability to confine the analysis to a relatively small number of characteristics with measurable properties. Lancaster proposes that practical studies should be limited to the relevant characteristics; that is, if ignoring its existence would lead to different predictions about the choice of ordering of the products by consumers (Lancaster, 1977).

Various definitions of quality are used in the economic literature. Dhrymes (1971, p. 88) defines quality as 'the set of identifiable characteristics exhibited by a given product'. Leffler (1982, p. 956) states that 'quality refers to the amounts of the unpriced attributes contained in each unit of the priced attribute'. Dorfman and Steiner (1954, p. 831) define quality as 'any aspect of a product ...which influences the demand curve'. Maynes (1975, pp 530-531) describes the quality of a product/brand/model/seller combination as the 'subjectively weighted average of characteristics'.

In order to define quality, Garvin (1984) proposes a framework for thinking about the basic elements of quality in terms of eight dimensions:

- performance (primary product characteristics);
- features (secondary product characteristics);
- reliability (probability of product failing);
- conformance (degree to which design and operating characteristics match pre-established standards);
- durability (product life);
- serviceability (speed, courtesy and competence of repair);
- aesthetics (how the product looks, feels, sounds, tastes or smells); and
- perceived quality.

Quality for the purpose of this study encompasses both product and service quality. Product quality refers to the actual composition of the water. Quality in the context of service delivery comprises several components which express values of service provision and, as part of this, the relationship between the service provider and the customer. These values may differ between geographic regions, depending on cultural and political backgrounds. Consumers may perceive that quality has improved even if increases in the amounts of some characteristics are partly offset by declines in the amounts of others.

3.2 Concepts of regulatory design

The purpose of regulation is to promote economic efficiency and perhaps economic fairness, and it does so through restrictions on the economic opportunities of the utility firm. The need for incentives relates to the information asymmetry problem discussed in chapter 2. Given the information asymmetry between the firm and the regulator, power to tell the firm what to do is of little value. Instead, value can be gained from giving the firm some discretion.

A second reason why good regulatory design is important relates to the costs of regulation. These costs can be grouped under three broad categories. First, regulation can impose significant administrative and compliance costs — the regulated firm must devote resources to supplying the regulator with information and the regulator must have means to independently verify that information. Second, significant costs can arise through regulatory failure (that is, inefficient or inappropriate regulatory practices). The costs of regulatory failure are less transparent and more difficult to assess than administrative and compliance costs. Third, the risk of changes in the regulatory environment may increase perceptions of sovereign risk and deter new investment. More specifically, there is a risk that unexpected regulatory change will affect the value of existing assets and increase uncertainty about expected returns from future investments.

If the costs associated with regulation are greater than the benefits, economic efficiency will be reduced rather than enhanced. The design of a regulatory regime must therefore weigh up the potential benefits and costs involved.

Incentive regulation

Incentive regulation, broadly defined, is an effort by regulators and regulated firms to access the potential gains from restructuring regulation. Asymmetry of information gives rise to imperfect incentives resulting in inefficiency. However, two points need to be made: first, the inefficiency of regulation cannot be eliminated altogether; and second, regulation is itself an incentive mechanism (see Blackmon, 1994, p. 1).

Principal-agent theory is concerned with the design of incentives for efficiency under conditions of asymmetric information. The principal (the government or the regulatory authority) is less informed than the agent (the manager of the firm) about cost conditions, for example, and the regulator seeks to induce the firm to make pricing, output and investment decisions in accordance with the public interest given the cost conditions that exist. With this perspective, a system of regulation can be regarded as an *incentive mechanism* (Vickers and Yarrow, 1988. P. 92).

Another way of thinking of the regulatory process is as a contract between the government on the one hand and the utilities on the other (Bishop et al, 1995, p. 6). The government acts on behalf of consumers. The contract sets out certain conditions that firms must satisfy. In return, the utilities are offered certain revenue streams which may be specified as maximum price-caps. The regulatory regime should aim to balance the interests of suppliers and consumers.

Trade-offs between internal and allocative efficiency may result from asymmetric information. At the optimum, price should equal unit cost. If the government cannot observe cost it runs the risk of imposing a price at which the firm refuses to supply the market. The government's regulatory scheme must therefore make a compromise. Price generally exceeds unit costs at the optimal compromise so that the firm makes a positive profit through its 'monopoly of information'. This results in allocative inefficiency. On the other hand, if the government can observe the level of costs but not the effort to reduce costs there is a trade-off between internal efficiency (ie optimal effort given output) and allocative efficiency (ie optimal output given effort). Setting price equal to unit cost gives perfect incentives for internal efficiency but poor allocative efficiency. The optimal compromise involves lower output and higher price than at the optimum, resulting in internal inefficiency (see Laffont and Tirole, 1986).

Ex poste auditing of the conditions of the firm can enhance efficiency by diminishing the asymmetry of information between regulator and firm (Baron and Besanko, 1984). Over time the regulator may be able to learn about the cost conditions facing the firm, and choose a regulatory mechanism that uses the information that emerges.

To regulate price or profit?

Various ways of regulating utility industries are discussed at Appendix B. The most common mechanisms worldwide to manage monopoly power of utility industries and prevent abuse is to either control profit through rate of return regulation (used extensively in the US) or to control price through price-cap regulation (recommended by Littlechild (1983) in relation to the UK utility industry privatisations).

Under rate of return (RoR) regulation the firm is guaranteed a specified return on its investment. Prices track costs closely and reviews of prices are frequent. The firm (knowing that it cannot retain additional returns) sets prices accordingly. Because the firm makes little supernormal profit the scheme has poor incentive properties — any improvement in operating efficiency that lowers observed costs will quickly lead to a cut in the allowed price.

Price-cap regulation on the other hand — a ceiling on the amount by which public enterprises can increase prices over a specified period of time — provides profit incentives to utility providers to reduce relative costs. Under a price-cap scheme, price increases are constrained to a level determined by an index, usually the general rate of inflation, less an 'X' factor to encourage productivity improvements. The specified period, the regulatory lag, is long relative to that under rate of return regulation. The firm keeps the benefit of any increase in profits derived from a reduction in costs, at least until the next price review.

According to Baumol and Willig (1989, p. 3):

> … rate of return regulation does ultimately influence prices, more or less indirectly, but the workings of its effects are complex and often even the direction of its influence may be difficult to predict and will not always favour consumers … Price cap regulation puts an end to all that by ensuring that the regulatory mechanism pursues the goal of preventing excessive prices; it thus pursues the objective that genuinely matters to consumers' economic welfare.

Price-cap regulation can in fact evolve into RoR regulation, particularly where review periods are short. This occurs due to incentives for firms to induce cost increases in order to induce a favourable price constraint — or 'X' factor — for the following period. The scheme used to regulate the UK water industry, while nominally a price-cap, has many of the features of rate of return regulation. The duty of Ofwat to ensure reasonable returns means that the rate of return on capital features significantly in price reviews and in cost pass through applications. Although the nominal lag of 5-10 years is long, Ofwat has intervened frequently to alter 'K' factors (see chapter 5 and appendix B for further details).[5] It has persuaded firms to withhold some price increases to which they were entitled, and formalised the process in 1992 when it required reductions in 'K' for 17 firms, on the basis that the recession in Britain had reduced construction costs below the estimates used when price limits were originally set.

The two different regulatory structures also have different implications for quality levels. The Averch-Johnson thesis (1992) states that rate of return

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[5] Each water company is subject to the adjusted price cap regulation, whereby its revenue is limited by RPI+K, where K varies according to investment expenditures required by each firm particularly in responding to EC quality directives. There are in effect two elements to the K factor in the formula: an X element relates to usual utility operations, and a Q element relates to mandatory improvements in quality and the environment (ie RPI-X+Q).

regulation would create an incentive to over-invest and, by implication at least, set quality levels too high. Price cap regulation on the other hand creates incentives for industry management to improve profitability by reducing service levels, where provision is not made for the regulation of quality (see discussion below).

3.3 Quality under price-cap regulation

In competitive markets, consumers can choose between a range of goods and services at different price/quality levels. Prices are related more closely to marginal supply costs, leading to allocative efficiency. Survival in competitive markets requires productive efficiency and response to consumer preferences. Hence, competition has the potential to offer a market 'solution' to the problem of an under (or in some cases over) supply of quality. In the absence of any price regulation each firm chooses the mix of quantity and quality which maximises its profit. Given the quality of a good or service, it is possible to draw the Marshallian demand and supply curves and find the equilibrium price.

In monopolistic markets such as the water industry, customers have little choice of supplier and cannot switch to better quality 'brands'. The firm has an incentive to limit its outlays on quality control, while the regulator is concerned to bid up quality standards without the same regard to the cost of implementing them. A price-cap will induce adjustments in quality as well as the quantity produced — firms will choose a new profit maximising quality/quantity mix subject to the price constraint (a less efficient outcome). In the short run firms will reduce quality but may increase or decrease units of produce or services, but in the long run will also reduce the flow of services, making consumers worse off (see Amit, 1981, p. 1056). For a monopoly utility traditional analysis shows that a price-cap will always increase output and lower price, and thus benefit consumers.

Amit uses Lancaster's characteristic approach to analyse the effect of regulation on quality and quantity produced under both competition and monopoly. In the competitive case he finds that in the short run consumers may benefit from either price or quality regulation. However, in the long run price or quality regulation will hurt consumers and benefit firms. Traditional analysis predicts that price regulation will reduce output in both the short and long run. When quality is introduced as a decision variable these results are changed.

In the case of a monopoly firm that can choose quality as well as quantity, Amit finds that a price-cap may result in a lower consumer surplus. He finds that the traditional results (where a price-cap will always result in higher output and therefore a higher consumer's surplus) do not necessarily hold if a monopoly can adjust both quantity and quality.

Conventional economic theory suggests that, under familiar but restrictive conditions, an unregulated monopolist will supply goods of equivalent quality to firms in a competitive market; all monopoly profit will be taken in prices (Waterson, 1984). In other more general circumstances, however, an unregulated monopolist may find it profitable either to oversupply or undersupply quality depending upon demand conditions (Spence, 1975).[6] Therefore although the main objective of regulation such as a price-cap is to protect consumers from excessive price increases, this focus on price should not be to the exclusion of quality: 'because a reduction in quality of service would be tantamount to an increase in price' (Vickers and Yarrow, 1988, p. 227). In designing a price-cap for the longer term, such as in relation to the water industry, special attention should be paid to incentives and structural flexibility, as well as to considerations of quality.

Lewis and Sappington (1988) also studied regulatory design to motivate the provision of quality by the regulated firm. In their model also, the firm can only improve quality by increasing costs. They examine simple models of regulation in which the regulated firm must be motivated to enhance the quality of the product it sells. Two polar cases are emphasised: first, where the level of quality supplied by the firm can be observed by the regulator (such as the case of aesthetic dimensions of water; and second where the induced level of quality is unobserved by the regulator (such as undetected bacterial contamination).

They find that when quality is observable, higher levels of quality are induced, regulated prices are lower, and both consumers' surplus and profits are higher than when quality is unobservable. Thus, both the regulator and firm prefer that the regulator is able to monitor quality perfectly. This coincidence of interests for the regulator and firm is the main finding of the study. When quality is publicly observed, it is less costly for the regulator to motivate its supply, and so higher levels of quality are achieved. The resultant increase in total welfare more than offsets the increase in profit.

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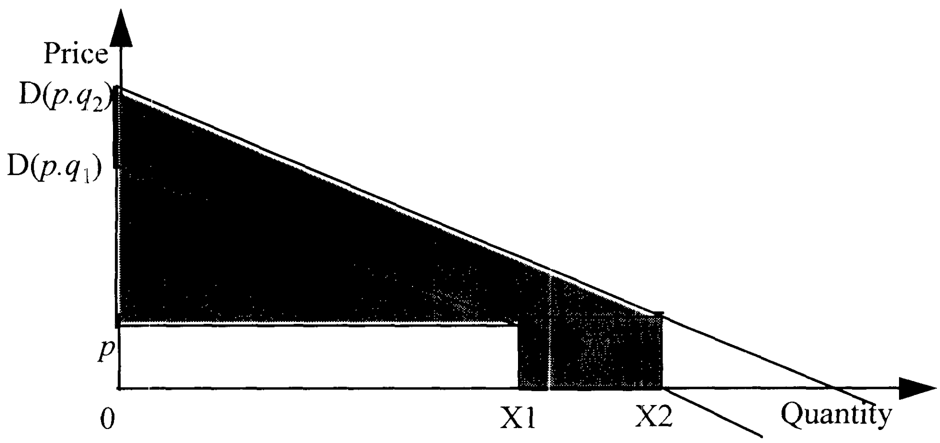
[6] Spence showed that an unregulated monopolist will not in general supply the optimum quality. If the price is fixed (as under a price-cap regime) the firm sets a quality level that is too low, given the price. The marginal benefit to the firm of extra quality is the increase in revenue from extra sales at the fixed price, but the marginal social benefit of extra quality includes the increase in consumer surplus of intra-marginal customers. Thus the firm does not capture all of the marginal social benefit and so will under-provide quality (for a given price).

Rovizzi and Thompson (1992) also considered the appropriate role of quality in the regulation of monopoly utilities. In examining data from several utility industries, they in fact found little evidence to suggest that quality under competitive supply has turned out lower than under monopoly public ownership. This observation weakens the case discussed below that public ownership results in the over-provision of quality. However, when they examine the introduction of price-cap regulation and parallel shifts in the regulation of those enterprises which have remained in public ownership, they find evidence to suggest a fall in quality following the introduction of price-cap controls where no specific provision was made for quality regulation (see figure 3.1).

Figure 3.1: Price-cap regulation effects of service quality



Source: Vickers and Yarrow, 1988, p. 413.

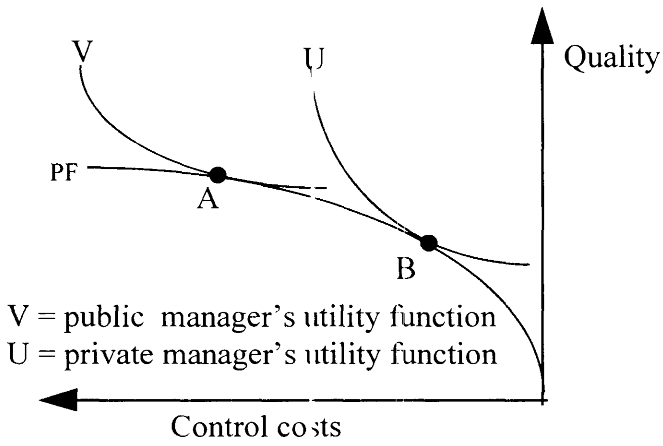
Figure 3.1 shows that an enterprise can reduce costs by reducing quality (from q_2 to q_1). This is worthwhile in financial terms if the forgone revenue (shaded area π) is less than the cost savings. However, it will not be efficient in terms of resource allocation if the change in consumer surplus (shaded area S) more that offsets the financial benefits. The significance of this is likely to be greater where demand is more inelastic, where the valuation placed on quality change by marginal consumers is low relative to the average and, related to this, where price discrimination is not feasible. In the absence of price discrimination, the firm responds to the marginal individual valuation of quality changes, whereas the average consumer's valuation is the relevant quantity for welfare. A potential misallocation in the determination of the level of quality is the result of this failure.

3.4 Quality levels and ownership

Although objectives of quality regulation may be transparent this does not mean that the quality standards are set at the correct levels. When assessing quality changes as a result of reform, consideration should be given to the 'appropriate' level of quality in terms of what consumers are willing to pay.

It has been argued that under traditional public ownership — prior to privatisation and the parallel shifts in public sector reform — levels were set too high (Bös and Peters, 1988). The essence of the argument is that management in publicly owned non-commercial firms lack the incentive to pay sufficient attention to the costs of achieving higher levels of quality (illustrated below in figure 3.2).

Figure 3.2 Quality and the costs of bureaucratic control



Source: Bös and Peters, 1988, p. 238.

Higher levels of quality can be achieved by incurring 'costs of control' shown on the horizontal axis. These are effectively the costs of internal management control within the organisation, such as monitoring and administration costs. The trade-off between control costs and quality is illustrated by the production frontier (PF). If managers in public enterprises are relatively indifferent to higher control costs (because, for example, they are associated with bureaucratic conformity to processes and procedures, accountability and industrial democracy), they will tend to set quality at relatively high levels (point A). If privatisation, or a shift towards more commercial objectives under public ownership, results in greater recognition of the relevance of control costs, the result will be that quality is set at lower levels (point B). This is described by Bös and Peters as a 'price which has to be paid for the reduction of excessive bureaucratisation, a price measured in terms of the quality of supply' (p. 255).

Thus although privatisation, or parallel shifts in public enterprise regulation, would be expected to result in quality levels being reduced, the explanation under this analysis reflects an unwinding of the too-generous provision for quality made under public ownership. This argument contrasts with the view that a price-capped firm will reduce quality below efficient levels in order to meet financial constraints.

3.5 Monitoring and regulating quality

To monitor and regulate quality at least three stages are needed. First, the standards to which an industry is working need to be set and made public. Second, performance needs to be measured and monitored. Third, there should be penalties on industry management for non-performance, and redress for individual consumers who receive less than adequate service. Some form of customer consultation is desirable at all stages. Customer contracts or consumer charters are a useful way of achieving this.

Standard setting

An approach involving minimum quality standards, where the provider is penalised for failure to meet the standards, should guarantee a particular level of quality and reassurance that standards will not fall below pre-specified levels.

Where basic quality aspects are technical and capable of being precisely specified, and where it is important to have a consistent standard across an industry, it might be more appropriate for the standards to be set in legislation. This is particularly true for water quality where certainty is more important than flexibility and the public health aspects are important enough for minimum or set standards. In some cases the specific standard or technical details may be mandated, while in others the legislation may refer to a requirement to comply with an externally set standard.

Australian standards are developed by expert committees and published by Standards Australia which provide legislative force. Standards Australia regularly updates standards to reflect latest scientific and industry experience. Legislation is able to reflect the current standard without needing to be continually updated.

A related service quality improvement tool is certification in terms of service quality standards, such as the ISO-9000 and related series. The advantage of certification is that an outside, neutral third party sets requirements for the organisation's quality management systems and monitors that the requirements are met. Such accreditation is often used in the marketing of a service.

Participants in a utility industry are often required to obtain a licence to operate. Where this occurs, such as in the case of Sydney Water, service quality standards are often incorporated into licence conditions. Failure to comply with the standards represent a breach of licence conditions. An alternative approach is to impose a licence condition to comply with an approved code of conduct or 'Consumer Charter' (discussed below). This removes the need to prescribe precise standards of quality and services within the licence, allowing for flexibility and innovation in the setting of standards, while still ensuring compliance with the standards through making compliance a licence condition.

An implied threat of regulation if standards are not maintained and improved may result in a higher level of quality than specific legislated minimum standards. But an implied or even explicit regularly threat mechanism will be effective only if firms regard the threat as serious and if adequate monitoring mechanisms are established to measure quality, recognising that it will be more difficult to determine what aspects to monitor if no standards are set.

Performance monitoring

Specifying quality levels of itself does not ensure quality outcomes. For instance, although the version of price-cap regulation introduced for Telecom Australia (now Telstra) by the telecommunications regulator Austel did include a quality of service provision which allows Austel 'to judge the price of a service to have increased if the quality decreases', it has been observed that:

> there is no indication as to how Austel might value the reduction in quality or determine the change in quality which might be deemed to have met the price cap given the variations in the prices of other services (Abraham 1993, p. 8).

Appropriate mechanisms for monitoring and reporting compliance with the standards need to be considered, as do mechanisms to ensure that standards are regularly reviewed.

A common approach to assessing quality is the degree of satisfaction of users. Other approaches involve identifying the incidence of service failure. Further removed from the impact of the service on clients are monitoring techniques involving accreditation and the quality of inputs.

Measurement difficulties

Quality is clearly difficult to define and measure (in contrast to price). While it is relatively easy to agree on formal measures for the quality of some physical features, it is less easy to devise measures which accurately capture the added welfare that flows from access to some aesthetic or gimmick feature. In fully competitive markets, managers have direct incentives to capture this complexity. Regulated monopolies, by contrast, are likely to take a more restricted view of quality measurement.

Regulatory systems tend towards measures that are easily quantifiable and can be made statistically reliable. Yet these may fail to measure what consumers are mainly interested in. Utilities themselves often rely on reports from their own staff, while consumer organisations normally collect data from users of the service. The gap between the two accounts can be considerable and the resultant information may be of little use as a consumer performance indicator.

Penalties and sanctions

Problems may arise in enforcing quality standards. One of the effects of public enterprise reform, from direct Ministerial control to either corporatisation or privatisation, is that previously existing quality mechanisms such as an appeal to the Ombudsman about treatment, or a complaint to the Minister, may no longer be available. Such mechanisms had the effect of ensuring the provision of some level of service quality. While common law provides some rights and legal remedies, the cost is often prohibitive for individual consumers.

If standards are regulated through licence conditions alone, the issuer should be prepared to take positive action for a breach of a condition such as by setting penalties, especially if individual consumers are not able to enforce a breach. Graduated penalties and remedies for breaches of the standards or conditions associated with service provision include customer compensation schemes, fines, adverse publicity, corporate community service orders, and modification (or where feasible revocation) of a licence where practical.

Access to justice considerations is important if contracts are to be used to maintain service quality standards. If such standards are based on individual contracts, consumers must be able to enforce the terms through an accessible disputes resolution mechanism. Litigation may be inaccessible for many consumers but low value disputes could be handled in small claims jurisdictions. Alternatively, independent industry dispute resolution schemes could be established to enable consumers to enforce contractual terms.

Consumer charters

Consumer charters, also known as citizens' charters, customer service guarantees and customer service contracts, involve the development of performance objectives and standards that place competitive pressure on monopoly service providers. Effective consumer charters can help to fill a void by setting in place mechanisms aimed at improving service delivery, being more customer oriented and responsive, and providing for a visible and accessible complaint mechanism and advisory service.

Citizens' charters were first introduced in the UK in 1991, guaranteeing standards of service in both public and privatised utilities. By the end of 1992, there were 28 separate Citizens' charters' in the UK, which define citizens' rights and set out mechanisms for redress across a wide range of public services (HM Treasury, 1995).

In Australia there has been increased interest in the use of consumer charters or guarantees of service for both public utilities and for other government services. Utilities throughout Australia are now developing published standards of service which consumers are entitled to expect, including mechanisms on what to do if the service provided does not meet the expected standards.

Consumer charters should provide for compensation to customers if commitments by the suppliers in the charters are not met. If individual customer contracts are used to impose quality and service standards, only those who are party to the contract (ie the consumer and service provider) could enforce the provisions. Third parties such as other household members, consumer groups and regulators would not be able to enforce the provisions of the contract. However, legal mechanisms for redress are available, such as statuted common law. Both the legal status of the charter, and the extent to which the standards can be enforced by consumers or other parties, need to be clearly articulated.

According to Asher (1995):

> Because effective charters involve receiving inputs from users, the provision of redress mechanisms and accessible complaint handling, they are setting up mechanisms which private firms in a competitive industry would set up in response to the impulses from the market place. In other words, responsive charters can act as a form of surrogate competition where none exists. This is important where utilities have no effective competition with their services.

A supply contract between the service provider and the customer could contain service quality standards. In the absence of contractual terms to the contrary, a breach of the standards would entitle the consumer to a claim for damages for any loss caused by the breach. Contractual terms can be tailored to the needs of different customers and can often be easily varied.

However, negotiations could be difficult for small consumers when dealing with a large firm. Often they either have to accept the terms and conditions of a standard form contract or do without supply. For water supply urban customers do not have the latter option since they are required to be connected to the mains. Standard form supply contracts can impose fairly restrictive terms on consumers, and can often unreasonably limit the liability of the supplier for failure to honour service quality guarantees. Some intervention by a regulatory body may be needed to prevent unfair contracts.

Alternatively, a consumer charter between the regulator, the utility and consumer representatives could be incorporated into standard form contracts to ensure that unreasonable terms and conditions are not imposed.

3.6 Conclusion

Under a price-cap firms have no way of increasing revenue by improving quality unless the costs are allowed to 'pass-through' the price-cap. Therefore, even if quality improvements affect consumption of water at the margin, the effect is unlikely, of itself, to induce firms to increase costs to improve quality. This is the essence of Rovizzi and Thompson's argument. The implication is that effective monopoly regulation requires consideration of quality and service as well as price.

When quality standards are set the opinions of the firm should match those of the community and take account of expert opinion. This allows clear guidance in setting relevant quality parameters. In setting standards, for instance, appropriate consultation on the content of the standards is required, appropriate enforcement and monitoring needs to be introduced, and sufficient reporting requirements need to be incorporated into the regulatory regime.

4 REGULATION OF WATER QUALITY

Regulation of the water industry poses more complex problems than the regulation of many other business enterprises, public or private, because of the limited scope for competition and the problem of asymmetric information. Regulation of water quality has to oversee the implementation of drinking-water standards imposed by governments and international organisations. As for most utilities, service quality aspects, such as the way in which customer inquiries and complaints are handled, are also important. Hence, quality may relate to the water itself (water quality) or to an aspect of its delivery (water service quality).

4.1 Defining water quality

Water quality has many dimensions, as encapsulated by Alexandra, et al (1993) in the following quote:

> Water quality is highly multi-dimensional. While it may be characterised roughly in terms of concentrations of dissolved solids, suspended solids and microbiota, not only do the actual constituents under these three headings make a water supply suitable or unsuitable for different uses, but there are many other important dimensions of water quality which do not come under these headings (p. 22).

The majority of water quality standards are based on *Australian Drinking Water Guidelines* intended to define 'good' water quality. These provide the framework for drinking water quality in Australia.[7] Others are based on earlier versions of the Australian Guidelines or the 1993 World Health Organisation (WHO) *Guidelines for Drinking Water Quality*, intended to define 'safe and acceptable' water quality. Each reflect consideration of both health and aesthetic effects. The WHO guidelines provide guidance for general applicability, with the suggestion that water quality criteria can be adapted to suit local conditions.

The guidelines are applicable to any waters intended for drinking, irrespective of their source or their place of use. They have not been developed for regulatory purposes and the values given are not standards. They represent a

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7 Developed jointly by the National Health and Medical Research Council (NHMRC) and the Agricultural Resource Management Committee of Australia and New Zealand (ARMCANZ).

framework for identifying acceptable water quality through community consultation. Achievement of the values ensures generally aesthetically acceptable water which does not carry any significant health risk to the consumer.

While water quality in Australia is a State responsibility, the purpose of the Australian Drinking Water Quality Guidelines is to provide water authorities, health officials and consumers with guideline values of drinking water quality, the attainment of which is a national objective. The degree of acceptance of the guideline values depends on local circumstances; each authority develops its own level of service based on estimates of risk and cost as well as local knowledge of the source of the water. Factors influencing quality include the degree of catchment protection, treatment processes, distribution history and the quality assurance program or other regulation exercised over its operation. Authorities are expected to ensure that sufficient monitoring occurs within their systems to enable them to investigate and take remedial action where necessary.

There is a close relationship between the quality of water that it is consumed at the tap and the amount of pollution in the water environment or the quality of the water at source. In Melbourne, for instance, raw water quality is sufficiently high to substantially reduce the number of full water treatment facilities. Residents of South Australia, on the other hand, must regularly clean out their hot water heaters to prevent the element from sitting in sludge rather than water (Bursill, 1996).

Until recent decades many Australian cities had untreated water delivered from healthy, forested catchments. Australia's two most populous cities, Sydney and Melbourne, benefit from forested catchments — the Blue Mountains and Upper Yarra respectively — which escaped clearing in the early days of settlement because they were largely unsuitable for farming. Adelaide's catchment, the Adelaide hills, was cleared for farming. Consequently, its population drinks poor quality water from farm land run-off or pumped from the Murray.

Three dimensions of drinking water quality are discussed below: first, aspects that are harmful to health; second, aesthetic qualities; and third, appropriate levels of additives that affect aspects such as pH, which may in turn affect health or aesthetic quality.

Although most Australians receive water of good to excellent quality, many small communities have inadequate supplies, both in terms of quality and quantity. In 1983, the Water 2000 Report identified the water supplies for small towns as a pressing water quality problem, noting the inability of many small communities to meet the cost of necessary improvements (Department of

Resources and Energy, 1983). The major water quality problems identified in the report were turbidity, colour, microbiological contamination and hardness.

Health

Although appearance, taste and odour are useful indicators of the quality of drinking water, suitability in terms of public health is determined by microbiological, physical, chemical and radiological characteristics. Of these, the most significant is microbiological quality. It can be the less discernible aspects of water quality such as concentrations of lead, copper and zinc, and the presence of other harmful substances, that are more important from a health perspective. For instance, in older properties that may still have lead pipework, some lead could be transferred from the pipe to the drinking water.

One of the principal input parameters in the assessment of the microbiological risk to consumers is the concentration of micro-organisms in the raw water. For micro-organisms of primary concern only limited data are available for Australian waters (Stevens, et al, 1995). While considerable oversees information of the occurrence of some pathogens is available, the relevance of this information for Australia is uncertain.

Both sets of guideline values — the Australian and WHO — reflect toxicological considerations rather than, say, detection limits. This involves a 'risk-based' approach to setting the individual health-based criteria. For many constituents of water there is sufficient toxicological information available on which to base maximum acceptable concentrations. However, for some constituents, the toxicology is uncertain, requiring changes in guideline values as more information becomes available.

The most significant health-related parameter in the Australian guidelines is the faecal coliforms measure. The guidelines state that:

> where 100 or more scheduled samples are taken annually, at least 95 per cent of those samples should contain no faecal coliforms in 100 millilitres.

Coliforms are a group of bacteria found in the intestine and faeces of most animals and can sometimes be found in untreated water. The treatment process removes them and disinfection prevents their reappearance in the distribution system. They could arise because of a problem in the treatment works or distribution system, or sometimes because of dirt on a consumer's tap.

Assessment of the health risks associated with microbiological contaminants requires knowledge of several parameters that determine the likelihood that an individual will become ill from ingestion of water containing the micro-organism, including the virulence and concentration of the pathogen and susceptibility of the host. For example, gastrointestinal illness (gastro), the most common form of waterborne microbial illness, is not generally considered life-threatening in healthy adults. However, research has shown that mortality rates for gastro in the elderly and in very young infants, range from 3 to 5 per cent (Glass, 1991). Cryptosporidium, a waterborne parasitic micro-organism believed to originate from livestock, has been identified as responsible for a small number of acute diarrhoea cases (cryptosporidiosis). But cryptosporidiosis is the leading cause of death in AIDS patients in the US. In Australia, it was the AIDS determining condition for 2.3 per cent of AIDS patients (National AIDS Database, 1995).

When the overall consumer risk is assessed, consideration needs to be given to:

- the risk of cancer or other chronic health effects associated with long term exposure to chemical contaminants in water;
- the risk of acute health effects associated with major spills and leaks, blue-green algal toxins, chemical overdoses or high doses of micro-organism due to contamination from sewers, etc;
- the occurrence of epidemic illness, such as gastro, associated with micro-organisms present at relatively low levels in the water supply due to ineffective treatment;
- the risk of an epidemic associated with failure of treatment systems when there is a significant excursion in raw water microbiological quality (eg caused by a storm); and
- the risk of adverse taste, odour, laundry staining or other undesirable aesthetic effects.

Each results in different frequency and severity of effect and different costs to the community. A means to weight each risk is difficult and open to subjective judgement. The acceptable lifetime risk of cancer associated with chemical contamination is often cited as one in 1,000,000, whereas the acceptable risk of gastro associated with consuming pathogens my be in the order of one in 10,000 per year (Stevens, et al, 1995). Judgements about the acceptability of risk need the input of both the community and professionals working in the field, balancing the risk of illness from the many other sources against the social and economic cost of waterborne illness.

Under a risk-based assessment approach, water managers need to make informed decisions regarding:

- the basis for improving water quality in terms of reduction in risks and overall costs to customers;

- negotiations with stakeholders about acceptable risk;
- the most cost-effective means by which improvements in water can be achieved; and
- the contaminants or sources which pose the greatest risk.

The WSAA, through the auspices of the CRC on water quality, is conducting a major water quality study in Melbourne aimed at measuring the contribution, if any, filtered water makes to endemic gastroenteritis. The gastrointestinal health of 600 volunteer families is being measured directly using a randomised double blind clinical trial supported by rigorous statistical analysis (WSAA, 1997, p.18). This is expected to shift the focus of regulation of drinking water quality from rigid water quality standards to measurements of public health outcomes. The test group of families drink normal tap water and have a sham water treatment unit. The control group have working water treatment units and drink ultrafiltered water. Neither the families nor the researchers know which is which (see box 4.1). The study is scheduled for completion in March 1999.

Box 4.1 Victorian water quality study

Six hundred Melbourne families are taking part in a study into new ways of measuring the acceptability of current drinking water quality. The aim is to directly measure the effects of drinking water on people's health.

The 600 households are keeping a detailed record of family health over an 18 month period. Half of the families are drinking tap water, with the other half drinking water filtered at their taps. None of them know what kind of water they are drinking. At the end of the study, the health records of the two groups will be compared.

Source: Melbourne Water, *Annual Report*, 1997.

Aesthetics

The measurable physical parameters which determine the largely subjective qualities of water that people experience when they drink or use it are colour, turbidity (cloudiness), hardness, total dissolved solids, pH, temperature, taste and odour. The physical quality of water is still the primary determinant of aesthetic acceptability. In general these physical characteristics do not threaten public health. However, if water appears to be of poor quality, then even though it may be quite safe to drink, the consumer may seek other water sources which may not be as safe from a health perspective.

What is aesthetically acceptable will depend to some extent on customer expectations, and should ideally be determined by water suppliers in consultation with their customers, taking into account the costs and benefits of further treatment. Old pipes, for instance, can become badly rusted inside. The rust restricts the flow through the pipe and may discolour the water. Small concentrations of pesticides may also affect the appearance and taste of drinking water although unlikely to harm health. Community acceptance of a supply is determined by a number of factors including cultural conditioning, perceptions of equity and access to clean water, perceptions of safety, add-on costs to improve water quality, level of consumer education and fears about the possible effects of water treatment processes.

Additives

The extent of treatment required of drinking water depends on the nature of the water entering the water treatment works. Water from springs, for example, might only require disinfection because it has filtered naturally. Water from dams and rivers normally requires more extensive treatment depending upon the source quality. Such processes may involve the use of chemicals to coagulate particles too small to be removed by screens; addition of lime for pH correction; and disinfection, usually with chlorine, to ensure that the water is suitable to drink.

Treatment of drinking water may create health problems of their own:

> While most decisions about water quality management involve setting maximum values of undesirable contaminants, two chemicals are often deliberately added to drinking water. Chlorine is added so as to maintain a residue for disinfection, and fluoride is added to reduce dental caries. Both are toxic to humans in high concentrations so that upper limits must be set. With chlorine there is the added complication that it can combine with some organic chemicals which may be present in small concentrations to produce compounds which are highly toxic (Alexandra et al, p. 23).

Water treatment therefore requires consideration of the need to balance long-term chemical risk against short-term microbiological risk. Water treatment in this context includes water source protection, filtration, disinfection and prevention of contamination in pipework.

In most cities, reticulated water is becoming more processed, adding to cost and with implications for health. Town and city water is extensively treated using a range of methods and technology. Up to 80 different chemicals are added to town water in treatment processes. In recent years there has been much public debate on the health implications of chlorination, fluoridation, and clarification additives, among others. For example, aluminium compounds used to flocculate dirty water have been linked to Alzheimer's disease and chlorination has been linked to cancer, though the matter is subject to continuing debate (Archer, 1991). Correspondingly, there has been a surge in demand for bottled water and domestic-scale water filters.

The first evidence that disinfection of drinking water resulted in the formation of by-products was reported in 1974 when the formation of trihalomethanes (THMs) was observed in water that had been chlorinated (Bellar et al, 1974; Rook, 1974). It is now recognised that THMs are just one of many by-products of disinfection. Chlorination of drinking water is the major source of THMs to the consumer and the predominant THM formed is chloroform. THM formation depends on raw water quality, pH and temperature of the water, chlorine dose and contact time. There is only limited evidence of long-term effects of exposure to chlorinated by-products, although epidemiological evidence suggests they may be responsible for an increase in certain cancers (Bull, 1992).

4.2 Defining water service quality

Water service quality relates to aspects of the delivery of water supply such as reliability of supply and handling of customer complaints and queries. Several service quality indicators relating to the water industry are discussed below.

Service reliability/supply disruptions

A water supply interruption begins when a water main is shut down to allow repair or maintenance to be carried out causing loss of water supply to customers connected to the main. The interruption ends when water supply is restored.

Water supply disruptions may be planned or unplanned. A planned interruption is scheduled (eg for routine maintenance); an unplanned interruption is unscheduled and results from such causes as a burst water main or damaged fire hydrant.

The number of unplanned interruptions is influenced in part by factors within the company's control, such as preventative maintenance programs. Factors beyond the company's control, such as weather patterns and soil type, also influence the rate of burst pipes. Such extraneous factors need to be taken into account when monitoring performance. Climatic changes can lead to soil movement (and subsequent asset failure) due to:

- changes in water table/soil moisture content;
- frost heave and clay shrinkage;

- and loss of anchorage/support.

Climatic variability and underlying geology affect the aging of assets and hence failure rates due to changes in water table/soil moisture content; frost heave and clay sinkage; and loss of anchorage/support (WSAA, 1996, p.63). A business whose predominant soil type is sand will, all else being equal, have a much more stable failure rate than one whose predominant soil type is expansive clay (WSAA, 1997). Natural disasters such as seismic shock waves can also contribute to failure rates.

Water meter accuracy

Water meter accuracy is important where customers are charged for water usage. When meters give inaccurate readings consumers inadvertently may be charged too much or too little; some consumers may be cross-subsidising others. Meters may be tested at the customer's request, or initiated by the water company in the case of unusual readings.

Water pressure

Low water pressure is inconvenient because it affects the operation of water-using appliances and equipment in domestic and business properties (although lower pressure reduces wastage from leakage).

The pressure in urban water supply systems in Australia is generally around '45 metres head'. This high pressure is to provide enough 'head' to a double storey building and help in fire fighting. In remote places such high pressure is not necessary. In most cases, the water supply pressure is such that it will fill a storage tank at a first floor level. In technical terms this is equivalent to a water pressure of 10 metres head at the boundary stop tap. By way of illustration, this pressure would allow a 2 gallon bucket to be filled in one minute from a downstairs tap with the tap on full. Water companies are generally subject to such a minimum standard.

Water pressure and flow rates in the home can be affected by a number of factors:

- the height of the property above the water main and its height in relation to the local storage reservoir or tower;
- the condition of the service pipe;
- whether the property shares a supply pipe with other properties;
- peak demand conditions; and

- the property's internal plumbing.

Some factors, such as the condition of the pipes from the property boundary to the tap and plumbing maintenance, are the responsibility of the property owner.

Customer satisfaction/response to complaints

Customer contracts and the ability of the average customer to access comparative performance data are important parts of the reform process. One of the edicts of the Guidelines is for water authorities to establish drinking water standards of service (SOS) with their customers.

Service quality may also include alternative payment arrangements for arrears in water rates and charges for customers in financial hardship, and information on government assistance. The quality of such services are likely to be reflected in the number of restrictions and disconnections for non-payment of accounts.

Whereas large industrial customers account for most consumption of electricity and gas, three quarters of urban water is used by households. This more dispersed demand profile, together with a lack of competition in supply, has implications for service quality. Large industrial customers, particularly if they have alternative sources of supply, can influence service quality when their market power countervails that of the utility companies. For the dispersed demand profile of water users, a more systematic approach to handling customer problems needs to be provided by the supplier.

4.3 The price/quality trade-off

It is important for consumers to achieve value for money and for firms to provide a level of service for which the customer can afford or is willing to pay for. This places a duty for regulators of quality to balance costs against benefits to avoid the inefficiencies associated with standards being set too high.

As the Director General of Ofwat stated (Ofwat 1994):

> Assets should be properly maintained, but customers should not have to pay for gold plating. Companies should maintain the overall service capability of their assets; they will have to take account for this...

A more important problem arises from the existence of separate regulators with different duties and powers. Separate regulators facilitate more transparent objectives but they also need to cooperate to ensure the compatability of standards and objectives. The inefficiencies associated with quality levels being set at inappropriate levels due to the interaction of several regulators is known as a problem of common agency (Bernheim and Whinston, 1986). Only if there is close cooperation between the regulatory agencies and if their duties are compatible could we expect to obtain efficient standard setting.

Tighter water quality standards are likely to confer high cost penalties in the form of steeper water rates on consumers. This could place pressure on water authorities and in turn on health agencies to provide a more realistic if conservative assessment of health risks. The quality of source water can have significant implications for the cost of meeting drinking water standards; extra pollution increases the cost of meeting a given standard of water purity. A risk-based assessment approach would enable, say, the cost of constructing a water filtration plant to be balanced against the risk reduction likely to be achieved, and the relative benefit of such a strategy compared with less costly alternatives.

Price reforms are important to the incentive structure for water quality. A water company has little incentive to increase the quality of water supply without a meter. If it increases quality this might encourage an increase in consumption without a direct means to obtain extra revenue as a result of the incremental increase in demand.

The Sydney Water Board conducted benefit-cost studies of water quality improvements. The studies identified the following principal benefits from improved quality (SWB & Dwyer-Leslie Pty Ltd, 1991):

- reduced risks to health;
- reduced damaged to pipe, pipe linings and water using devices;
- lower delivery system, operating and maintenance costs through lower cleaning costs;
- savings in the cost of water treatment by some industries (eg hospitals); and
- reduced spending on the alternatives (bottled water, filters, etc.) by consumers.

The 1991 present value of these benefits (avoided costs) to the Sydney region was estimated to exceed the present value of the costs by $1,200 million. This represented a net benefit of approximately $40 per person per year (Chapman and Cuthbertson, 1996).

Without regulation, monopolistic utility industries may generate significant resource allocation and inefficiency from their monopoly pricing and lack of attention to quality. At the other extreme, direct regulation can cause its own inefficiencies, including the cost of the regulatory body; the administrative costs imposed on the regulated firm and the scope for it to engage in unproductive strategic behaviour; the compliance costs arising from arising from imperfect regulation; and the losses associated with the possible corruption of the system through 'regulatory capture'.

Water authorities might be tempted to lower costs by lowering quality. However, in the interests of maintaining good customer relations and enhancing its public image — and the possibility of reprisal through claims for damages — the firm has an incentive to provide high quality.

With respect to aesthetic dimensions of water quality and service quality, consumers are likely to have complete information before they consume. However, many aspects of drinking water quality, such as concentrations of metals, cannot easily be assessed by consumers without testing the water themselves.

The climate variability experienced in Australia increases the cost of transporting water. Water transport systems have been designed to meet the peak period flows required to provide security against drought, including water on demand to irrigate gardens, in the face of significant variability of rainfall and run-off. The high variability in demand has led to significant periods during the year where water transport and treatment systems are under utilised. This is a key driver of wholesale water supply costs.

High service standards can drive the renewal of water reticulation systems before their economic lives are reached. Customer requirements for minimum pressures or rates of flow, for instance, directly increase both capital and operating costs. In Sydney, unnecessarily high water pressures have been cut to reduce wear and tear on the distribution system (Roberts, 1997). A supply-side view of the market driven by a preoccupation with engineering excellence is said to have resulted in an excess of capital resources. For example, the Warriewood water treatment plant in Sydney was built with a row of pumps that will never be used.

Current regulatory regimes may not be sufficiently flexible to deal with the diversity of consumer preferences and different cost/benefit trade-offs between regions. The Industry Commission (1992) examined the incentives facing regulators to over-regulate. It found that although the tightening of standards for drinking water may reflect a shift in consumer demand it more likely reflects a concern by regulators to cover themselves against all foreseeable eventualities irrespective of cost.

Determining the right balance between price and quality is difficult in practice. The rule is that cost and benefits should be equal at the margin. One problem in achieving this balance is the difficulty of estimating consumers' preferences for marginal changes in quality. There are techniques for estimating willingness to pay for given improvements, including direct questioning or contingent valuation, but their application is often difficult, especially in the water context.

4.4 Evaluating and reporting water quality

In ancient Rome, the water — which according to Henschel would be considered hard, ranging from 110 to 480 ppm calcium carbonate — was tested for quality by the way it cooked vegetables; the presence or absence of sediment in a vessel on standing, or on the sides and bottom on boiling down. Water was also examined for taste and odour. And if the local inhabitants who used the water were in good health, the water was considered safe (Goldfinch, 1997, pp 9-10). These are perhaps the classic beginnings of evaluating water quality.

In practice, it is neither physically nor economically feasible to test for all harmful materials or organisms which may be present in water. For the majority of characteristics, local conditions and knowledge of the supply system will help determine whether and how frequently an analysis should be undertaken.

It is not at all clear what the basis of drinking water standards should be other than the fact that water quality should be regulated from a public health perspective. In the case of urban water supply, some people may consider it essential to provide a fully reticulated, high pressure, contaminant free water and aesthetically pleasing supply of relatively unlimited quantity without any interruption or restriction. However, responses to community consultation forums and surveys conducted by ACTEW suggest that the majority of consumers do not wish even to take the time to have a view on this particular issue (ACTEW, 1996). Most people's view is that someone in whom they have confidence should make the decision about the appropriate levels of, say, nitrate in water.

In Australia there are two national sources of comparative data for water industry businesses. The Water Services Association of Australia (WSAA) has been collecting and reporting information for the two years since its formation in 1995. This is by means of a major questionnaire distributed and filled in by its 18 member water businesses throughout Australia. WSAA's earlier performance information is based on previous reviews conducted under the auspices of the Australian Water Resources Council and its successors. WSAA has expanded its service delivery indicators in 1996/97 to include customer contacts and intends to develop an adequate comparative performance reporting methodology on customer satisfaction for future editions of its *Facts* publication.

The second source of comparative data is the Steering Committee on National Performance Monitoring of Government Trading Enterprises (SCNPMGTE), which has been reporting annual financial data since 1991-92. Service quality comparative data by the SCNPMGTE is more recent and limited by what the utilities are willing to supply. Some claim that

> disclosure (of non-financial performance indicators such as interruptions to supply) is inconsistent with competitive neutrality because it would advantage potential private sector competitors by providing them with commercially sensitive information (SCNPMGTE, 1997, foreword by Chairman Bill Scales).

Results are reported in chapter 6 for selected Australian water businesses for the years 1990-91 to 1996-97. Due to the wide variety of standards and guidelines used by regulatory authorities for measuring quality, the results only show compliance with the standard or guideline specified in the authorities' licence.

Interpretation of the data requires consideration of the different service levels, regulatory prescriptions (eg water quality standards) and operating environments (physical and structural). For this reason cross-business analysis is not as useful for this study as the trend or time series analysis. The latter is potentially useful for assessing how the quality of individual water businesses has changed over time, and hence under different regulatory, institutional and structural arrangements.

The UK Water Services Association (WSA) was formed in 1886. The UK water regulatory authorities are responsible for reporting comparative data (discussed in chapter 5). WSA compiles aggregate water quality data for its member businesses, reported on in chapter 6 for the years 1990/91-1994/95.