Consumer willingness to pay for improvements in the water sector

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This is a translation of the analysis "Forbrugernes betalingsvilje for forbedringer i vandsektoren" published October 2020.

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Summary

1.1 Background and purpose

The water sector consists of natural monopolies. This means that water and waste water companies are not exposed to competition. Therefore, consumers and companies cannot switch to another company offering a lower tariff. Water sector companies consequently do not face the same pressure of improving user experience and lowering their costs on an ongoing basis.

In a well-functioning market, consumers often have the option of choosing between product variants with different price and quality combinations. In this way, consumers can signal whether they are willing to pay the price for increased quality or whether they prefer a less expensive product variant of a lower quality. Also this mechanism is not applicable to natural monopolies.

The water companies are therefore subject to economic regulation. An annual revenue cap is fixed for the water companies which stipulates the revenue that the water companies may generate through the tariffs that they charge their customers. In this connection, the water companies are also subject to continuous requirements that, like companies that are exposed to competition, they must improve the efficiency and productivity of their water production and waste water management. The purpose of the regulation is to ensure that costs, and thus tariffs, are not unnecessarily high in relation to the tasks that the companies are to perform.

A political agreement on adjusted regulation of the water sector was entered into in 2018. One of the areas governed by the agreement is that consumer preferences in the sector of drinking water and waste water will play a role in the future economic regulation of the water companies. This means that the Danish Water Regulatory Authority can lay down measurable and objective quality requirements in the form of, for example, security of supply and service. It also means that non-compliance or compliance with these requirements may be sanctioned or rewarded to give the companies a financial incentive not to reduce security of supply and service.

In order to implement this, it is important to know how much importance consumers attach to security of supply, service and quality, and whether the willingness to pay for these attributes is greater than the price they actually have to pay for them. The specific purpose of this analysis is therefore to measure consumer willingness to pay for, for example, security of supply, water hardness and service.

1.2 Results

The overall findings of the analysis indicate that Danish consumers are willing to pay a slightly higher water bill for increased security of supply and softening of their drinking water (calcium removal). In turn, there is no indication that consumers are willing to pay to achieve better customer service.

The ascertained willingness to pay is fundamentally the maximum price that consumers are willing to pay for the measures in question. It is not, however, an expression of the 'payment'

in the form of higher revenue caps that a water company will receive for, for example, softening its water. In such case, consumers will not achieve any net benefit. Consumers will only achieve a net benefit if a water company can soften its drinking water at a *lower* cost – and preferably significantly lower cost – than what consumers are willing to pay to have their water softened, and that the lower cost also manifests itself in a correspondingly lower tariff.

Consumer preferences for security of supply are illustrated in the analysis based on two different security of supply dimensions for drinking water:

» Security of supply (calculated as unplanned supply interruption minutes)
» Health-related quality of the water supplied (measured as the percentage of water samples that exceed the threshold value for bacteria).

The security of supply for drinking water is already high in the Danish water sector. The average household thus only lacks water for 13 minutes a year as a result of unplanned interruptions in the supply of drinking water. The survey suggests that consumers are willing to pay a limited amount to achieve even fewer interruption minutes. Based on the findings of the survey, the households are willing to pay an additional amount of between DKK 2-7 for their drinking water for each minute by which the number of interruption minutes can be reduced.

The reason for the range of DKK 2-7 is that the willingness to pay for fewer interruption minutes depends on how many responses are included in the calculation. If the responses from all respondents in the survey are used, the households are willing to pay an additional amount of just under DKK 7 for their drinking water for each minute by which the interruption minutes can be reduced. Excluding respondents for which there may be doubt about the quality of their answers, we arrive at a slightly lower willingness to pay of DKK 5-6 per year for each minute by which the interruption minutes are reduced. A single sensitivity analysis shows an even lower willingness to pay of DKK 2 per minute (and where the willingness to pay is not statistically significantly different from zero). Criteria connected with the quality of the answers include very short time used to answer the survey and a lack of consistency in answers across questions.

On average, the threshold value for the contents of bacteria is exceeded in 5 in 1,000 water samples in water companies that are subject to economic regulation. Based on the survey, households are willing to pay a higher water bill if the proportion of samples exceeding the bacteriological threshold value (overruns) can be reduced. In specific terms, the survey indicates that households are willing to pay DKK 90 per year in increased water bill for one less overrun per 1,000 samples. The analysis also shows that there is a difference among consumers in the willingness to pay for bacteriological overruns. According to the calculation, 26 per cent of the respondents are thus not willing to pay extra for fewer overruns.

It may be difficult for participants in the study to assess the health risk associated with bacteriological overruns. For example, the literature highlights that the risk of events occurring with very little probability is often overestimated and that the benefit of a reduction of a risk of a negative event, which is already very low, is often overestimated. This must be seen in the light of the possibility that the relative improvement may create an illusion that the improvement is greater than it actually is. There may therefore be a risk that the expressed willingness to pay for a reduction in bacteriological overruns is overestimated.

Consumers are also willing to pay for a softening of their water, i.e. for a reduction of the calcium content of the water. On average, households are thus willing to pay a higher water bill of between DKK 220-800 per year for a halving of the calcium content. The amount depends on whether the household lives in an area with hard water (a high level of calcium) or soft water (a low level of calcium). Households living in areas with the hardest water are willing to pay the most to have their water softened.

In turn, the survey does not suggest that consumers are willing to pay more for improved customer service in the form of longer opening hours as well as faster responses to inquiries. This may indicate that consumers only contact their water company relatively rarely.

The ascertained willingness to pay for better security of supply and softening of the drinking water is generally consistent with corresponding results from previous surveys published in scientific journals. However, relatively few comparable published surveys have been identified.[1]

It has been examined whether there is a difference in the willingness to pay for households with different income levels. There is no evidence that low-income households systematically have a lower willingness to pay for security of supply (supply interruptions and bacteriological overruns) than households with higher income. This suggests that there will be a benefit across income groups if the value of increased security of supply for consumers exceeds the companies' cost for ensuring a higher security of supply. [2]

Regarding softening of the drinking water, however, there are indications that low-income households in areas with relatively hard water generally have a slightly lower willingness to pay than households with higher income. This could potentially mean that water softening is more in the nature of a luxury good than security of supply. If the cost of softening the water is higher than low-income households' willingness to pay, softening of the drinking water will therefore entail a loss of welfare for low-income households.

It has not been possible to identify relevant waste water attributes which can be explained to consumers in a specific, clear and relevant manner and which can also be calculated and measured based on existing waste water supply data. Therefore, it has not been estimated whether consumers are willing to pay a higher water bill for waste water supply improvements. Instead, general questions have been asked about consumer preferences for different waste water measures. The findings from these general questions indicate that consumers prefer measures aimed at ensuring further waste water treatment and improvements in management of heavy rainfalls rather than measures aimed at reducing energy consumption. However, one should be careful not to interpret these views on waste water too rigidly; there may be differences in the level of costs (and, ultimately, the water bill) of the various measures in the field of waste water management.

1.3 About the method

As water companies are natural monopolies, consumers do not have the option of switching companies to achieve, for example, higher security of supply even if they would like to do so. It is therefore not possible to use actual market data to calculate consumers' willingness to pay for security of supply and service.

Therefore, a questionnaire-based valuation method has been used instead. Specifically, a so-called discrete choice experiment has been used. In discrete choice experiments, respondents must choose between different hypothetical alternatives, where the drinking water supply is

[1] Two surveys that highlight consumer willingness to pay for fewer interruption minutes can be mentioned as examples. One study finds a willingness to pay that is not statistically significantly different from that found here, while the other survey arrives at a significantly higher willingness to pay per interruption minute, see Chapter 5.

[2] If, for example, the average willingness to pay for increased security of supply was a reflection of a high willingness to pay among high-income households, whereas low-income households did not want to pay more at all, it would entail a loss of welfare for low-income households if the water bill was increased to achieve a higher security of supply. However, the analysis does not suggest that this is the case.

described by different parameters for the service provided (security of supply, customer service, annual cost, etc.). Discrete choice experiments are one of the most commonly used hypothetical valuation methods. The method is particularly useful when you want to examine the willingness to pay for different attributes in the product that you are analysing.

There are many attributes/parameters that may potentially be indicators of water supply quality. In the survey, importance has been attached to selecting parameters that can provide relevant input to the above analysis of how the current economic regulation of the water companies can integrate economic sanctions or rewards related to security of supply and consumer satisfaction. A number of criteria have consequently been used for the selection of parameters: They must be parameters with good data at company level. These data should be based on actual calculations and not model calculations with great uncertainty.[3] Furthermore, the method presupposes that you can describe in a clear and concise manner the consequences for consumers of changes in the level of a given parameter. In addition, parameters/attributes that are already subject to regulation that provides a financial incentive, for example a green tax, have been excluded. This has been done to avoid double regulation. Against this background, the focus of this analysis is on parameters related to drinking water.

The analysis is based on responses from 2,200 private water consumers collected in spring 2020. In addition, previously published surveys have been reviewed and a qualitative interview survey has been conducted of water consumers' attitudes to drinking water and waste water.

It is important to note that the estimated willingness to pay, calculated using hypothetical valuation methods, reflects the consumers' own (private financial) valuation of the various improvements in security of supply, etc. In practice, such willingness to pay is often used as a measure of the socio-economic benefit per household of improvements in the relevant good. However, there may be differences between the socio-economic benefit and the personal financial benefit measured by private consumers' willingness to pay. This will be the case if there are external effects that consumers do not include in their assessment of how much more they are willing to pay for, for example, increased security of supply.

There are a number of known challenges with hypothetical valuation studies that are taken into account in the design of the survey and in various types of testing of the results.

An often highlighted challenge is whether hypothetical valuation surveys result in an overestimation of consumers' willingness to pay because, in practice, the respondents will not have to pay the amounts that they state that they are willing to pay in their answers (so-called hypothetical bias). However, the research indicates that hypothetical bias may be limited if it can be made clear to the respondents that their answers may actually affect their future drinking water costs. This means that a potential hypothetical bias is reduced if the respondent is aware that the responses may have actual financial consequences. The questionnaire emphasises that this can be done with reference to the survey being conducted by the regulatory authority responsible for implementing the economic regulation of the water companies.

The survey also meets a number of other established validity criteria. For example, it has been tested whether the willingness to pay increases with the size of the assessed improvement. This means that the estimated willingness to pay is higher when the improvement in security of supply is large relative to small improvements. Correspondingly, the willingness to pay for

[3] The reason for this is that it may be problematic to impose a financial sanction on (or grant a financial reward to) companies based on model calculations instead of observable data.

softening of the water (halving of the calcium content) is greater for households with hard water. Finally, the results are generally quite stable across different assumptions about the criteria for selecting the final population of respondents used in the calculations.

Chapter 2
Background and purpose

The political agreement on adjusted economic regulation of the water sector stipulates that "*security of supply and consumer satisfaction must be integrated into the future economic regulation. The Danish Water Regulatory Authority will therefore be able to make measurable and objective requirements for security of supply and for consumer satisfaction in the long-term economic regulation. The companies must therefore be rewarded or sanctioned according to whether they meet the targets set. This ensures that the companies provide both high service and quality while also meeting the ongoing requirements for efficiency improvement that ensure lower prices for consumers.*"

To assess consumer satisfaction in the water and waste water sector, it is necessary to identify consumer preferences for the services provided by water companies to consumers. In the present analysis, this is done based on behavioural science and the scientific methods in economic valuation.

On this basis, empirical measures have been obtained for water consumers' willingness to pay for selected, measurable attributes in the water companies' services which are assessed as having a potential influence on consumer satisfaction. This applies, for example, to security of supply and water hardness (calcium content). The water companies can affect the selected attributes in the organisation of their production.

Consumers' willingness to pay thus shows their preferences for the attributes in question in their water supply, and the calculated willingness to pay can potentially be included in the calculation of – and thus have an effect on – a water company's revenue cap.

The purpose of integrating measures of consumer preferences in economic regulation is to ensure that water companies can better adjust their production so that they provide the services that consumers ultimately demand. This must be seen in relation to this being a sector with natural monopolies which is not governed by general market mechanisms. If consumer preferences can be measured with reasonable precision, this will, for example, allow companies to better take consumer considerations into account when organising their production and in their compliance with the ongoing statutory requirements for efficiency improvement.

Consumers' interests are already handled in the Danish utilities sector to a greater or lesser extent. The revenue cap regulation ensures, for example, that consumers and companies do not pay unnecessarily high prices. In this way, the economic regulation directly addresses the 'market fault' inherent in natural monopolies not being exposed to competition which creates an incentive for efficient operations. At the same time, consumer interests are involved to some extent through ownership structure and board composition, etc.

The 2018 agreement stipulates that it must be possible to reward or sanction the water companies for their security of supply performance. The Danish Water Regulatory Authority is preparing an analysis of how security of supply can be integrated in the benchmarking model that will be published in 2021. The Danish Water Regulatory Authority has also published an analysis of the overall incentive structure of economic regulation with a model for sanctions

and rewards for consumer satisfaction and security of supply[4]. It is of central importance that the incentives in a sanction model interact expediently with the other regulation. .

[4] https://www.kfst.dk/media/pfiailpe/20210607-forsyningssikkerhed-og-regulering-af-vandsektoren.pdf

Chapter 3
Method

When identifying consumers' willingness to pay, a general distinction is made between two types of preference analysis methods: revealed (observed) or stated (hypothetical).

Revealed preference analysis methods are based on real market transactions, as opposed to stated preference analysis methods, which establish a hypothetical market to which the respondent must relate. Revealed preference analysis methods are usually preferred, as they rely on real behavior, but they require that consumers' market choices can be observed[5]. However, in markets with monopolies, such as the water supply sector, there are no market transactions that can be used to value the attributes of the supply service. As mentioned above, this is reflected in citizens and companies not being able to switch suppliers and in the general market mechanisms having thus been deactivated.

Discrete choice experiments are a widely used (stated) preference analysis method for valuation of non-marketed goods. They are well suited for examining how the consumer values the individual attributes[6]. Discrete choice experiments are a questionnaire-based method in which respondents are asked to choose from different hypothetical alternatives. The alternatives consist of different levels for selected water supply attributes, for example security of supply, and the respondents' choices are then used to determine how the attributes are prioritised in relation to each other. When the price of water is included as an attribute, it is possible to estimate the respondents' willingness to pay for the different attributes.

There are a number of challenges with stated preference methods because the method analyses hypothetical behaviour in which, unlike in a real market, the consumers do not experience the consequences of their choices. Some common sources of error are[7]

» Hypothetical bias (see section 3.4)
» Protest and strategic behaviour (see Appendix 2)
» Insensitivity to scope (see sections 3.2 and 5.3)

Hypothetical bias occurs when the respondents overestimate their willingness to pay for the attribute they are being asked about. Protest and strategic behaviour means that, for various reasons, the respondents do not reveal their actual preferences. Finally, problems may arise if the respondents misunderstand the survey or valuation scenarios or if the descriptions of the

[5] For example, consumers' costs for water softening can be used for a valuation of the softening of the drinking water, see, for example, Lanz, B., & Province, A. (2016). The demand for tap water quality: Survey evidence on water hardness and aesthetic quality. Water Resources and Economics, 16, 52-63.

[6] Hanley, N., S. Mourato and R. E. Wright (2001). "Choice modelling approaches: a superior alternative for environmental valuation?" Journal of Economic Surveys 15(3): 435-462

[7] Andreasen, L. D., & Ladenburg, J. (2018). Værdisætning af offentlige investeringer og serviceydelser (Valuation of public investments and services). https://pure.vive.dk/ws/files/1905606/11539_vaerdisaetning_af_offentlige_investeringer_og_serviceydelser_1_.pdf

individual attributes are not sufficiently accurate. This may result in an insensitivity to the scope of the individual improvements.

In the design of the questionnaire and the subsequent analysis, commonly used methods have been used to test for these sources of error and minimise their impact on the results. In addition, a number of analyses have been done to ensure the validity of the survey results (see Chapter 5).

3.1 Design of the questionnaire

The questionnaire (Appendix 1) contains both general questions about the respondents' attitudes to their water supply and a discrete choice experiment concerning preferences for drinking water supply. The contents of the questionnaire have been prepared based on a number of prior studies:

1. A review of the existing literature on consumer preferences for drinking water and waste water
2. Dialogue with selected stakeholders in the drinking water and waste water sector
3. A qualitative survey of consumers' attitudes towards drinking water and waste water conducted in collaboration with the consulting firm Morphic (Appendix 4[8]
4. An in-depth interview with five respondents to validate the final draft of the survey, conducted in collaboration with the consulting firm Userneeds
5. A pilot test with 181 respondents.

The prior analyses have been necessary for a number of reasons, including to ensure that the focus is on attributes that are relevant to consumers, measurable and adjustable for the companies. In addition, it has obviously been a key objective to find credible estimates of consumers' willingness to pay for the attributes in question.

3.1.1 Structure of the questionnaire

The questionnaire consists of approximately 40 questions and has the following structure:

» Background characteristics
» Questions about and attitudes to current water supply
» Information about the discrete choice experiment
» The discrete choice experiment
» Debriefing
» Preference questions about waste water supply
» Concluding general questions.

The questionnaire begins with general demographic questions about gender, age and place of residence. These questions are used in an assessment of whether the respondents constitute a representative selection of Danish consumers.

Questions are subsequently asked about the respondents' attitude to their current water supply. The primary purpose of these questions is to 'warm up' the respondents by drawing their

[8] KFST (2019), Vand, Rapport, Private Forbrugere (Danish Competition and Consumer Authority (2019), Water, Report, Private Consumers)

attention to their water supply. This should make it easier for the respondents to consider the choice scenarios in the discrete choice experiment. In addition, one of the questions is used to ensure that the questionnaire is not answered by respondents who receive their water from a private water borehole.

This is followed by an introduction to the discrete choice experiment that explains the attributes that the respondents are to consider. Here, the respondents are asked questions about their attitudes to and experience with the current levels of the attributes. The purpose of these questions is to direct the respondents' thoughts towards their drinking water supply and enable them to answer the choice scenarios as accurately as possible. After the description of the attributes, the respondents are asked a series of control questions that make it possible to check how well the individual respondent understands the choice scenarios.

In the discrete choice experiment, the respondents must choose the alternative (out of three options) they prefer. There are a total of five different choice sets. The design of the choice sets is described in section 3.2. The choice sets are shown in random order, except for the fifth choice set, which always appears last and solely serves as control questions.

In the subsequent debriefing, a number of questions are put to the respondents who always choose the current alternative and to the respondents who always choose something other than the current alternative. These questions are used to identify protest and strategic behaviour (see Appendix 2).

The discrete choice experiment only examines the respondents' preferences for the supply of drinking water (see section 3.2). In the waste water part of the questionnaire, the respondents are therefore only presented with a brief introduction to waste water and asked to rank three possible improvements in waste water management. The respondents must subsequently choose between an improvement of their drinking water or waste water supply. The purpose of this part of the questionnaire is to provide an overall insight into the respondents' preferences for improvements in their waste water management.

Finally, a number of supplementary demographic questions are asked about the respondents' income, education and family situation.

3.2 Design of the discrete choice experiment

As mentioned above, the attributes in the discrete choice experiment have been selected based on prior studies. The identified attributes have subsequently been evaluated based on a number of structural criteria:

- the individual attributes must be measurable and comparable across water companies,
- it must be possible for the water companies to affect the attributes,
- the attributes must not be covered by the existing environmental regulation if this gives the water companies an incentive to improve the individual attribute[9] and
- the attributes (and adjustments thereof) must be clearly and concisely describable for consumers.

[9] There is already regulation in a number of matters that consumers highlight as important. For example, the prior study indicates that consumers demand that companies reduce water waste from their production. However, water waste is already subject to a tax (if it exceeds a certain level). If the companies could increase the price of drinking water because they lowered water waste, they would, in effect, obtain a double gain (less tax plus higher price), which is regarded as inexpedient.

On the basis of the prior study and these criteria, five relevant drinking water attributes were identified.

It is not possible to find attributes for waste water that meet the structural criteria. For example, the parameters from the Danish Environmental Protection Agency's performance benchmarking of waste water cannot be determined and linked to the individual company with sufficient accuracy. Moreover, the attributes of waste water are difficult to describe in such a way that consumers have an actual opportunity to value them.

The effect of many attributes related to waste water are also spatially dependent (for example overflow)[10]. However, there is a lack of data to link the effect of the attribute to the respondent's address, which means that it is not possible to describe what the actual effect of, for example, overflow will be on the individual respondent.

The discrete choice experiment thus only focuses on drinking water supply attributes. The selected attributes and their levels are shown in Table 3.1. The levels describe the current state of the attributes (marked in bold) as well as the possible improved states. The levels of the attributes are combined into different alternatives which are presented in the choice sets (see Figure 3.1).

Table 3.1 **Attributes and levels in the discrete choice experiment**

Attributes	**Levels**[1]
Unplanned water supply interruptions	**Once per 9 years**, Once per 15 years, Once per 24 years
Risk of bacteriological overruns	**5 in 1,000**, 4 in 1000, 2 in 1,000
Softening of the water	**Not softened,** Softened[2]
The water company's customer service	**Current customer service,** Improved customer service
Annual increase in water costs	**DKK 0**, DKK 40, DKK 100, DKK 250, DKK 450, DKK 700, DKK 1,000

Note 1: The levels of attributes describing consumers' current water supply are marked in bold.

Note 2: Softening of the water is described as a halving of the calcium content of the water. The specific description of the consequences of this in the questionnaire depends on the respondent's current water hardness.

In discrete choice experiments, one of the alternatives in the choice sets must correspond to the consumer's current water supply, i.e. be a combination of the levels of the attributes that correspond to the current state. For the attributes 'unplanned interruptions' and 'bacteriological overruns', this level is based on the average values from the Danish Environmental Protection Agency's performance benchmarking of water companies from 2019[11]. The current level of calcium in the respondents' drinking water, i.e. the hardness of unsoftened water, is based on the water hardness scale chart published by Geological Survey of Denmark and Greenland

[10] This means that the direct consequences of the attributes only apply to specific geographical areas.

[11] Miljøstyrelsen (2019), "Performancebenchmarking af drikkevandselskaber i 2017 til 2019" (Danish Environmental Protection Agency (2019), Performance Benchmarking of Water Companies in 2017 to 2019), https://mst.dk/natur-vand/vand-i-hverdagen/vandsektoren/performancebenchmarking/performancebenchmarking-af-vandselskaber-2017-til-2019/performancebenchmarking-af-drikkevandselskaber-i-2017-til-2019/

(GEUS)[12]. The level of customer service is based on data from the websites of the largest water companies. The levels of the annual increase in water costs are based on the available literature on consumer willingness to pay in this area.

Unplanned water supply interruptions

In the qualitative analysis, the consumers highlighted security of supply as an essential attribute of their drinking water supply. In the analysis, security of supply is defined as the number of unplanned interruptions, i.e. the time in which the household is without water and where no prior notice thereof has been given 48 hours in advance.

Danish water utilities generally have a high security of supply, and consumers are not immediately concerned about the current security of supply level (see report in Appendix 2). According to the Danish Environmental Protection Agency's performance benchmarking from 2019 (with data from 2018), a household in Denmark is without water for an average of approximately 13 min. per year as a result of unplanned interruptions. Planned interruptions, for example in connection with planned renovation work, have not been included in the survey. Naturally, interruptions typically last longer than 13 minutes (just as the typical household does not experience interruptions every year). In the survey, the unplanned interruption minutes from the performance benchmarking have therefore been converted into the[13] risk of a household experiencing a two-hour unplanned interruption. A two-hour duration was used based on discussions with experts in the Danish Water and Wastewater Association (DANVA), as there are no figures for the duration of an average interruption.

Samples with bacteriological overruns

Another important attribute of the water supply is the quality of the drinking water. Water quality may concern more subjective conditions such as taste, appearance, etc., which are difficult to measure. The only one of the assessed conditions that is objectively measurable and comparable across companies is the number of harmful bacteria in the water. The Ministry of Environment of Denmark's performance benchmarking calculates the number of water samples that exceed a set threshold value for bacterial contents (overrun) at the individual water utilities. The analysis uses this 'risk of overruns' as a measure of water quality[14]. The current risk is equal to an overrun occurring in 5 in 1,000 water samples. The small changes in the risk of overruns are illustrated in the questionnaire by means of a 'grid' of 1,000 squares (water samples), where the number of coloured squares show the number of samples with overruns. This type of illustration has been thoroughly tested in the literature[15][16], and it is regarded as a good way to communicate small risks, as respondents generally find it difficult to relate to

[12] De Nationale Geologiske Undersøgelser for Danmark og Grønland (2020), "Kort over drikkevandets hårdhed" (Geological Survey of Denmark and Greenland (GEUS) (2020), Water Hardness Scale Chart), https://data.geus.dk/geusmap/?mapname=drikkevand&lang=da

[13] The conversion assumes that the risk is evenly distributed among the Danish population.

[14] The survey uses the data of the performance benchmarking for the number of overruns for which the water supply is regarded as responsible. These are divided by the sum of the number of statutory microbiological samples and planned accredited microbiological own control samples in addition to the statutory samples.

[15] OECD (2012): Mortality risk valuation in environment, health and transport policies.

[16] Krupnick, A., A. Alberini, M. Cropper, N. Simon, B. O'Brien, R. Goeree and M. Heintzelman (2002): Age, health and the willingness to pay for mortality risk reductions: A contingent valuation survey of Ontario residents. Journal of Risk and Uncertainty, 24 (2), pp. 161-186.

these[17]. Despite this, the importance of a further reduction of fairly small risks can be overestimated because the relative improvement creates the illusion that the improvement is greater than it actually is[18].

In the analysis, there is a risk that the respondents may find it difficult to grasp and assess the scope of any improvement. This may be the case if the valuation exercise is not performed appropriately, for example because the valuation scenarios or attributes are not sufficiently precisely described[19]. This may, for example, result in the payment willingness not varying with the scope of the improvement. In discrete choice experiments, this can be tested by a so-called internal scope test in which it is examined whether the willingness to pay increases with (the levels of) the improvements in bacteriological overruns. In this survey, an external scope test, which is a more rigid sensitivity test, is also performed. Here, a group of respondents in the survey are presented with a greater improvement in the risk of bacteriological overruns than that shown in Table 3.1[20]. The survey meets the external scope test if the willingness to pay is affected by the scope of the improvement. The respondents who have been presented with a greater improvement should thus be willing to pay at least just as much for this improvement as the respondents who were presented with the smaller improvement.

Many respondents are not familiar with or have experience with bacteriological overruns and their specific consequences. The respondents may therefore be more uncertain about their preferences and willingness to pay for reductions in the number of bacteriological overruns relative to more well-known attributes with more specific consequences[21]. The description of the attribute may therefore have a relatively greater impact on the respondents' choices.

In the survey, the respondents have been explicitly informed that a bacteriological overrun does not necessarily have health-related consequences, as there is no precise description of the causal connection between the level of bacteriological overruns and illness[22]. To ensure a correct description of the consequences of bacteriological overruns, the specific description of this connection has been discussed with experts in this field.

It has also been made clear to the respondents that the attribute does not describe findings of pesticides in the drinking water. Pesticides have not been included in the survey, as the presence of pesticides is largely beyond the water companies' control.

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[17] Bateman, I.J., R.T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett and D.W. Pearce (2002): Economic valuation with stated preference techniques: A manual. Edward Elgar Publishing.

[18] Hammitt, J. K., & Graham, J. D. (1999). Willingness to pay for health protection: inadequate sensitivity to probability?. Journal of risk and uncertainty, 18(1), 33-62.

[19] Carson, R., Flores, N. & Meade, N. (2001), "Contingent Valuation: Controversies and Evidence", Environmental and Resource Economics, vol. 19, no. 2, pp. 173-210.

[20] In the scope test part, the improved levels of bacteriological overruns have been described as two overruns per 1000 samples or one overrun per 1000 samples.

[21] According to "discovered preference hypothesis" (Plott, 1996, "Rational individual behavior in markets and social choice processes: the discovered preference hypothesis", McMillian), it can be assumed that the respondents 'discover' their preferences for more unknown attributes during the survey in line with their receipt of more information about the attribute and their choices in the choice sets.

[22] Engelsborg, C. C., Andersen, U. T., Albrechtsen, H-J., Ethelberg, S., & Bagge, L. (2009). Undersøgelse af: Mikrobiologiske drikkevandsforureninger 2000-2002 omfang, årsager, aktion og sygdom. By- og Landskabsstyrelsen, Miljøministeriet. (Study of: Microbiological drinking water contaminations 2000-2002, scope, causes, action and illness. Danish Urban Affairs and Landscape Agency, Ministry of Environment of Denmark) https://naturstyrelsen.dk/media/nst/70157/Final_drikkev.pdf

Softening of the water

One of the most obvious attributes of drinking water is the amount of calcium in the water, i.e. the hardness of the water. In the survey, the calcium level of the choice scenarios was described so that it generally fits the specific degree of hardness in the respondent's municipality.

The municipalities have been divided into five[23] different 'hardness groups' based on GEUS's water hardness scale chart[24]. Respondents who stated that they live in the Municipality of Brøndby have been excluded, as the water in the Municipality of Brøndby is already being softened.

In the choice scenarios, softening of the water is described as a halving of the amount of calcium in the water, which roughly corresponds to the softening done at the water utilities in the Municipality of Brøndby. In the survey, the specific effects of the softening have been described as slightly lower energy consumption, slightly longer useful life of household appliances as well as less time spent on cleaning[25]. For respondents who reside in municipalities in which the drinking water is already soft, it is pointed out in the description that the softening does not result in lower energy consumption or a longer useful life of household appliances, but that it only has a possible effect on the taste of the water and the experience, for example in connection with washing their hair. In the description of the attribute, all respondents are informed that the softening will not have any health effects. This is based on the Danish Patient Safety Authority's assessment that the overall health effect of softening will be very limited[26].

The water company's customer service

According to the qualitative analysis (Appendix 2), the water company's customer service has an influence on customer satisfaction. However, there are no systematic data for conventional service targets for Danish water companies which can be used to define customer service in an objective and comparable way. In addition, it is difficult to define the current service level, as this may vary from company to company.

Despite these challenges, a description has been included of a possible improvement of the company's customer service, corresponding to the water company being more available to the customer through longer opening hours as well as faster response times for inquiries. The current customer service level is assessed based on information available on some of the major water companies' websites.

Increase in annual water costs

In surveys of the willingness to pay, one of the attributes in the discrete choice experiment must describe the 'price' of the alternative or the cost for the respondent. The survey uses an increase in the respondent's annual water costs to describe the price of the alternatives. This

[23] Municipalities with 'extremely hard' and 'very hard' water have been merged into one group, as these only cover 3 and 2 per cent of the Danish population.

[24] De Nationale Geologiske Undersøgelser for Danmark og Grønland (2020), "Kort over drikkevandets hårdhed" (Geological Survey of Denmark and Greenland (GEUS) (2020), Water Hardness Scale Chart), https://data.geus.dk/geusmap/?mapname=drikkevand&lang=da

[25] Miljøstyrelsen (2017), "Blødt vand i en cirkulær økonomi" (Danish Environmental Protection Agency (2017), Soft Water in a Circular Economy), https://mst.dk/media/145463/rapport-bloedt-vand-i-en-cirkulaer-oekonomi.pdf

[26] Ibid.

means that the price increase that the respondent considers is equal to the price of the improvements that an alternative consists of (for example fewer microbiological overruns, fewer interruptions, less calcium, etc.).

However, many consumers do not know how much they are currently paying for their water. In the description of the attribute, the respondents are therefore presented with typical average annual water costs for different households in 2019[27].

When setting the price levels, it is important that the prices are appropriate and ensure sufficient data variation, i.e. that the price differences cover low prices that most consumers are willing to pay and high prices that most consumers are not willing to pay. The analysis was therefore based on data on consumer willingness to pay from the existing preference literature in this area, which was tested in a pilot study in spring 2020. Based on the pilot study, the price levels were adjusted downwards to avoid a so-called *choke price bias*[28], where too many high prices flatten the demand curve, resulting in an overestimation of the willingness to pay.

Choice scenarios

The composition of the levels of the attributes in the different alternatives and the composition of the alternatives into choice sets were designed in the program NGENE[29], which is software specialised in the development of experimental designs for discrete choice experiments. In the chosen design[30], the results from the pilot study were used to generate a design that measures the relevant preferences as efficiently as possible.

The final experimental design consisted of 24 hypothetical alternatives. These were distributed on 12 choice sets. A choice set consisted of three alternatives: two hypothetical alternatives that vary between choice sets as well as an alternative representing the attributes of the respondent's current drinking water supply. The 12 choice sets were divided into three blocks, each consisting of four choice sets. A respondent was presented with one block, i.e. a respondent assessed a total of four choice sets, which were presented in random order. Figure 3.1 is an example of a choice set.

[27] DANVA (2019), "Vand i tal" (Danish Water and Wastewater Association (DANVA), Water in Numbers), https://www.danva.dk/media/6199/2019_vand-i-tal.pdf.

[28] Mørkbak, M., Christensen, T. & Gyrd-Hansen, D. (2010), "Choke Price Bias in Choice Experiments", Environmental and Resource Economics, vol. 45, No. 4, pp. 537-551.

[29] ChoiceMetrics (2018). "Ngene 1.2. User Manual & Reference Guide", Sydney, Australia

[30] The type of design is "Bayesian efficient design", see ChoiceMetrics (2018)

Figure 3.1 **Example of a choice set**

Choose the water supply alternative you prefer by clicking the alternative and then pressing the button at the bottom to proceed:
If you do not agree with any of the suggested alternatives, you can always choose your current water supply, which does not increase your annual water costs.

Current water supply	**Alternative water supply A**	**Alternative water supply B**
2 hours without water (unplanned) once in **9 years**	2 hours without water (unplanned) once in **24 years**	2 hours without water (unplanned) once in **15 years**
Bacteriological overrun in **5** in 1,000 samples	Bacteriological overrun in **2** in 1,000 samples	Bacteriological overrun in **4** in 1,000 samples
Not softened	**Not softened**	**Softened** (50% less calcium)
Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** and **8-20** Response time: **1 day**
Increase in annual water costs **DKK 0**	Increase in annual water costs **DKK 100**	Increase in annual water costs **DKK 450**

3.3 The theory behind discrete choice experiments

The basic underlying assumption of discrete choice experiments is that the utility of a good or a service can be described via its attributes[31]. When a consumer, *n*, makes a choice, the utility, *U*, for alternative *i*, can be described as a function of its attributes, *x*, and the consumer's preference weights, β, for these attributes

$$U_{in} = \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_{PRICE} x_{PRICE,i} + \varepsilon_{in}$$

In this survey, *x* thus describes the levels of the attributes for water supply alternative *i*, and $x_{PRICE,i}$ describes the increase in annual water costs by alternative *i* (see Table 3.1).

It is not possible to measure directly the utility that the consumer gains from a choice. Instead, the consumer's choice between alternatives can be observed, and these choices reveal which

[31] Lancaster, K.J. 1966, "A New Approach to Consumer Theory", Journal of Political Economy, vol. 74, no. 2, pp. 132-157.

of the alternatives gives the consumer the greatest utility. It is assumed that not all factors affecting the consumer's choice can be observed. The utility is therefore divided into an observable (deterministic) part, βx and a non-observable (stochastic) part, ε, which is from the same independent statistical distribution for each consumer.

Different assumptions about this distribution give rise to different choice models. In the vast majority of choice models, a so-called Gumbel distribution is used, which means that the probability, *P*, of alternative *i* being chosen can be described by the logistical probability of choice

$$P_i = \frac{\exp(\beta x_i)}{\sum_{j=1}^{J} \exp(\beta x_j)}$$

The β coefficients are estimated and represent the utility change of the marginal change in attribute. The ratio between two β coefficients equals the marginal substitution rate, based on the assumption that consumers have maximised their utility. The willingness to pay for a marginal change in an attribute can then be found when the denominator in the ratio is the β coefficient for an attribute that describes the price of the alternatives, which, in this study, is the increase in the annual water costs[32].

$$Willingness\ to\ pay_1 = \frac{\beta_1}{\beta_{price}}$$

This analysis uses a so-called *mixed logit* model, which has a number of advantages over simpler models (see Train (2009) [33] for an in-depth description of the model), and is the model type most commonly used in analysis of discrete choice experiments. One of the advantages of the model is that it allows a specification and estimation of certain distributions for the willingness to pay for individual attributes, i.e. the model takes into account any unobserved variation in the willingness to pay.

3.4 Hypothetical bias

One of the greatest challenges of discrete choice experiments (and other hypothetical valuation methods) is that the respondents are asked to make choices in hypothetical scenarios that have no immediate consequences for the respondent. There is consequently a risk that the respondents will overestimate how much they would actually be willing to pay for the improvements in the service. This is called hypothetical bias in the literature[34].

One of the most important strategies for minimising hypothetical bias is to ensure that the descriptions of the service and the valuation scenario are unambiguous and credible, so that the respondents experience that their choices have consequences for the future service. Credible descriptions also ensure that the respondents are motivated to answer according to their true preferences[35] (i.e. the questions in the analysis are *incentive compatible*). Before being asked to

[32] In the analysis, however, the utility is specified in *willingness-to-pay space* (Train, K., & Weeks, M., 2005, "Discrete choice models in preference space and willingness-to-pay space". In Applications of simulation methods in environmental and resource economics (pp. 1-16). Springer, Dordrecht.), which means that the models directly estimate the willingness to pay for the attributes, and the conversion of the β coefficients into willingness to pay does not explicitly need to be made.

[33] Train, K. E. (2009). Discrete choice methods with simulation. Cambridge university press.

[34] List, J. & Gallet, C. 2001, "What Experimental Protocol Influences Disparities Between Actual and Hypothetical Stated Values?", Environmental and Resource Economics, vol. 20, No. 3, pp. 241-254

[35] Carson, R. & Groves, T. 2007, "Incentive and informational attributes of preference questions", Environmental and Resource Economics, vol. 37, no. 1, pp. 181-210.

make the choices in the discrete choice experiment, the respondents are reminded that the survey is being conducted by the regulator and that it could therefore potentially be of importance to the regulation of the water companies. The respondent is therefore asked to respond as if it were a real situation. This type of reminder is assumed to increase the credibility (sometimes called *consequentiality*[36]) of the survey and thus reduce the risk of hypothetical bias.

Another strategy for minimising hypothetical bias is to remind the respondents that there is this tendency to overestimate how much you are willing to pay[37]. In discrete choice experiments, this approach has meant that the respondents in each choice set are reminded to choose the current situation if they think that the other alternatives are too expensive[38]. In certain cases, these *opt-out reminders* (OORs) have completely eliminated the hypothetical bias[39]. Such an OOR has been used in each choice set in the survey.

3.5 Testing and sending out of questionnaire

Before the final questionnaire was sent out, a draft questionnaire was tested through five so-called think-aloud interviews. This test was conducted by the survey company Userneeds. The interviewed respondents completed the questionnaire and were subsequently asked about their answers, experience and understanding of the questionnaire. The questionnaire was corrected based on the comments from the test, after which the questionnaire was pilot tested by 181 respondents at the end of March 2020.

The respondents of the final questionnaire were invited by email through Userneeds' Internet panel[40] in April 2020. The respondents were to answer the questionnaire on a computer or tablet, as it was assessed that the illustrations in the questionnaire did not function optimally on smaller screens such as mobile phones.

[36] Penn, J. M., & Hu, W. (2018). Understanding hypothetical bias: An enhanced meta-analysis. American Journal of Agricultural Economics, 100(4), 1186-1206.

[37] Cummings, R. G. and L. O. Taylor (1999). "Unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method." American Economic Review 89(3): 649-665.

[38] Ladenburg, J. & Olsen, S. 2014, "Augmenting short Cheap Talk scripts with a repeated Opt-Out Reminder in Choice Experiment surveys", Resource and Energy Economics, vol. 37, pp. 39-63.

[39] Alemu, M. H., & Olsen, S. B. (2018). Can a Repeated Opt-Out Reminder mitigate hypothetical bias in discrete choice experiments? An application to consumer valuation of novel food products. European Review of Agricultural Economics, 45(5), 749-782.

[40] Internet panels are a widely used method for collecting answers to hypothetical valuation studies, and previous surveys have not found significant differences between Internet surveys and mail surveys (Olsen, 2009 'Choosing between internet and mail survey modes for choice experiment surveys considering non-market goods.' Environmental and Resource Economics 44(4): 591-610.) or face-to-face interviews (Nielsen, 2011, Use of the Internet for willingness-to-pay surveys: A comparison of face-to-face and web-based interviews. Resource and Energy Economics, 33(1), 119-129).

Chapter 4
Results

This chapter presents selected results from the analysis as well as the estimated willingness to pay from the discrete choice experiment.

4.1 Final population and descriptive statistics of respondents

A total of 1,805 questionnaire responses were collected. Of these responses, 206 respondents expressed protest or strategic preferences, and they have therefore been excluded from the analysis. The effective population in the analysis is thus 1,599 respondents.

Table 4.1 **Exclusion of respondents**

	Number
Full sample	1,805
Protest responses[1]	79
Strategic responses[1]	127
Total excluded	206
Final population	**1,599**

Note 1: The categorisation of protest and strategic responses is based on a combination of the respondents' choices in the choice sets and a follow-up question about the reasons for their choice (see Appendix 3 for an in-depth discussion)

Source: Own calculations.

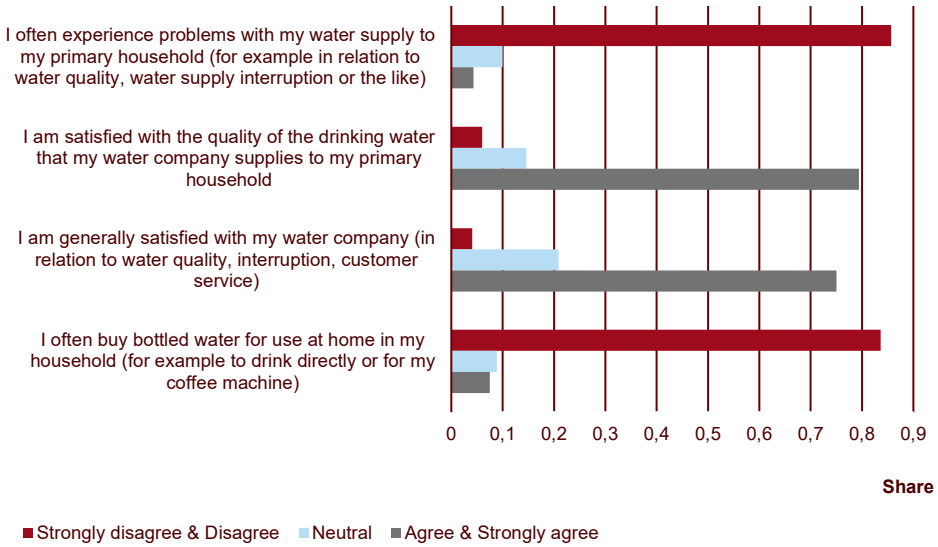
The population is representative of the Danish population between 18-65 years of age, distributed on three age groups, gender and region. The respondents who have chosen to declare their household income (78 per cent of the population) have stated a slightly higher income than the average income of the Danish population[41].

[41] According to Statistics Denmark https://www.statistikbanken.dk/INDKF112, the average family income in 2018 was DKK 521,281. Using the middle and end points of the range from the income question in the survey, the average household income can be calculated as DKK 552,514. A *Chi-square* test rejects the assumption that the income distributions correspond to the Danish population. No weighting of the willingness to pay based on this difference was done in the survey, as this effect is not assessed as significant and because a large part of the population has not declared their income (22 per cent).

4.2 Attitudes to, and experiences with, the current supply of drinking water

Most of the respondents state that they are satisfied with their current water company and that they rarely experience problems with the water supply or the quality of the water supplied, see Figure 4.1 .

Figure 4.1 **Attitudes to current water supply**



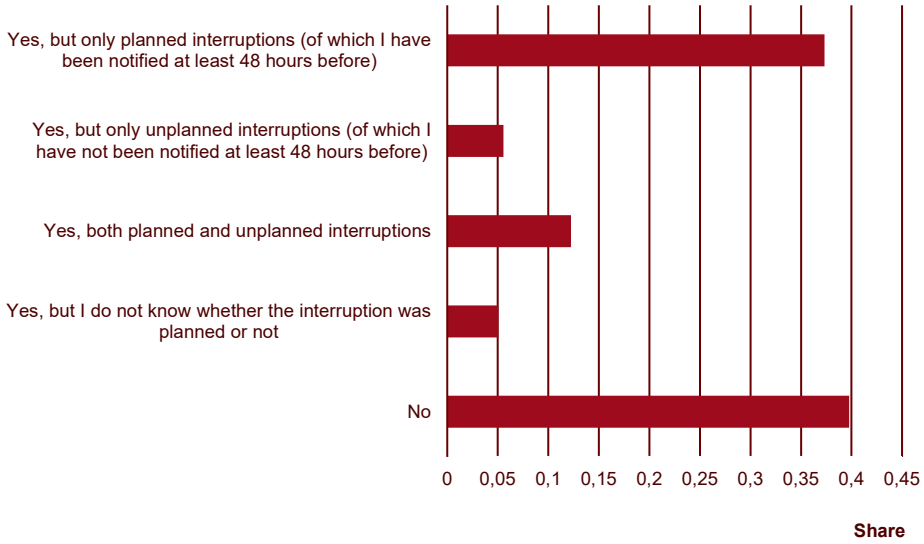
Note: Question text: "How much do you agree or disagree with the following statement?"

Source: Own calculations

The majority of the respondents (60 per cent) state that they have experienced interruptions of their water supply in the past two years. 18 per cent[42] have either only experienced planned interruptions or both planned and unplanned interruptions, see Figure 4.2.

[42] This figure is the sum total of respondents who have stated that they have only experienced unplanned interruptions (6 per cent) and respondents who have experienced both planned and unplanned interruptions (12 per cent).

Figure 4.2 **Experiences with water supply interruptions**



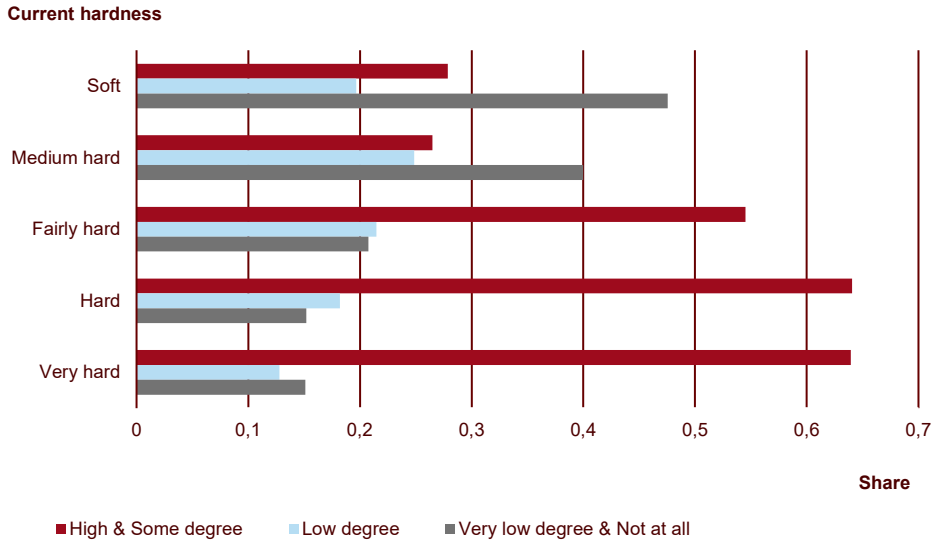
Note: Question text: "Have you experienced any interruptions (either planned or unplanned) in your water supply in the past two years, i.e. the water supply in your household was shut off?"

Source: Own calculations

The vast majority of respondents (90 per cent) have not experienced problems with bacteriological overruns in the past two years.

The hardness of the drinking water varies in Denmark, which is reflected in the respondents' attitudes to the current amount of calcium in the water. In municipalities in which the water is already soft or medium hard, approx. half of the respondents state that they are not bothered at all or to a very low degree by the amount of calcium in the water. In municipalities with water that is harder (than medium hard), most respondents state that they are bothered by the calcium to some or a high degree Figure 4.3.

Figure 4.3 **Nuisances from water hardness**



Note: Question text: "To what degree are you bothered by the current amount of calcium in your water?"

Source: Own calculations

Just under a fourth of the respondents (23 per cent) state that they soften their household water using some equipment (such as a softener system or other type of filter).

Over half of the respondents (59 per cent) have not been in contact with their water company in the past year. 22 per cent of the respondents state that they have been contacted by their water company by email or text message, while 17 per cent and 15 per cent of the respondents state that they have used the water company's website or self-service solutions. 5 per cent state that they have called their water company in the past year.

Just under half of the respondents (42 per cent) state that they do not know how much their household pays for water a year. The respondents who have entered an amount (range) for their annual water costs pay an average of approx. DKK 4,500[43] for their water annually. This can be compared with the annual water cost of DKK 5,600, which, according to the Danish Water and Wastewater Association (DANVA), is the average for a Danish household[44].

4.3 Willingness to pay for water supply improvements

Table 4.2 presents the estimated willingness to pay based on the choice scenarios to which the respondents were presented in the discrete choice experiment. A mixed logit regression

[43] The mean point in the stated range as well as the end points of the range for the first and last ranges are used in the calculation.

[44] DANVA (2019), "Vand i tal" (Danish Water and Wastewater Association (DANVA), Water in Numbers), https://www.danva.dk/media/6199/2019_vand-i-tal.pdf

model (see section 3.3) has been used in the estimation. The presented results directly reflect the respondents' willingness to pay. For selected attributes, it is assumed that the consumers' willingness to pay follows a normal distribution, and, for these attributes, the model therefore estimates a mean value for this distribution as well as the spread of the distribution (standard deviation). In the estimation it has been assumed that the willingness to pay to avoid interruption minutes and bacteriological overruns increases linearly with increases in these (these assumptions are tested in section 5.5). Softening of the drinking water and improvements to the water company's customer service have been estimated in discrete form, i.e. the estimated willingness to pay indicates the willingness to pay for the improvement in question.

Table 4.2 **Estimated willingness to pay in DKK**

Attribute	Mean parameter	Default error	p-value
Interruption minutes	6.6	2.3	0.004 **
Bacteriological overruns	90.0	8.4	0.000 ***
Softening of the water (from soft)	222.3	77.1	0.004 **
Softening of the water (from medium hard)	453.7	42.6	0.000 ***
Softening of the water (from fairly hard)	564.1	25.6	0.000 ***
Softening of the water (from hard)	560.4	30.9	0.000 ***
Softening of the water (from very hard)	797.5	73.5	0.000 ***
Improved customer service	-82.2	10.6	0.000 ***
Price parameter	3.8	0.2	0.000 ***
Constant (current)	303.8	22.8	0.000 ***
Constant (alternative 1)	-38.0	16.8	0.024 *
Standard deviation (Interruption minutes)	0.3	2.7	0.925
Standard deviation (Bacteriological overruns)	138.0	12.3	0.000 ***
Standard deviation (Improved customer service)	0.2	1.0	0.804
Standard deviation (Constant: current)	497.4	29.5	0.000 ***
Standard deviation (Constant: alternative 1)	172.6	31.7	0.000 ***
McFadden R2	0.253		
Number of respondents	1.599		

Note: The model is a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in the simulation of the maximum likelihood function. ***, ** and * indicate significant difference from zero at 99.9 per cent, 99 per cent and 95 per cent confidence intervals.

Source: Own calculations

The respondents have a positive and significant willingness to pay for improvements in security of supply, which is equal to them being willing to pay DKK 6.6 per minute to reduce the average interruption minutes (from the current 13 minutes)[45].

For bacteriological overruns, a willingness to pay of DKK 90 is estimated for one less overrun per 1,000 samples. Today, there are an average of 5 overruns in 1,000 samples. The analysis shows that there is a difference among consumers in the willingness to pay for bacteriological overruns (based on the significant standard deviation for the attribute). According to the calculation, 26 per cent of the respondents are thus not willing to pay more for fewer overruns[46].

Due to the varying amount of calcium in the drinking water in Denmark, it can be assumed that the willingness to pay for softening of the water depends on what the respondent's current water hardness is. The willingness to pay for softening the water is therefore estimated separately for respondents from municipalities in the five different water hardness groups. On average, the willingness to pay for softening of the water is positive and significant for all hardness groups. At the same time, the willingness to pay is greater for groups with harder water. The respondents are willing to pay between DKK 222 and DKK 798 per year to have their water softened, depending on their current water hardness.

The respondents are not willing to pay for improvements of the water companies' customer service. Here, the willingness to pay is estimated at DKK -82, which, in principle, means that the respondents will take a positive view of (pay for) a marginal reduction of the service level. This result thus indicates that the respondents at least do not want to pay for additional service. However, the finding that the estimated willingness to pay is significantly negative (and not 0) is rather counterintuitive, see the discussion in section 5.4.

The model also estimates relevant parameters for the alternative that corresponds to the respondents' current water supply and the middle alternative in the choice set. The constants capture the effect on the consumers' choice not described by the attributes, and thus control that the estimates of the willingness to pay for the attributes is not influenced by known biases, specifically the so-called *status quo effects*[47](i.e. that the current situation is preferred over all changes) and *position biases*[48](i.e. that the position of the alternatives in the choice set influences the choices).

The explanatory power of the model (goodness of fit), expressed by a McFadden R2 of 0.253, can be regarded as good[49].

4.4 Preferences for improvements in waste water management

As mentioned above, waste water has not been studied in the discrete choice experiment due to challenges in describing the attributes and effects of changes in these in waste water management (see section 3.2). To acquire insight into the respondents' waste water preferences,

[45] Consumers have been presented with the improvement of security of supply as a risk of experiencing a two-hour interruption. The estimation uses the average interruption minutes corresponding to this risk, with the assumption of a linear willingness to pay. For the estimation of discrete improvements, see section 5.5.

[46] Based on the estimated mean value and standard deviation from the assumed normal distribution, this is the proportion of respondents who have a negative willingness to pay.

[47] Meyerhoff, J. and U. Liebe (2009). "Status quo effect in choice experiments: empirical evidence on attitudes and choice task complexity." Land economics 85(3): 515-528

[48] Chrzan, K. (1994). "Three kinds of order effects in choice-based conjoint analysis." Marketing Letters 5(2):165-172.

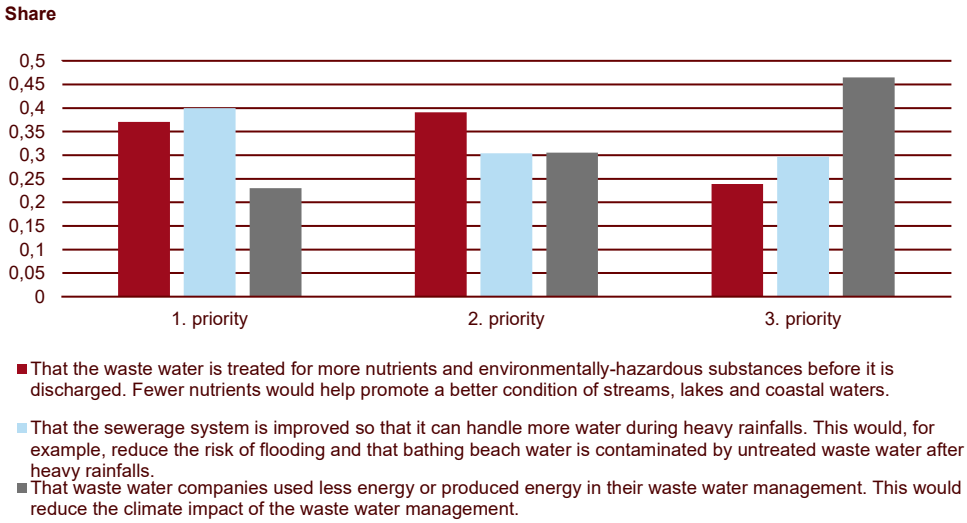
[49] Louviere, J., D. A. Hensher, & J. Swait (2000): Stated Choice Methods. Analysis and Applications. University Press, Cambridge, UK.

they were nevertheless asked to rank different measures which all represent waste water supply improvements.

The measures have been described as improvements in waste water treatment, the management of heavy rainfalls and reductions in energy consumption for waste water management. The descriptions of the measures are of an overall nature (e.g. the descriptions do not comprise the scope of the effects or the cost of the measures). Therefore, the results of the waste water analysis only describe overall preference features and not an actual valuation of improvements of the attributes.

The proportion of respondents who ranked the measures as first, second and third priority, respectively, is shown in Figure 4.4. The results indicate that consumers prioritise improvements in the management of heavy rainfalls and treatment of waste water over improvements in energy consumption. It is not unambiguous which measure the respondents regards as the best one. Approx. 40 per cent of the respondents prioritised improvements in the management of heavy rainfalls, while 37 per cent prioritised improvements in treatment of waste water (37 per cent). Waste water treatment has more second priorities (39 per cent) than the management of heavy rainfalls (30 per cent).

Figure 4.4 **Prioritisation of measures**



Source: Own calculations

The respondents were also asked whether they preferred a measure aimed at ensuring less polluted bathing beach water at the beach they usually use or improvements in their drinking water supply. This was done in two steps. The respondents were first asked to choose whether they preferred the waste water measure that ensured better bathing beach water quality, or a softening of their drinking water. They were subsequently asked whether they preferred the waste water measure or an improvement in the security of supply, corresponding to one unplanned interruption per 24 years.

As there are no data for how often pollution of beaches can be attributed to waste water overflows, the respondents were asked to assume that this happens once a year at the bathing beach they usually use and that the measure ensured that this did not occur.

The answers to these questions show that the waste water measure has relatively high priority. 58 per cent prefer the waste water measure rather than a softening of their drinking water, while 26 per cent prefer the waste water measure rather than the improvement in security of supply, but not above softening of their drinking water. Conversely, 10 per cent prefer the drinking water measure to the waste water measure[50].

It should be stressed that the interpretation of these results is uncertain, as the description of the waste water measure does not meet the same criteria of measurability and credibility as the improvements of the drinking water. The results must therefore be taken with considerable reservations.

[50] 6 per cent of the respondents state that they prefer the waste water measure above softening of the drinking water, but not above improvement of the security of supply, which is not in accordance with the assumption about transitive preferences.

Chapter 5
Discussion of the results

This chapter presents a number of analyses to validate the estimated willingness to pay for improvements in drinking water supply.

The analyses show that the willingness to pay is not significantly affected when the calculation excludes respondents who, based on a number of criteria, can be assumed not to have answered the questionnaire based on their actual preferences. This indicates that the responses from these respondents do not have a systematic bias that affects the results of the analysis.

In addition, the analyses of whether there is a correlation between willingness to pay and income, and whether the study passes a so-called external scope test, i.e. that the willingness to pay roughly corresponds to the extent of the improvement are presented.

The section also compares the estimated willingness to pay in this analysis with previous studies in this area. There is generally a good accordance. The only exception is for security of supply, where the willingness to pay is lower in this survey than in previous analyses. For customer service, no comparable results have been found from other studies.

Relaxing the assumption of linearity in the willingness to pay for security of supply indicates that consumers are not willing to pay for small changes. The willingness to pay for bacteriological overruns is fairly accurately described under the assumption of a linearity, but, statistically, the consumers' choices are better explained when the willingness to pay is defined as discrete improvements.

5.1 Sensitivity analyses for selection of final population

In the analysis of the willingness to pay in Chapter 4, certain respondents have been excluded because their responses show signs of so-called protest and strategic behaviour. For these respondents, there are consequently good reasons for assuming that they have not answered the questionnaire based on their actual preferences.

There are also other factors that may indicate whether answers are connected with errors or misunderstandings that could potentially bias the results of the survey. This section tests the sensitivity of the willingness to pay when respondents are excluded based on the following criteria:

1. Time spent on the questionnaire and information pages
2. Inconsistent answers
3. Whether they pay for the water themselves
4. Incorrect answers to control questions

Re 1. The time a respondent uses to answer the questionnaire may indicate that the respondent does not answer the questionnaire sincerely, e.g. a respondent may complete the questionnaire so quickly that the respondent cannot have had time to read the questions properly. The five per cent fastest respondents, i.e. those who answered the whole survey in less than five minutes, are excluded in the sensitivity analysis. In addition, the five per cent slowest re-

spondents, i.e. those who spent more than three hours answering the questionnaire, are excluded. Finally, respondents who spent a total of less than 20 seconds on the descriptions of the five attributes in the discrete choice experiment are excluded.

Re 2. The fifth choice set in the discrete choice experiment was a control question in which one of the alternatives was dominant, i.e. objectively better in all attributes. Respondents who chose one of the dominated alternatives have been excluded, as this response indicates that they have misunderstood the task or not taken it seriously.

Re 3. Some respondents have also stated that they do not pay for their water themselves. This may mean that they lack the necessary experience to assess the increase in water costs, which, in turn, may result in a too high (or low) estimate of the willingness to pay.

Re 4. After the respondents were presented with the descriptions of the attributes, they were asked seven control questions (see Appendix 4). They were subsequently presented with the right answers to these questions. The sensitivity analysis (model 4) checks whether the respondent has answered the control questions about the attributes incorrectly. If the respondent answered a control question incorrectly, that respondent's answer regarding the corresponding attribute has been excluded from the estimation of the willingness to pay[51]. In this model, the willingness to pay is thus based only on respondents who provided correct answers to the control questions. This type of 'exclusion' may also cause bias. The incorrect answers to the control questions do not necessarily mean that consumers answered the choice sets based on an incorrect understanding of the description, as the respondents were presented with the correct answers as part of the survey before the experiment itself began.

A total of four models have been estimated which *cumulatively* exclude respondents based on the additional response requirements. The number of exclusions for each step, and the number of respondents for each model, are stated in Table 5.1.

Table 5.1 **Further exclusion of respondents**

Model		Exclusion	Number
	Final population		**1,599**
1	- Based on time spent	257	1,342
2	- Inconsistent answers	41	1,301
3	- Do not pay for the water themselves	71	1,230
4	- Answer the control question incorrectly	0[1]	1,230

Note 1: In model 4, no further respondents are excluded for the population, but, in the estimation, the willingness to pay for the individual attributes is not influenced by respondents who answered the control questions incorrectly relative to the attribute in question (see Appendix 4).

Note: The exclusion of respondents based on the criteria is done cumulatively from model 1 to model 4.

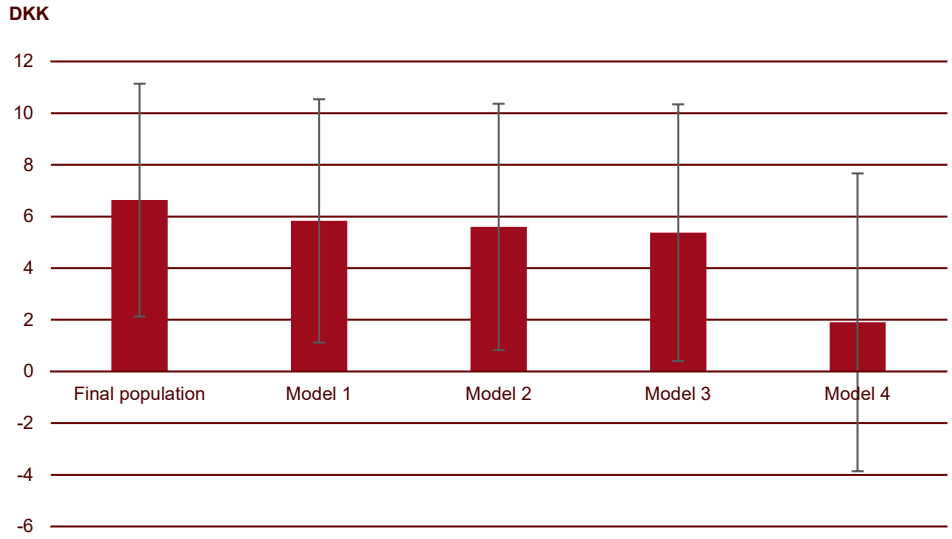
Source: Own calculations

[51] This is done by estimating separate parameters for the willingness to pay for respondents who answered correctly and respondents who answered incorrectly, see Appendix 4.

The willingness to pay for the attributes is presented in Figures 5.1 to 5.4 below. Overall, the estimates of the willingness to pay are relatively robust.

The willingness to pay for a one-minute reduction in interruption minutes across the models is presented in Figure 5.1. The willingness to pay is significant and amounts to DKK 5 or more in all cases, except, however, for model 4, which also excludes respondents who have not answered the control question about unplanned interruptions correctly. This may indicate that the willingness to pay is driven by these respondents, thus indicating that the result should be interpreted cautiously.

Figure 5.1 **Willingness to pay (interruption minutes)**

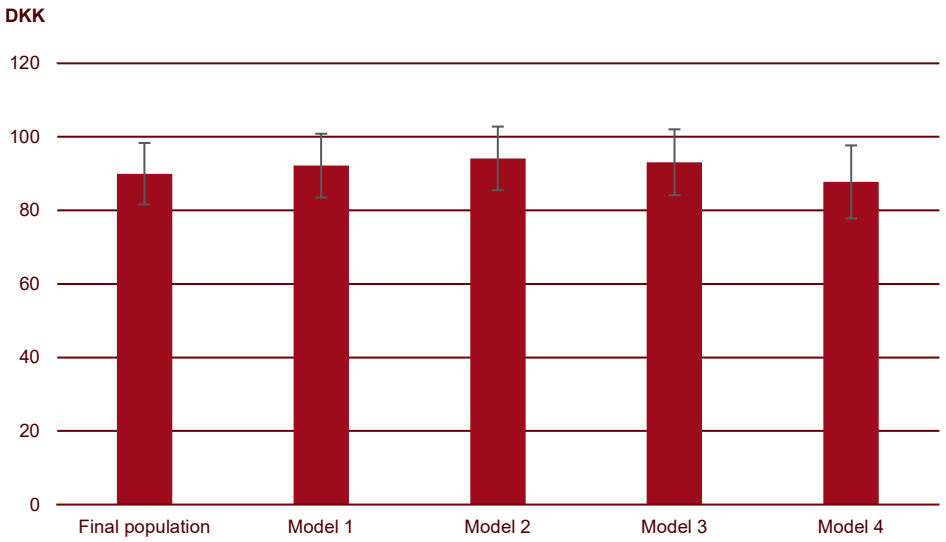


Note: The willingness to pay has been estimated using a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. The error bars correspond to a 95 per cent confidence interval.

Source: Own calculations.

The willingness to pay for bacteriological overruns (Figure 5.2), softening of the water (Figure 5.3) as well as improvement in customer service (Figure 5.4) is stable and significant in all the models. There are no statistically significant differences in the willingness to pay.

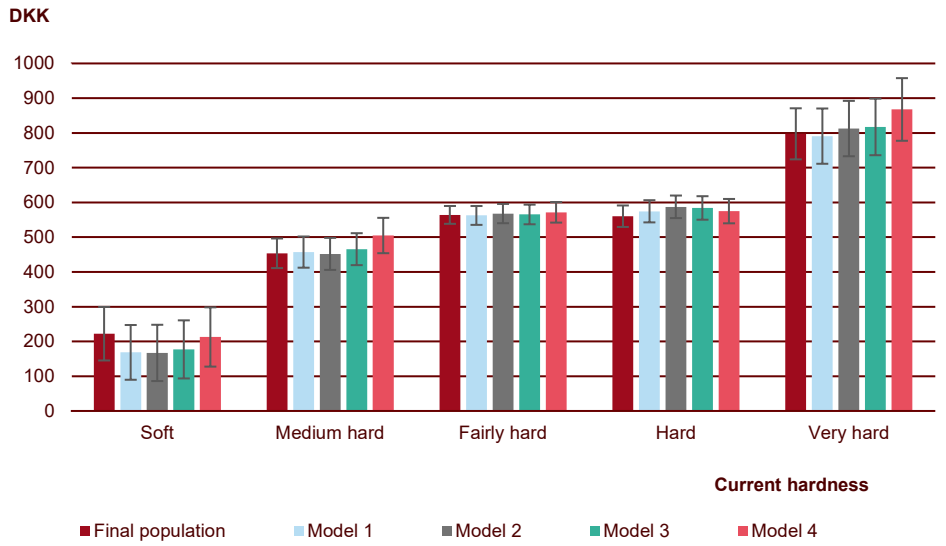
Figure 5.2 **Willingness to pay (bacteriological overruns)**



Note: The willingness to pay has been estimated using a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. The error bars correspond to a 95 per cent confidence interval.

Source: Own calculations.

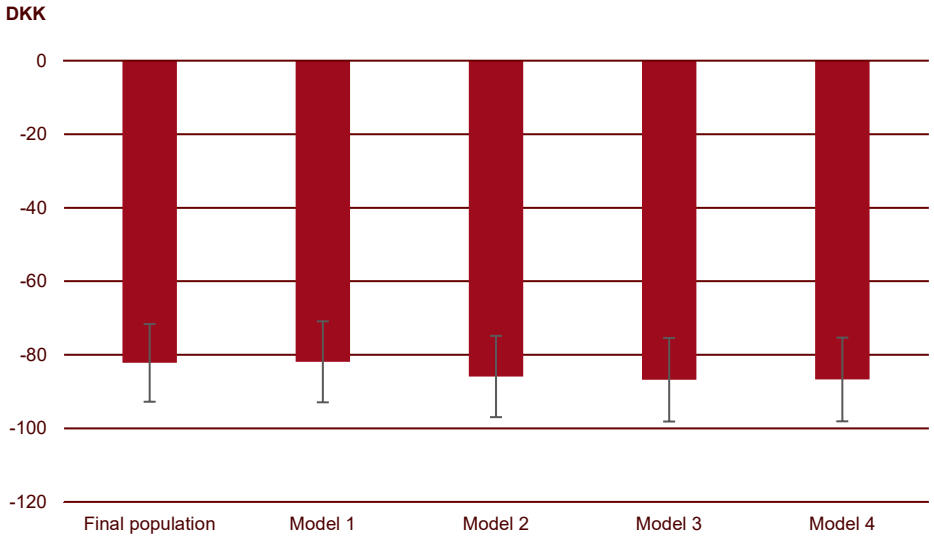
Figure 5.3 **Willingness to pay (softening of the water)**



Note: The willingness to pay has been estimated using a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. The error bars correspond to a 95 per cent confidence interval.

Source: Own calculations.

Figure 5.4 **Willingness to pay (customer service)**



Note: The willingness to pay has been estimated using a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. The error bars correspond to a 95 per cent confidence interval.

Source: Own calculations.

5.2 Relationship between willingness to pay and income

It is also relevant to assess whether respondents with higher income have a higher willingness to pay than those with lower incomes. Other things being equal, it can be expected that higher-income respondents will have a higher willingness to pay, as this group has a higher ability to pay and often a lower price sensitivity.

The correlation between willingness to pay and income is examined by the respondents being divided into three income groups[52] and with the willingness to pay being estimated separately for each group. The willingness to pay across the income groups is presented in Figure 5.5 – Figure 5.7. Overall, there are no statistically significant differences in the willingness to pay for interruptions and bacteriological overruns between the income groups[53]. This indicates that the willingness to pay from Table 4.2 is not driven by a specific income group, and that the use

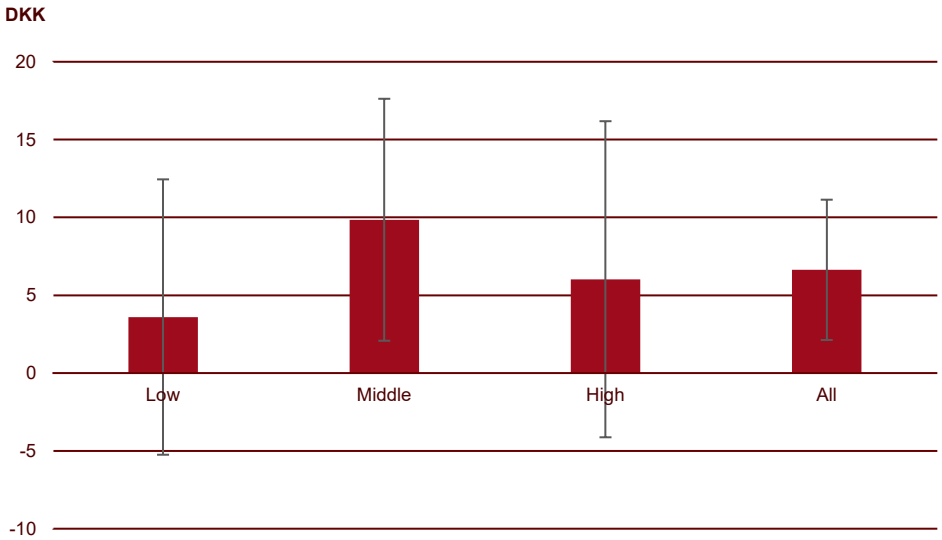
[52] The groups are based on the respondents' declared household income before tax. The respondents were categorised as either low income (below DKK 399,999), middle income (DKK 400,000 – DKK 799,999), high income (over DKK 800,000). The number of respondents per group varies between 301 and 486. 346 respondents did not declare their income and are not included in this part of the analysis.

[53] An in-depth analysis (not reported here) finds a significantly lower price sensitivity for the high-income group than for the low-income and middle-income groups. This means that respondents with high incomes are not as sensitive to increases in water costs as the other groups. In this model, the utility is specified in *preference space* (as opposed to the specification in *willingness-to-pay space* in the other models), and separate price parameters are estimated for the different income groups on the assumption that the preferences for the other attributes are the same across the income groups.

of the average willingness to pay in regulation does not, for example, put low-income households at a disadvantage.

However, for the willingness to pay for softening of the water, there are indications that respondents with high incomes are willing to pay more for softening of the water than persons with low incomes if the group's water is fairly hard or harder. However, this does not apply to respondents with soft or medium hard water, where the results indicate that low-income respondents are willing to pay more than respondents with higher incomes. However, the estimates for the different income groups that already have soft water are based on very few respondents in each income group (19, 17 and 11 respondents in the low, middle and high income groups, respectively). Overall, the willingness to pay for softening of the water in areas with soft water is driven by a small group of respondents who state that they are nevertheless bothered by the amount of calcium in their water, see section 5.4.

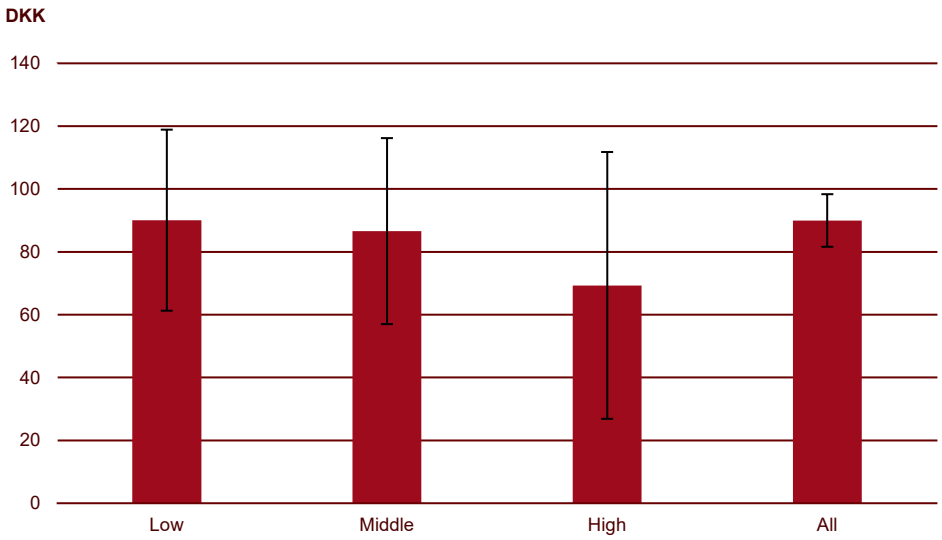
Figure 5.5 **Willingness to pay (interruption minutes) across income groups**



Note: The groups are based on the respondents' declared household income before tax. The respondents are categorised as low income (below DKK 399,999), middle income (DKK 400,000 – DKK 799,999) or high income (over DKK 800,000). 'All' includes respondents who have not stated their income and is the result from Table 4.2.

Source: Own calculations.

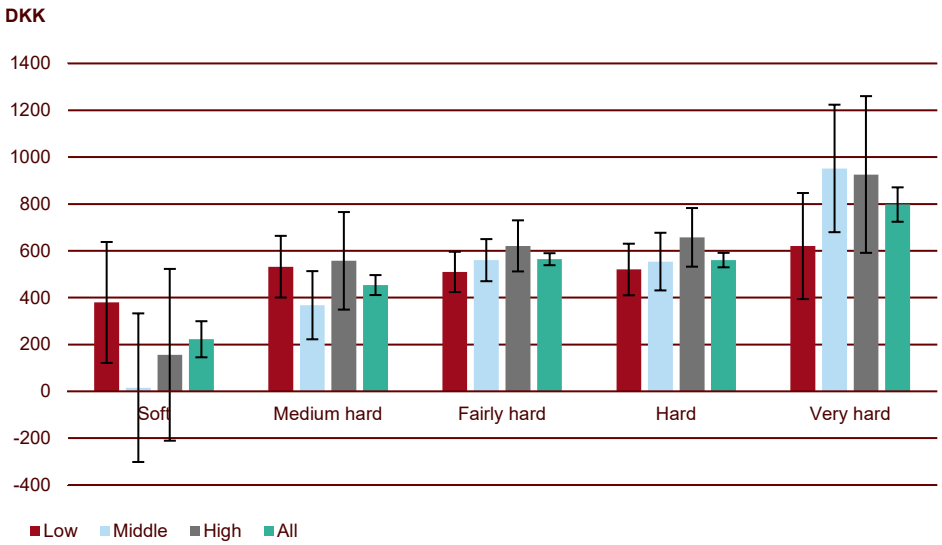
Figure 5.6 **Willingness to pay (bacteriological overruns) across income groups**



Note: The groups are based on the respondents' declared household income before tax. The respondents are categorised as low income (below DKK 399,999), middle income (DKK 400,000 – DKK 799,999) or high income (over DKK 800,000). 'All' includes respondents who have not stated their income and is the result from Table 4.2.

Source: Own calculations.

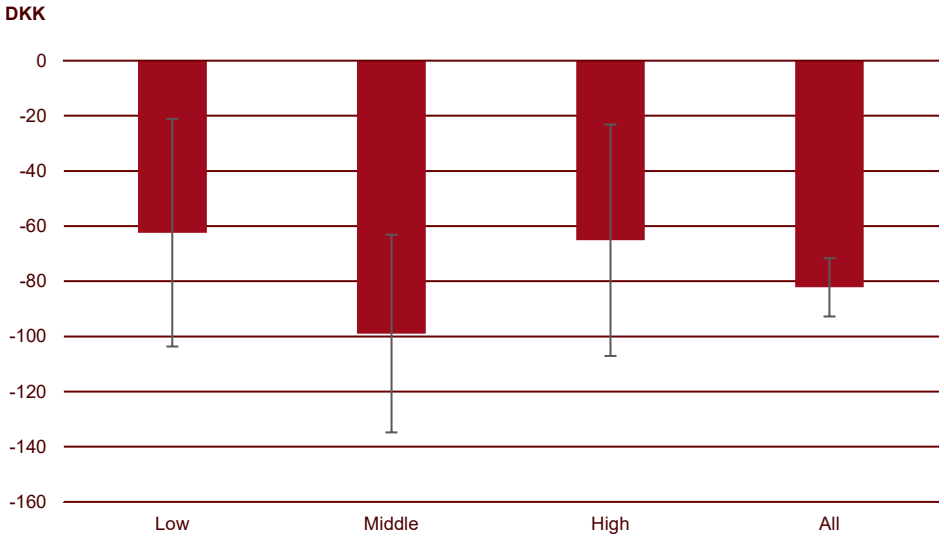
Figure 5.7 **Willingness to pay (softening of the water) across income groups**



Note: The groups are based on the respondents' declared household income before tax. The respondents are categorised as low income (below DKK 399,999), middle income (DKK 400,000 – DKK 799,999) or high income (over DKK 800,000). 'All' includes respondents who have not stated their income and is the result from Table 4.2.

Source: Own calculations.

Figure 5.8 **Willingness to pay (customer service) across income groups**



Note: The groups are based on the respondents' declared household income before tax. The respondents are categorised as low income (below DKK 399,999), middle income (DKK 400,000 – DKK 799,999) or high income (over DKK 800,000). 'All' includes respondents who have not stated their income and is the result from Table 4.2.

Source: Own calculations.

5.3 External scope test

As mentioned in section 3.2, the respondents may find it difficult to relate to the scope of an improvement. Whether this can be said to be a problem can, to some extent, be tested using an external scope test, where some of the respondents in the survey are presented with a greater reduction in the risk of bacteriological overruns. For this group, it was stated that the risk is reduced corresponding to a reduction from 5 to 1 or 2 overruns in 1,000 water samples. For the other respondents, it was stated that there is a reduction from 5 to 2 or 4, respectively, see Table 3.1.

A total of 450 respondents responded to the scope test version of the discrete choice experiment. Out of these respondents, 16 respondents were excluded due to protest behaviour and 43 respondents were excluded due to strategic behaviour. The willingness to pay is thus estimated based on 391 respondents.

The scope test shows that consumers are willing to pay more for large-scale improvements and that the average willingness to pay for one less overrun is the same in the scope test and the primary analysis (DKK 113 and DKK 90 on average, which is not a statistically significant difference (p-value 0.087).

5.4 Relationship between willingness to pay and experiences with the individual attributes

The relationship between the willingness to pay and the respondents' attitudes to and experiences with their current water supply is examined by including interaction terms (multiplying an attribute level with an indicator of the respondent's attitude to or experience with the attribute) in the model. An estimate can thus be made of how the willingness to pay varies based

on the experience or attitude towards the attribute in question. The estimates are presented in Table 5.2 (and can be compared with the results in Table 4.2).

Table 5.2 **Estimated willingness to pay in DKK (with interaction terms)**

Attribute	Average parameter	Default error	p-value
Interruption minutes	5.0	2.5	0.043 *
Bacteriological overruns	89.7	8.5	0.000 ***
Softening of the water (from soft)	83.7	99.9	0.402
Softening of the water (from medium hard)	354.3	46.1	0.000 ***
Softening of the water (from fairly hard)	513.9	30.8	0.000 ***
Softening of the water (from hard)	534.0	38.5	0.000 ***
Softening of the water (from very hard)	778.5	91.1	0.000 ***
Improved customer service	-69.6	15.6	0.008 ***
Price parameter	3.9	0.2	0.000 ***
Constant (current)	299.4	22.4	0.000 ***
Constant (alternative 1)	-37.3	16.7	0.026 *
Standard deviation (Interruption minutes)	0.1	7.4	0.988
Standard deviation (Bacteriological overruns)	139.4	12.2	0.000 ***
Standard deviation (Improved customer service)	0.5	1.0	0.633
Standard deviation (Constant: current)	487.1	28.9	0.000 ***
Standard deviation (Constant: alternative 1)	172.0	31.6	0.000 ***
Softening (soft) * bothered	439.0	132.9	0.001 ***
Softening (medium hard) * bothered	414.4	98.6	0.026 ***
Softening (fairly hard) * bothered	134.9	43.8	0.002 **
Softening (hard) * bothered	66.0	57.6	0.252
Softening (very hard) * bothered	50.8	142.8	0.722
Interruption minutes * experience	-4.3	2.5	0.085
Bacteriological overruns * experience	18.6	31.1	0.551
Improved customer service * No contact	-16.4	20.0	0.413
McFadden R2	0.257		
Number of respondents	1,599		

Note: The model is a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. ***, ** and * indicate significant difference from zero at 99.9 per cent, 99 per cent and 95 per cent confidence intervals.

Source: Own calculations.

If the respondents have answered that the current amount of calcium in the water bothers them to a high degree or some degree, and the water is not actually particularly hard, a higher willingness to pay for reducing the hardness of the water is estimated than for persons with the same water type who are not bothered by the hardness of the water. This result is clearly significant. For those respondents who generally have harder water, however, there is not the same trend – for these respondents, the willingness to pay is not significantly different. The results also suggest that respondents with soft water who are not bothered by the amount of calcium in the water are not willing to pay for a softening of the water.

The interaction term 'Interruption minutes * experience' tests how the willingness to pay varies between respondents who have experienced unplanned interruptions in the past two years (18 per cent of the respondents) and respondents who have not had such an experience. The experience parameter thus has a value of 1 if a respondent has experienced unplanned interruptions, and 0 if this is not the case. The estimate for the interaction term is negative (DKK -4.3). This indicates that respondents with the experience in question have a lower willingness to pay than respondents who have not experienced unplanned interruptions. However, the estimate is not statistically significant at the 5 per cent level, but significant at the 10 per cent level. This may indicate that there are differences in the willingness to pay depending on whether the respondent has been subject to an unplanned interruption.

The willingness to pay for bacteriological overruns is not affected by whether the respondents have experienced a bacteriological overrun in the past two years. A slightly greater willingness to pay is estimated for respondents who have experienced overruns, but the difference is not statistically significant.

If the respondents have been in contact with their water company, this does not affect the willingness to pay for improvements in the water company's customer service. An additional model (not reported here) tested the effect of the size of the respondent's home municipality on the willingness to pay for customer service. The hypothesis was that the description of customer service levels was less credible for small water companies, which are most often found in small municipalities. This hypothesis has partly been confirmed, as the willingness to pay was more negative (approx. DKK -100) for municipalities with less than 175,347 inhabitants than for large municipalities (approx. DKK -58), but the result cannot clearly explain the negative willingness to pay for the attribute.

5.5 Test of the assumption of linearity in willingness to pay

The estimation of the willingness to pay has so far assumed a linear willingness to pay for security of supply (interruption minutes) and bacteriological overruns. This assumption can be tested by estimating the willingness to pay for the discrete improvements to which the respondents have been presented. The results from this model are shown in Table 5.3.

The estimates from the model with discrete improvements cannot directly be used for regulation, because these estimates can only be linked to the specific discrete improvements tested. Therefore, the model serves as a control of the assumption of linearity in the primary model, which is used to estimate consumers' willingness to pay per 'unit' of any improvement.

Table 5.3 **Estimated willingness to pay in DKK (discrete improvements)**

Attribute	Average parameter	Default error	p-value
Interruption minutes (from 13 to 8 min.)	-44.0	22.7	0.053

Interruption minutes (from 13 to 5 min.)	41.9	18.9	0.027 *
Bacteriological overruns (from 5/1000 to 4/1000)	118.5	24.1	0.000 ***
Bacteriological overruns (from 5/1000 to 2/1000)	262.4	29.4	0.000 ***
Softening of the water (from soft)	217.9	69.3	0.002 **
Softening of the water (from medium hard)	454.3	40.6	0.000 ***
Softening of the water (from fairly hard)	549.6	23.6	0.000 ***
Softening of the water (from hard)	543.7	28.5	0.000 ***
Softening of the water (from very hard)	757.4	67.5	0.000 ***
Improved customer service	-40.2	15.6	0.01 **
Price parameter	4.5	0.2	0.000 ***
Constant (current)	296.9	22.5	0.000 ***
Constant (alternative 1)	-43.2	16.9	0.01 *
Standard deviation (Interruption minutes, to 8 min.)	1.6	2.7	0.558
Standard deviation (Interruption minutes, to 5 min.)	11.2	9.2	0.225
Standard deviation (Bacteriological overruns, 4/1000)	304.2	25.7	0.000 ***
Standard deviation (Bacteriological overruns, 2/1000)	386.4	36.2	0.000 ***
Standard deviation (Improved customer service)	4.9	3.1	0.114
Standard deviation (Constant: current)	443.1	24.3	0.000 ***
Standard deviation (Constant: alternative 1)	209.9	25.3	0.000 ***
McFadden R2	0.267		
Number of respondents	1,599		

Note: The model is a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. ***, ** and * indicate significant difference from zero at 99.9 per cent, 99 per cent and 95 per cent confidence intervals.

Source: Own calculations

For security of supply (interruption minutes), the results indicate that the assumption of linearity in willingness to pay does not hold. The respondents are not willing to pay for the minor improvement from the current 13 interruption minutes per year to 8 min. per year (the estimate for this improvement is not statistically significant, p-value 0.053). The estimate of the major improvement, equal to an improvement from the current 13 interruption minutes per year to 5 minutes per year, is, however, positive and statistically significant, i.e. the respondents are willing to pay for this improvement.

The estimates for the discrete improvements in the risk of bacteriological overruns are more in accordance with the assumption of a linear willingness to pay. The improvements are equal to one and three fewer overruns per 1,000 samples, respectively. If the estimates are adjusted for the number of overruns, this gives a willingness to pay of DKK 119 and DKK 87, respectively, per reduced overrun, which is fairly close to the estimated DKK 90 in Table 4.2. Formally, it can be tested whether the estimates are identical through a likelihood-ratio test. This

test shows that the model with discrete improvements has a statistically significantly higher explanatory power than the linear model and that the willingness to pay is thus not linear[54].

It is not unexpected that a more flexible formulation of the relationship between willingness to pay and the scope of the improvement has a better model fit than the more restrictive assumption of linearity. The discrete model emphasises that caution should be exercised when interpreting the willingness to pay for minor improvements in the security of supply.

The estimates for bacteriological overruns show that the survey passes an internal scope test for this attribute, i.e. that the respondents have a higher willingness to pay for major improvements. In theory, it can also be said that the willingness to pay for less interruption minutes is monotonously increasing and thus consists of an internal scope test, as the willingness to pay for the improvements is not statistically lower than the previous level of the attribute.

5.6 Comparison with similar analyses

There are a number of previous empirical studies which have examined, using different methods, consumers' willingness to pay and preferences in the water and waste water sector (see, for example, Beaumais et al., 2014[55] for an overview). However, most of these articles concern consumer preferences in countries and areas in which the quality of the water supply is much poorer than in Denmark, and they therefore cannot be used for comparison. The most relevant discrete choice experiments have been conducted in the UK by Willis et al. (2005)[56] as well as Lanz & Provins (2015)[57]. Both studies examine the willingness to pay for security of supply and various water quality aspects.

For security of supply, Lanz & Province (2015) find a willingness to pay that is equal to approximately GBP 1.2 per reduced interruption minute, i.e. DKK 9.9, which is within the confidence interval for the estimate in Table 4.2[58]. In the survey, the 'current' security of supply was equal to approximately 9 interruption minutes per year, a level that is close to the current Danish conditions (about 13 interruption minutes per year). Willis et al. (2005) find a willingness to pay which, based on the information from the article, is translated into approximately GBP 5.7 per interruption minute, which, adjusted for inflation[59], is equal to DKK 73 per minute (nominally DKK 47). This is a significantly higher amount than the estimate of DKK 6.6 from Table 4.2. The reason for this difference may be that the interruption described in Willis et al. 2005) is quite long compared to this survey and Lanz & Provins (2015). In both articles, security of supply is described through the number of households experiencing an interruption each year, as opposed to the description in this survey of the 'risk' that the respondent's household will experience an interruption. This may affect the respondents' view of the attribute and lead to different results.

[54] The models estimated for the likelihood ratio test are based on a simpler multinominal logit model.

[55] Beaumais, O., Briand, A., Millock, K., & Nauges, C. (2014). What are households willing to pay for better tap water quality? A cross-country valuation study.

[56] Willis, K., Scarpa, R., and Acutt, M. (2005), Assessing water company customer preferences and willingness to pay for service improvements: A stated choice analysis, Water Resource Research, 41, 1-11

[57] Lanz, B., & Provins, A. (2015), Using discrete choice experiments to regulate the provision of water services: Do status quo choices reflect preferences?, Journal of Regulatory Economics, 47, 300-324

[58] In the survey, the calculations are based on the water company servicing 3,500,000 customers, which is not mentioned in the article, but the information has been provided by the authors through personal communication.

[59] https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator

In relation to water quality, Willis et al. (2005) find that the respondents are willing to pay approximately GBP 7.5 for a 0.1 per cent reduction in the risk of water samples not meeting quality requirements. Adjusted for inflation, this is equal to approximately DKK 96. This is within the confidence interval for bacteriological overruns in Table 4.2.

Lanz & Provins (2015) also examine consumers' willingness to pay for the water company getting fewer complaints about water hardness, which could be interpreted as a proxy for consumers' willingness to pay for softening of the water. This willingness to pay is positive and significant, but it is not comparable with the willingness to pay from Table 4.2, which estimates the willingness to pay for a specific measure.

However, there are a number of other methods that have previously been used to assess the willingness to pay and the benefit for consumers of a softening of the water. Lanz & Provins (2016)[60] estimate the willingness to pay based on the respondents' stated costs for various softening products. The result indicates that consumers would be willing to pay approximately DKK 165 per year to halve the amount of calcium in the water[61]. The method used – which is based on how much is actually paid – means that the estimate can be interpreted as a lower threshold for the willingness to pay for the softening of the water.

The willingness to pay for softening estimated in Table 4.2 can also be compared to the estimated average benefits from the Danish Environmental Protection Agency's report[62], where the benefits from softened water are estimated at approximately DKK 400-800, depending on the hardness level to which the water is softened.

No comparable analyses have been found of the willingness to pay for improvements in the water company's customer service.

In a new survey from Belton et al. (2020)[63], the respondents were asked to rank different measures in their drinking water and waste water supply. The measure with the highest ranking concerns the purity of beaches and rivers, which is comparable to the formulated waste water scenario in this analysis. Improvements of security of supply are ranked last of seven, and improvements of drinking water quality are ranked as number four. Overall, it is assessed that the ranking of the measures from Belton et al. (2020) is consistent with the results of this analysis. Belton et al. (2020) also estimate an overall willingness to pay for improvements of the water and waste water supply of approximately GBP 11 (approximately DKK 90). However, this result is not based on a recognised method and is therefore not comparable with the results from this analysis.

[60] Lanz, B., & Provins, A. (2016). The demand for tap water quality: Survey evidence on water hardness and aesthetic quality. Water Resources and Economics, 16, 52-63.

[61] Lanz and Province (2016) find a willingness to pay of GBP 0.08 for a reduction of one mg of CaCO3. The difference between very hard water (hardness degree of 28) and fairly hard water (hardness degree of 14) is approximately 250 CaCO3. GBP 0.08 * 250 = GBP 20, which is equal to approximately DKK 165 (June 2020).

[62] Miljøstyrelsen (2017), "Blødt vand i en cirkulær økonomi" (Danish Environmental Protection Agency (2017), Soft Water in a Circular Economy), https://mst.dk/media/145463/rapport-bloedt-vand-i-en-cirkulaer-oekonomi.pdf

[63] Belton, C. A., Lavina, C., & Lunna, P. D. (2020). Eliciting trade-offs between water charges and service benefits in Scotland (No. WP655). https://www.esri.ie/system/files/publications/WP655_1.pdf

Appendix 1: Questionnaire

Questionnaire for the analysis 'Consumer willingness to pay for improvements in the water sector'

Question 1

Are you…?

- Male
- Female

Question 2

How old are you?

- _____

Question 3

In which municipality do you live?

Question 4

In which postcode do you live?

- _____

Info1
This survey is about water supply in Denmark. The study has been conducted on behalf of the Danish Competition and Consumer Authority to examine whether there is a need to change how water companies are regulated.

As a consumer, you do not have the option of switching water companies if you are dissatisfied with the price, water quality or service that your water company provides. Therefore, the price for all large water companies is regulated by the Danish Competition and Consumer Authority.

Danish water companies must also ensure that there are no supply interruptions and that the water meets quality requirements, for example in the form of thresholds for the content of bacteria in the water. There are generally few water supply interruptions in Denmark, and the vast majority of samples taken to measure water quality are below the thresholds for bacteria in the water.

The purpose of the survey is to map your views on the correlation between water price, water quality and your water company's service.

There are no 'right' or 'wrong' answers in the survey, and the respondents do not need to have knowledge of the subject to answer the questions.

We would ask you to answer the questions honestly, as your answers may affect future regulation of the water companies.

Question 5
The vast majority of Danes get their water from a waterworks owned by a water company. Approximately 3-5% of Danes get their water from a private water borehole, typically a water well that supplies one or more households. Especially country estates and secluded summerhouses have private water supply.

From what source do you get water for your primary household?

- I get water from a water company
- From a private well or a borehole (not owned by a water company)
- Don't know

Question 5.1 [only if a) in 5]
My primary water company is:

Below is a non-exhaustive list of water companies in your municipality; not all water companies are necessarily listed. In some municipalities, we do not have examples of water companies in the municipality.

- [select water company from the list]
- Not on the list: _____
- Don't know

Question 6
How does your household pay for water in your primary household?

- According to the quantity of water consumed (e.g. based on a water meter)
- As a fixed amount (e.g. as part of the rent)
- Don't know

Question 7
Are you the primary person paying your household's water bill? (if you have shared finances, select yes in the answer category)

- Yes
- No
- Don't know

Question 8
An average household (of 2.1 persons) uses approx. 81 m^3 water a year. For persons living alone, the average water consumption is approx. 50 m^3 a year, while a family with three children uses approx. 170 m^3 water a year.

How much water does your household approximately use, in your primary household, a year?

- 50 m3 or less
- 51 m3 - 74 m3
- 75 m3 - 99 m3
- 100 m3 - 124 m3
- 125 m3 - 149 m3
- 150 m3 - 174 m3
- 175 m3 or more
- Don't know

Question 9
How much do you agree or disagree with the following statements? [Strongly disagree, Disagree, Neutral, Agree, Strongly agree]

- I often experience problems with my water supply to my primary household (For example in relation to water quality, water supply interruption or the like)
- I am satisfied with the quality of the drinking water that my water company supplies to my primary household
- I am generally satisfied with my water company (in relation to water quality, interruption, customer service)
- I often buy bottled water for use at home in my household (for example to drink directly or for my coffee machine)

Info2
In this part of the survey, you will be presented with various alternatives that concern changes to some of the 'attributes' of the water and the service that you receive from your water supply.

In a number of situations, you will be presented with three different alternatives where you are to choose the one you prefer. In each situation, one of the alternatives will correspond to your current water supply, and two alternatives will represent changes in your current water supply (and water costs).

The alternatives with which you are presented vary in five different attributes:

1. The risk of unplanned water supply interruptions
2. The risk of bacteriological overruns
3. The calcium content of the water (water hardness)
4. The water company's customer service
5. The water price

These attributes will be explained on the following pages.

To be able to answer the questions, it is very important that you read the following pages carefully.

Info3
Attribute 1: Unplanned water supply interruptions

The water companies must ensure that there is always water from the tap. How good the water companies are at securing the water supply is measured through the number of minutes a year in which there is no water from the tap **without at least 48 hours' prior notice having been given thereof.** Therefore, planned interruptions are not included in this survey (they may, for example, occur in connection with planned renovation work).

In Denmark, a household is without water for an average of 13 minutes a year due to unplanned interruptions. This is equal to YOUR HOUSEHOLD experiencing one **unplanned 2-hour interruption once in 9 years.**

Interruptions may occur around the clock, also when you are not at home or are not using the water.

The water companies can use various measures to lower the risk of unplanned interruptions. In the alternatives with which you are presented, the risk of an unplanned 2-hour interruption may be reduced to once in 15 years, or once in 24 years.

Current risk of unplanned interruptions	Possible improvements in the risk of unplanned interruptions	
2 hours without water (unplanned) **once in 9 years**	2 hours without water (unplanned) **once in 15 years**	2 hours without water (unplanned) **once in 24 years**

Question 10
Have you experienced any interruptions (either planned or unplanned) in your water supply in the past two years, i.e. the water supply in your household was shut off?

- Yes, but only planned interruptions (of which I have been notified at least 48 hours before) [go to question 10.1]
- Yes, but only unplanned interruptions (of which I have not been notified at least 48 hours before) [go to question 10.1]
- Yes, both planned and unplanned interruptions [go to question 10.1]
- Yes, but I do not know whether the interruption was planned or not [go to question 10.1]
- No

Question 10.1 [only if 'yes' in question 10]
When you have experienced interruptions in your water supply, what was the reason for the water supply being shut off?
Select all relevant options if you have experienced multiple interruptions

- Repair work in my building/property (not performed by the water company)
- Repair work outside my building/property, e.g. the pipeline network (performed by the water company)
- Other reason: _____
- Can't remember/don't know

Question 10.2 [only if 'yes' in question 10]
To what extent did it bother you that the water supply was shut off?

- Not at all
- To a very low degree
- To a low degree
- To some degree
- To a high degree
- Don't know

Info4
Attribute 2: The risk of bacteriological overruns

The water companies take samples of their drinking water on an ongoing basis to ensure that the water has the right quality. The samples measure a number of values, including that the quantity of bacteria in the water does not exceed a set threshold.

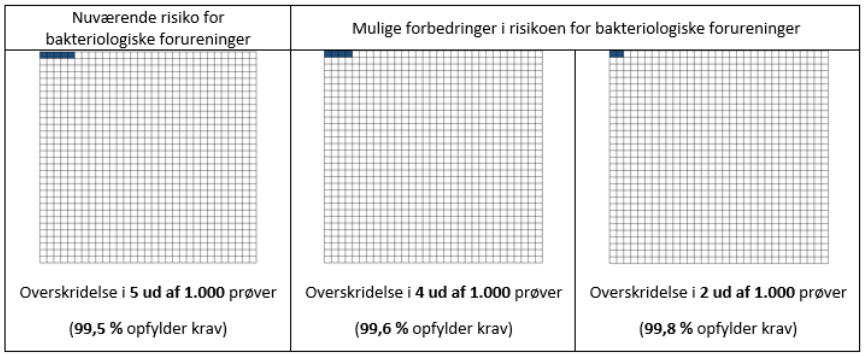
The water companies also measure the level of pesticides (crop sprays) and other harmful substances, but these have not been included in this survey and have no connection with bacteriological overruns.

Too many bacteria in the water may be due to soil, rainwater or sewage water having come into contact with the drinking water. If the threshold values are exceeded, this does not necessarily mean that the water is contaminated or harmful to your health.

But an overrun may result in people getting sick if they drink the water. In these cases, the most common symptoms are stomach pain, diarrhea, vomiting or fever lasting for a couple of days. However, this often passes by itself without treatment.

In case of serious bacteriological overruns, a recommendation to boil the water before use will be issued.

In 2018, there were bacteriological overruns in approx. **5 in 1,000 water samples.** This means that 99.5% of the samples met the requirements. In the alternatives with which you are presented, the risk of overruns may be reduced to 4 in 1,000 (99.6% meet the requirements) or 2 in 1,000 (99.8% meet the requirements). The risk is shown below, where the blue cells represent samples with overruns.



Translation
First box:
Current risk of bacteriological contaminations
Overrun in **5 in 1,000** samples (**99.5 %** meet requirements)

Second and third box:
Possible improvements in the risk of bacteriological contaminations
Overrun in **4 in 1,000** samples (**99.6%** meet requirements) or
Overrun in **2 in 1,000** samples (**99.8%** meet requirements)

Question 11
In the past two years, have you experienced problems with bacteriological contaminations of your water? (have you, for example, been informed that your water was contaminated with bacteria, or that you had to boil the water before use?)

- Yes
- No
- Don't know

Info5 [description according to the respondent's municipality]
Attribute 3: Softening of the water

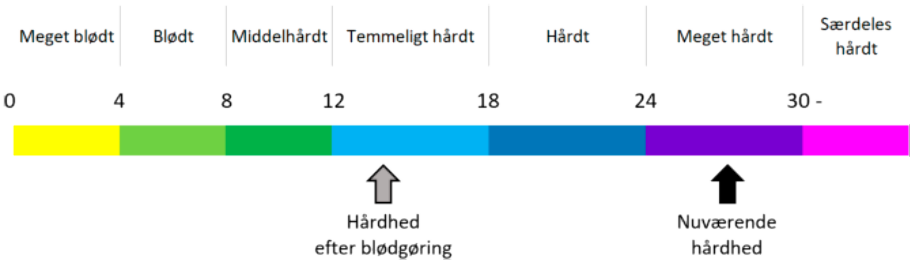
Water hardness is an expression of the calcium content of the water. A high calcium content gives hard water, and a low calcium content gives soft water. The water hardness is measured on a scale from 0 (very soft) to over 30 (extremely hard), and the hardness varies throughout Denmark. **The hardness in your municipality is approx. 27 (very hard).**

In some of the alternatives with which you are presented, the water company has softened the water by removing approx. half of the calcium. This will give your water a hardness of approx. 14 (fairly hard).

This will, for example, mean slightly less energy consumption for your washing machine, a slightly longer service life for household appliances (e.g. electric kettle, dishwasher, washing machine), less use of washing powder, shampoo and detergents as well as less time spent cleaning (less limescale).

Softening the water may also have an effect on how it tastes as well as the experience when washing your hair etc.

The Danish Patient Safety Authority finds that a reduction of the calcium content of drinking water will not have any health effects. Nor does the actual softening process pose any health risk.



Translation
Scale: Very soft - Soft - Medium hard - Fairly hard - Hard - Very hard - Extremely hard
First arrow: Hardness after softening
Second arrow: Current hardness

Question 12
To what degree are you bothered by the current amount of calcium in your water?

- Not at all
- To a very low degree
- To a low degree
- To some degree
- To a high degree
- Don't know

Question 13
Do you use any of the following tools to soften the water in your household?:

- Softening systems (e.g. private or shared systems)
- Filters for showerheads
- Water jug with filter
- Other: _____
- Have not used anything for softening
- Don't know

Info 6
Attribute 4: The water company's customer service

It may sometimes be necessary to contact the water company about, for example, bills, meter readings, consumption or in connection with planned water supply shut-offs. Most water companies post this information on their website or the information is available using the company's self-service solution.

If you need to call your water company, this can typically be done between 8-15 on weekdays. If you choose to write to your water company, most will reply within two working days.

In some of the alternatives presented to you, the water company may have improved their availability and response time. This will mean that the company's opening hours are until 20.00 on two days of the week and that they reply to written inquiries within one working day.

Current customer service	Improved customer service
Opening hours **8-15** Response within **2 days**	Open **8-15**, and **8-20** two days a week Response within **1 day**

Question 14
In the past years, have you:
Please tick all relevant options

- Used your water company's website?
- Used the water company's self-service solutions?
- Commented or contacted the water company via social media?
- Received an email or text message from your water company?
- Called your water company?
- Been in contact with them in any way?
- None of the above.

Info 7
Attribute 5: The water price
The table below shows the typical annual water consumption and the average annual water costs for different households.

	Household type	Annual water consumption	Water costs
	Single	50 m^3	DKK 3,920
	**Avg. household (2.1 persons)**	**81 m^3**	**DKK 5,670**
	Family with 3 children	170 m^3	DKK 10,620

Changes in the four attributes with which you have previously been presented may entail higher costs for the water company, which will be passed on to the customers through higher annual water costs.

Perhaps, you do not pay directly for your water consumption. If, for example, you live in rented accommodation, the price of water may be included in the rent you pay. You should therefore think of the increase in water costs as an annual extra expense for you.

In the alternatives with which you are presented, the costs will vary between **DKK 0 - 1,000 a year.**

Question 14.1
How much does your household approximately pay for water a year?

- Less than DKK 2,000
- DKK 2,000 - 2,999
- DKK 3,000 - 3,999
- DKK 4,000 - 4,999
- DKK 5,000 - 5,999
- DKK 6,000 - 6,999
- DKK 7,000 - 7,999
- DKK 8,000 - 8,999
- DKK 9,000 - 9,999
- Over DKK 10,000
- State amount: ___
- Don't know
- I do not pay for my water myself

Question 15
You will now be asked about some of the information you have just read: [Yes/No]

- Are pesticides (crop sprays) included as bacteriological overruns?
- If there is a bacteriological overrun, does this then always mean that you will get sick?
- The water supply interruptions in this questionnaire correspond only to the unplanned interruptions of which no notice has been given at least 48 hours in advance.
- Can unplanned interruptions occur when you are not using the water?
- Is a high calcium content in the water (i.e. hard water) harmful to your health?
- Are 5 in 1,000 a greater risk than 2 in 1,000?
- Is once in 15 years a lower risk than once in 9 years?

Info8
Here, you can see the correct answers to the questions from the previous page:

	Yes	No
Are pesticides (crop sprays) included as bacteriological overruns?		X
If there is a bacteriological overrun, does this then always mean that you will get sick?		X
The water supply interruptions in this questionnaire correspond only to the unplanned interruptions of which no notice has been given at least 48 hours in advance.	X	
Can unplanned interruptions occur when you are not using the water?	X	
Is a high calcium content in the water (i.e. hard water) harmful to your health?		X
Are 5 in 1,000 a greater risk than 2 in 1,000?	X	
Is once in 15 years a lower risk than once in 9 years?	X	

Info 8cs1
Explanation of the alternatives in the choice situations

You will soon be presented with five choice situations.

Each choice situation presents three alternatives, and you have to choose the one you prefer.

This is an example of how the alternatives in the choice situations are presented.

You will find an example of a choice situation on the next page.

Current water supply	One of the alternatives in the choice situations is not a new proposal, as it corresponds to your current water supply (shown on the left).
2 hours without water (unplanned) once in **9 years**	The current risk of unplanned interruptions is equal to the occurrence of a 2-hour unplanned interruption once in 9 years.
Bacteriological overrun in **5** in 1,000 samples	The current risk of bacteriological overruns is equal to the occurrence of overruns in 5 in 1,000 water samples.
Not softened	At present, the water company does not soften the water.
Opening hours: **8-15** Response time: **2 days**	The water companies' current customer service is typically open between 8-15 on weekdays and they respond to written inquiries within two days.
Increase in annual water costs **DKK 0**	As no changes are made, this alternative is not connected with an increase in your household's annual water costs.

This is an example of a choice situation!
In each choice situation, you will be presented with three different water supply alternatives, where you are to choose which you prefer.

In each question, one of the alternatives will correspond to your current water supply, with the attributes being equal to those you have in your current water supply.

In the other two alternatives, some of the attributes may have changed in relation to your current situation.

Current water supply	**Alternative water supply A**	**Alternative water supply B**
2 hours without water (unplanned) once in **9 years**	2 hours without water (unplanned) once in **15 years**	2 hours without water (unplanned) once in **24 years**
Bacteriological overrun in **5** in 1,000 samples	Bacteriological overrun in **2** in 1,000 samples	Bacteriological overrun in **4** in 1,000 samples
Not softened	**Not softened**	**Softened** (50% less calcium)
Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** and **8-20** Response time: **1 day**	Opening hours: **8-15** Response time: **2 days**
Increase in annual water costs **DKK 0**	Increase in annual water costs **DKK 250**	Increase in annual water costs **DKK 450**

Info10
You are now ready to choose. You will be presented with five different choice situations.

- In each situation, you are asked to choose the alternative that you prefer
- Your answers may result in regulatory changes for the water companies and higher water costs for you
- You should therefore choose exactly as you would have done in a real situation.

Each question represents a whole new situation. The questions must therefore be seen as independent of each other!

Choice scenarios 1-4 [The respondents saw four choice scenarios presented in random order]

Choose the water supply alternative you prefer by clicking the alternative and then pressing the button at the bottom to proceed:
If you do not agree with any of the suggested new alternatives, you can always choose your current water supply, which does not increase your annual water costs.

Current water supply	**Alternative water supply A**	**Alternative water supply B**
2 hours without water (unplanned) once in **9 years**	2 hours without water (unplanned) once in **24 years**	2 hours without water (unplanned) once in **15 years**
Bacteriological overrun in **5** in 1,000 samples	Bacteriological overrun in **4** in 1,000 samples	Bacteriological overrun in **5** in 1,000 samples
Not softened	**Softened** (50% less calcium)	**Not softened**
Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** and **8-20** Response time: **1 day**
Increase in annual water costs **DKK 0**	Increase in annual water costs **DKK 1000**	Increase in annual water costs **DKK 100**

Choice scenario 5 ['control' choice scenario]

Choose the water supply alternative you prefer by clicking the alternative and then pressing the button at the bottom to proceed:
If you do not agree with any of the suggested new alternatives, you can always choose your current water supply, which does not increase your annual water costs.

Current water supply	**Alternative water supply A**	**Alternative water supply B**
2 hours without water (unplanned) once in **9 years**	2 hours without water (unplanned) once in **15 years**	2 hours without water (unplanned) once in **24 years**

Bacteriological overrun in **5** in 1,000 samples	Bacteriological overrun in **4** in 1,000 samples	Bacteriological overrun in **2** in 1,000 samples
Not softened	**Not softened**	**Not softened**
Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** Response time: **2 days**	Opening hours: **8-15** Response time: **2 days**
Increase in annual water costs **DKK 0**	Increase in annual water costs **DKK 250**	Increase in annual water costs **DKK 0**

Question 16 [only if the respondent chose 'current water supply' in all choice situations]
In all choice situations, you have chosen your current water supply or an alternative that does not increase your annual water costs. What is the primary reason for this?

- The questions were too difficult
- I cannot afford to pay more for my water
- The options were difficult, so I simply chose the cheapest
- I am not interested in the subject
- I do not want to pay more for my water
- I think the municipality should pay for better water
- I think my current water supply works fine
- I do not think that the improvements will be made in reality
- Other, please specify: _____
- Don't know

Question 17 [only if the respondent never chose 'current water supply']
In all choice situations, you have chosen an alternative in which changes are made to your water supply. What is the primary reason for this?

- I am interested in these improvements, no matter how much they cost
- I did not understand the question
- The questions were too difficult
- I am not interested in the subject
- The changes to the water supply will be good and valuable for me and my household
- I feel that these were the morally correct answers
- I am not satisfied with my current water supply
- Other: _____
- Don't know

Question 18
Have you, within the past two years, been exposed to unplanned **power outages** where there was an interruption in the supply of electricity to your household for which the electricity company was responsible?

You are not to include outages that were due to power failures in your home caused by, for example, a blown fuse.

- Yes
- No
- Don't know

Question 19
What would you think was worst at 18.00 in the evening?

- A 2-hour failure in my power supply
- A 2-hour failure in my water supply
- They would be equally bad
- Don't know

Info 11
The next questions are about waste water.

All water from households, companies and institutions is treated so that pollutants are broken down and removed to a degree that renders them unharmful when the treated waste water is discharged into streams, lakes or the sea, or seeps into the ground.

Waste water companies also handle rainwater, i.e. treatment of rainwater that runs down into the sewers, before it is discharged. The sewerage system and waste water treatment plants can only handle a certain volume of water at a time. In connection with heavy rainfall, the volume of water may exceed the volume that can be handled. This means that untreated waste water is discharged directly into the aquatic environment, for example in a stream or creek, after which it ends up in the sea.

Waste water companies can also extract energy and heat from the waste water, for example by producing biogas or by using a heat pump to extract energy from the waste water. This type of energy production contributes to reducing the carbon footprint.

Which of the following improvements to wastewater management do you think are most important?

Please rank the three answer options below, where 1 is the most important, 2 is the second most important, etc.

- That the waste water is treated for more nutrients and environmentally-hazardous substances before it is discharged. Fewer nutrients would help promote a better condition of streams, lakes and coastal waters.
- That the sewerage system is improved so that it can handle more water during heavy rainfalls. This would, for example, reduce the risk of flooding and that the water by the beach is contaminated by untreated waste water after heavy rainfalls.
- That waste water companies used less energy or produced energy in their waste water management. This would reduce the climate impact of the waste water management.

Question 20
During heavy rainfall, untreated waste water may contaminate the water at beaches, so that bathing is not possible for 2-3 days after the contamination. Assume that this happens once a summer at your regular beach.

If you were to choose between the following alternatives, which would you prefer:

- That my water company softens my water by removing 50% of the calcium
- That my waste water company ensures that waste water cannot run into and contaminate bathing beach water

Question 21
During heavy rainfall, untreated waste water may contaminate the water at beaches, so that bathing is not possible for 2-3 days after the contamination. Assume that this happens once a summer at your regular beach.

If you were to choose between the following alternatives, which would you prefer:

- That my water company ensures that the risk of unplanned interruptions is equal to being without water for 2 hours (unplanned) once in 24 years (from the current risk of once in 9 years)
- That my waste water company ensures that waste water cannot run into and contaminate bathing beach water

Question 22
What is the total income before tax of your household?

- Less than DKK 100,000
- DKK 100,000 - 199,999
- DKK 200,000 - 299,999
- DKK 300,000 - 399,999
- DKK 400,000 - 499,999
- DKK 500,000 - 599,999
- DKK 600,000 - 699,999
- DKK 700,000 - 799,999
- DKK 800,000 - 899,999
- DKK 900,000 - 999,999
- DKK 1 million - 1½ million
- DKK 1½ million - 2 million
- DKK 2 million - 3 million
- Over DKK 3 million
- Don't know
- Don't want to answer

Question 23
Please tick your most recently completed education.

- Basic school 7th-10th grades (primary school, middle school, lower secondary school)
- Upper secondary school (e.g. Higher Preparatory Examination Programme (HF), Higher Commercial Examination Programme (HH), Higher Technical Examination Programme (HTX), adult upper secondary level programme ('studenterkursus')
- Vocational training programme (e.g. business school, technical school, artisan)
- Qualifying courses of study
- Short-cycle higher education (1-2 years, e.g. laboratory technician, computer scientist)
- Medium-cycle higher education (2-4 years, e.g. nurse, primary school teacher)
- Bachelor's degree
- Long-cycle higher education (over 4 years, university graduate)
- PhD or research degree programme
- Don't know /don't want to disclose

Question 24
How many members are there in your household, yourself included?

- _____

Question 25
How many children do you have who live at home?

- 1 child

- 2 children
- 3 children
- 4 children
- 5 children or more

Question 26
What type of accommodation do you live in?

- House
- Terraced house
- Flat
- Hall of residence
- Other, please specify: _____

Question 27
Do you think that the coronavirus crisis has made you more or less willing to pay higher water costs to reduce the risk of bacteriological overruns in your drinking water?

- The coronavirus crisis has made me more willing to pay for fewer bacteriological overruns
- No change
- The coronavirus crisis has made me less willing to pay for fewer bacteriological overruns

Thank you for your participation.

If you have any further comments, please feel free to write them here: ___

Appendix 2: Classification of protest and strategic behaviour

If the respondents in all choice scenarios chose their current situation and one of the two free alternatives in the fifth 'control' choice set, they were asked a follow-up question about the causes of this behaviour. If the respondent answers the follow-up question with an alternative indicating protest behaviour, shown in Table B3.1, the respondent is excluded from the analysis. These alternatives are characterised by the respondent not having answered the questions based on their preferences because, for example, they have strong opinions about who should pay for improvements, do not find the constructed scenario credible or think that the questions were too difficult.

Table B3.1 **Answer options for follow-up question about protest behaviour**

Answer option	Protest	Number of responses
I cannot afford to pay more for my water	No	40
I am not interested in the subject	No	11
I think the municipality should pay for better water	**Yes**	20
I think my current water supply works fine	No	220
I do not think that the improvements will be made in reality	**Yes**	14
I do not want to pay more for my water.	No	101
The questions were too difficult	**Yes**	2
The options were difficult, so I simply chose the cheapest	**Yes**	13
Other, please specify:	**Yes**/No	15[1]
Don't know	**Yes**	28

Note 1: Based on the respondents who answered 'Other' and wrote a reason, two respondents were classified as showing protest behaviour.

Note: Question text: "In all choice situations, you have chosen your current water supply or an alternative that does not increase your annual water costs, what is the primary reason for this?"

Source: Own calculations

If the respondents answered all the choice sets with one of the new alternatives, they were also asked a follow-up question about the reason for this behaviour. If the respondent chose one of the answer options that indicated that, for example, the respondent has not taken the payment seriously or, for other reasons, can be assumed not to state his or her true preferences, the respondent was excluded. These are shown in Table B3.2.

Table B3.2 **Answer options for follow-up question about protest behaviour**

Answer option	Strategic	Number of responses
I am not satisfied with my current water supply	No	9
I am interested in these improvements, no matter how much they cost	**Yes**	68
I did not understand the question	**Yes**	3
I feel that these were the morally correct answers	**Yes**	21
I am not interested in the subject	**Yes**	17
The questions were too difficult	**Yes**	3
The changes to the water supply will be good and valuable for me and my household	**Yes**	2
Other:	**Yes**/No	40[1]
Don't know	**Yes**	15

Note 1: Based on the respondents who answered 'Other', no respondents were excluded.

Note: Question text: "In all choice situations, you have chosen an alternative in which changes are made to your water supply, what is the primary reason for this?"

Source: Own calculations

Appendix 3: Control questions

After the description of the attributes, the respondents were asked some control questions about the information they had read, and afterwards shown the right answers to these control questions. Table B4.1 shows respondents' answers to the control questions.

Table B4.1 **Answers to control questions (percentage share)**

Question	Yes (per cent)	No (per cent)
The water supply interruptions in this questionnaire correspond only to the unplanned interruptions of which no notice has been given at least 48 hours in advance?	**57**	43
Can unplanned interruptions occur when you are not using the water?	**85**	15
Is once in 15 years a lower minor risk than once in 9 years?	**82**	18
Are pesticides (crop spray) included as bacteriological overruns?	53	**47**
If there is a bacteriological overrun, does this always mean that you will get sick?	11	**89**
Are 5 in 1,000 a greater risk than 2 in 1,000?	**85**	15
Is a high calcium content in the water (i.e. hard water) harmful to your health?	14	**86**

Note: The share of correct answers is underlined and marked in bold.

Source: Own calculations

The effect on the willingness to pay of answering incorrectly one of the seven control questions is presented in Table B4.2. The model has been estimated by two dummy variables having been constructed based on each control question, where the dummy variables indicates whether the respondent answered correctly or incorrectly. These are used to construct two interaction terms, one with the attribute and the dummy variable for correct answer (these represent the willingness to pay in model 4 in 5.1), and one with the attribute and dummy variable for incorrect answer (these are shown in Table B4.2).

Most of the estimates are not statistically significant, and many do not have the expected sign. However, a higher willingness to pay is estimated for the respondents who have answered the question about unplanned interruptions incorrectly and therefore thought that the survey also concerned planned interruptions. This could be expected as these respondents may have thought that they were considering a larger improvement (i.e. including planned interruptions). However, this estimate has a p-value of 0.09 and is thus not significant.

Table B4.2 **Effect of incorrect answer on willingness to pay**

Question	Attribute	Estimate	Default error	p-value

The water supply interruptions in this questionnaire correspond only to the unplanned interruptions of which no notice has been given at least 48 hours in advance?	Interruption minutes	4.4	2.6	0.09	
Can unplanned interruptions occur when you are not using the water?	Interruption minutes	3.8	4.2	0.37	
Is once in 15 years a lower minor risk than once in 9 years?	Interruption minutes	7.0	3.9	0.07	
Are pesticides (crop spray) included as bacteriological overruns?	Bacteriological overrun	5.0	7.2	0.49	
If there is a bacteriological overrun, does this always mean that you will get sick?	Bacteriological overrun	1.6	14.8	0.92	
Are 5 in 1,000 a greater risk than 2 in 1,000?	Bacteriological overrun	21.1	12.1	0.08	
Is a high calcium content in the water (i.e. hard water) harmful to your health?	Softening of the water (from soft)	-263.5	305.3	0.39	
	Softening of the water (from medium hard)	-272.3	106.7	0.01	*
	Softening of the water (from fairly hard)	-54.6	72.6	0.45	
	Softening of the water (from hard)	77.9	107.1	0.47	
	Softening of the water (from very hard)	-315.6	209.0	0.13	

Note: The model is a mixed logit model defined in 'willingness-to-pay space', and is estimated in the program R. 1,000 Halton draws have been used in connection with the simulation of the maximum likelihood function. ***, ** and * indicate significant difference from zero at 99.9 per cent, 99 per cent and 95 per cent confidence intervals.

Source: Own calculations

Appendix 4: The introductory qualitative analysis

The introductory qualitative analysis was conducted by the consultancy firm Morphic. It has not been translated, but can be found in the Danish version of this analysis[64].

[64] https://www.kfst.dk/media/kvchaxo4/forbrugernes-betalingsvilje-for-forbedringer-i-vandforsektoren.pdf