The poker game of sustainable selection
Why the tender with the lowest environmental impact will not always win

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Abstract

Contracting authorities can have a big role in stimulating sustainable development in the infrastructure industry by selecting a tender based on sustainability criteria. To be able to compare the sustainability of different tenders in a quantitative way the environmental costs indicator (Dutch: *Milieukostenindicator* (MKI)) can be used. However, to use the MKI to select the actual most sustainable tender, the MKI has to be calculated, assessed, and applied correctly. Interviews and a focus group session have been conducted with different stakeholders in the application of the MKI in the asphalt paving industry. This research identifies broad variation in assumptions, differences between the methods used by contracting authorities, lack of knowledge and reliable information at contracting authorities, and inaccurate control in practice by contracting authorities as the main factors causing the risk of adverse selection on the basis of MKI. It shows that, when implementing the MKI, the risk of adverse selection thwarts the rationales for innovation-friendly procurement. This research suggests composing an expanded manual including basic information on how to apply the MKI in the procurement of asphalt. The manual can help contracting authorities to use the methods for selecting and controlling the tender with the lowest MKI in balance with the available knowledge, information, time, and resources. This will be a step forward in securing contracting authorities to receive the desired results, stimulating contractors to invest in innovation, and stopping the poker game of sustainable selection.

Keywords: Sustainability, innovation procurement, asphalt, adverse selection, misrepresentation, information asymmetry

1. Introduction

Demand can be a major source of innovation, and one of the key elements of a demand-oriented innovation policy is public procurement (Edler & Georghiou, 2007; OECD, 2017). One of the rising demands in current society is sustainability. To put sustainability ambitions and policies into practice, sustainability procurement can be used. Since governmental organizations can influence demand of products and processes, they have a major role in stimulating sustainable development and innovation (Srivastava, 2007; Preuss, 2009).

In order to stimulate sustainable development through procurement, a contracting authority has to have the tools to assess and compare tenders on the basis of sustainability. Assessing and comparing sustainable aspects in a quantitative way can be done by focusing on the environmental impact of a product, process, or project. For comparing the environmental impact of products, processes, and products the environmental costs indicator (Dutch: *milieukostenindicator* (MKI)) is used (Stichting Bouwkwalitieit, 2019).

However, contracting authorities may struggle with the use of the MKI in their procurement strategy. When contracting authorities have limited information and knowledge, contractors may misrepresent the expected performance of their product, resulting in adverse selection by contracting authorities. Consequently, contracting authorities may select a tender on basis of the lowest MKI. Yet, in practice the selected tender is not the tender with the lowest environmental impact. Adverse selection of contractors will have various consequences, which are shown in the problem-cause diagram in Figure 1. First, the contracting authority will not receive the desired product. Second, the incentive for contractors to invest in sustainable development and innovation will decrease. The investments of contractors will not pay off, because other contractors can achieve lower MKI value without having a more sustainable tender. This may even lead to a third implication, in which contractors are stimulated to game the system (Rieley, 2001).

Contracting authorities will select the tender which they believe has the lowest environmental impact. Contractors benefit from the lowest possible MKI value and shall use all possible leeway to achieve this. Even if this means playing the poker

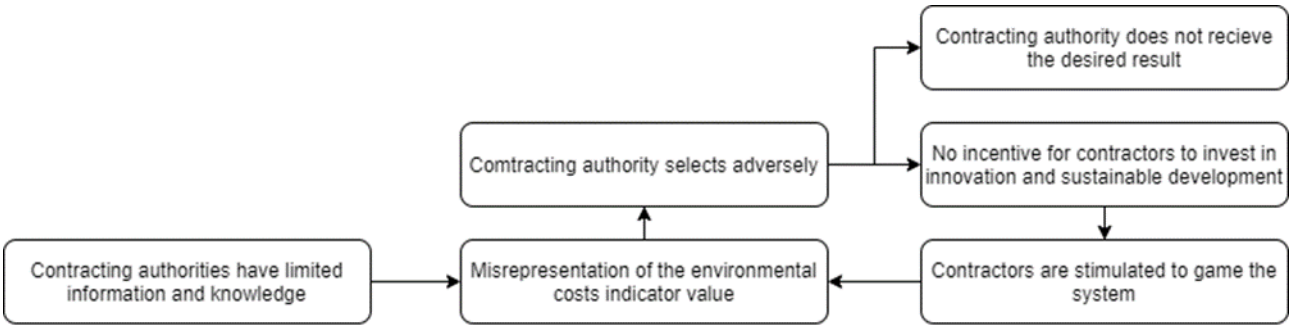

Figure 1 Problem-cause diagram

game of sustainable selection. Hence, it is in the interest of both contracting authorities, and contractors who invest in sustainable solutions, that the risk of adverse selection based on MKI is mitigated.

The objective of this research is to present measures that can be taken by contracting authorities to decrease the risk of adverse selection in the procurement of asphalt. To reach this objective, factors impacting the current method for assessing and comparing the MKI have been identified. Thereafter, the measures that could be taken to decrease the impact of these factors have been proposed. Taking these measures will help in mitigating the risk of adverse selection in the procurement of asphalt, increase the incentive for contractors to invest in sustainable solutions, and stop the poker game of sustainable selection.

2. Theoretical framework

A theoretical framework is drafted to create a basis for the interviews. The theoretical framework gives insight in the methods for stimulating sustainable development through procurement using the MKI. It further describes the characteristics of adverse selection and methods on how the risk of adverse selection may be mitigated.

2.1. Innovation procurement

Public procurement is increasingly seen as an important instrument for stimulating innovation (Lenderink, Halman, & Voordijk, 2019). Given the influence of government from a demand-side perspective, the interest on stimulating innovation through public procurement is increasing (Lember, Kalvet, & Kattel, 2011). Regular procurement practices that favour, or at least do not hinder, innovation can be referred to as innovation-friendly procurement (Uyarra & Flanaga, 2010; OECD, 2011; Edquist & Iturriagagoitia, 2015). Stimulating innovation through regular procurement can thus be carried out by innovation-friendly procurement (Lenderink et al., 2019).

Four rationales for the use of innovation-friendly procurement can be separated (Lenderink et al., 2019). The first rationale is that value-for-money of the procured products and services that are likely to improve, when innovation-friendly procurement is implemented. Second, existing solutions may not be sufficient to meet future needs. By enabling the market to be more innovative, quality of future public services will be ensured. Third, through innovation-friendly procurement, the competitiveness of contractors and suppliers will be enhanced. Fourth and last, since innovation-friendly procurement can be integrated in regular procurement strategies, limited time and resources are needed to implement innovation-friendly procurement. Since the required time and resources are limited, innovation-friendly procurement can influence innovation on a large scale.

Albeit implementing innovation-procurement in regular procurement requires limited time and resources, some changes in the procurement process are needed (Knutsson & Thomasson, 2014). Contracting authorities have to be able to compare both price and quality criteria. Contracting authorities may use most economical advantageous tendering (MEAT) to score contractors on both criteria (Parikka-Alhola, Nissinen, & Ekroos, 2006). Through MEAT a fictional price or reward can be given in accordance to the score of a tender on a specific criterium. Combining this fictional price or reward with the actual price will result in a winning tender with the best consideration of both price and quality (Dreschler, 2009).

2.2. Sustainability assessment

One of the major social and agency challenges at this moment is sustainability. One way to compare the sustainability of products and projects is through the environmental impact. In the Netherlands, to evaluate the environmental impact, the environmental costs indicator (MKI) is developed.

From LCA to MKI

In calculating the MKI of a product or project, various steps have to be taken. The first step in calculating the MKI is performing a life cycle analysis (LCA) of the materials, components and products that are used. The life cycle of a product is divided into four stages, schematically shown in Figure 2. The four stages are: A production and construction stage, B user stage, C end of life stage, and D reuse stage. Through performing an LCA, the environmental impact of a product over all the lifecycle stages is defined.

The result of an LCA is an environmental product declaration (EPD), which can be used to calculate the MKI. The EPD gives an overview of the environmental effects of a product and corresponding activities during all life cycle stages. The EPDs are used to calculate the MKI. In order to transform the EPDs into MKI, the costs of the environmental effects are evaluated. By evaluating these costs, the effects can be combined. The sum of the costs results in the MKI value of a project or product.

The Determination Method

The LCA and EPD can be made applicable for the calculation of the MKI through the Dutch Determination Method (Dutch: *Bepalingsmethode Milieuprestatie gebouwen en GWW-werken*). Both the LCA and EPD have to be composed conform the Determination Method and, the complementary product category rules (PCR), if present (Stichting Bouwkwalitieit, 2019). The goal of this method is to create an unambiguous and controllable way to calculate the MKI.

The way in which the LCA and EPD are composed is verified by a licenced verifier. The composer of the LCA selects a verifier himself. The verifier checks if the LCA and EPD are composed conform the latest version of the Determination Method, and complementary rules.

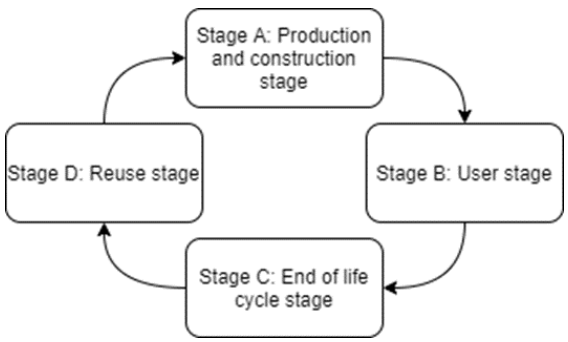

Figure 2 Lifecycle stages

The MKI in procurement

Both contractors and contracting authorities calculate the MKI value for a project, however using different information. Contracting authorities calculate the MKI value, with the available data in the National Environmental Database. With this MKI value contracting authorities can get a representation of the expected environmental impact of the project.

Contractors calculate the MKI during the tender phase. Most contractors have their own specific database which is not shared with the National Environmental Database. They combine their own data with data from the National Environmental Database to calculate the MKI value of their own products or projects.

From the submitted tenders the contracting authority can then select the most sustainable tender on the basis of the MKI. The contracting authority may reward tenders with a low MKI value with a discount on the tender price, as used in MEAT (Dreschler, 2009).

2.3. The risk of adverse selection

When using the MKI to select the most sustainable tender, the risk of adverse selection may emerge. Risk can be defined as the chance of an event happening multiplied by the consequence of the event happening (Ale, 2009). There is chance of adverse selection when there is information asymmetry between the contracting authority and the contractor (Akerlof, 1978). The consequence is the opportunity of misrepresentation. So, the situation occurs in which a contracting authority cannot be sure if the promises in the tender of the winning contractor can also be fulfilled.

The contracting authority that wants to select a contractor has to bridge the information asymmetry (Akerlof, 1978; Spence, 1978). Since there is a situation in which one party (contractor) has better or more information and knowledge than the other party (contracting authority), the contractor is the only one who knows if the delivered information is accurate. Furthermore, the contractor is also the only one who knows if he is going to use his full resources and capacity on behalf of the contracting authority. (Winch, 2009).

Information asymmetry may encourage misrepresentation by the contractor. This research will define two types of misrepresentation: unintentional misrepresentation and strategic misrepresentation.

Unintentional misrepresentation is the consequence of cognitive biases and mistakes. Due to the tendency to overestimate one's own performance, decisions made by contractors in the tender phase may be based on an optimistic view instead of rational consideration of benefit, loss, and possibilities (Tversky & Kahneman, 1974; Flyvbjerg, Garbuio, & Lovallo, 2009; Flyvbjerg & Sunstein, 2016). The major source of unintentional overestimation of project performance is the inside view (Tversky & Kahneman, 1986). Planners and designers have the tendency to focus strongly on single projects. They think about the plan and the obstacles to overcome to finish the project. Planners and designers may extrapolate the current progress of the specific project, creating an inside view which is causing overestimation of project performance (Flyvbjerg et al., 2009).

Besides unintentional misrepresentation, contractors may misrepresent strategically. Strategic misrepresentation takes place when decision-makers wittingly choose to underestimate project costs and time to increase their chances to be selected (Wachs, 1990). Furthermore, the research of Flyvbjerg et al. (2009) concludes that it is beneficial for planners to wittingly make optimistic forecasts and assumptions regarding the performance of projects. Especially, when competing over scare funds and subsidies. Since the infrastructure sector is a highly competitive market with low margins, strategic misrepresentation can be a powerful weapon to outsmart competition (Liu, Bannerman, Elliott, Ewart, & Atkinson, 2014).

There is a balance between strategic and unintentional misrepresentation. Both occur in forecast of future performance. Comparatively, strategic misrepresentation seems to outweigh unintentional misrepresentation as the stakes increase. When the stakes of a project increase, so do the strategic, political, and economic interests (Flyvbjerg et al., 2009).

2.4. Methods to mitigate the risk of adverse selection

In mitigating the risk of adverse selection, four methods are distinguished. Screening and signalling methods can be used to decrease the information asymmetry. To decrease the opportunity of misrepresentation contracting authorities may harmonise interests and use references. A schematic overview of the methods is shown in Figure 3.

The screening method is used by an uninformed party, in this case the contracting authority, to get information from the informed part, in this case the contractor. A typical way of screening is asking for guarantees and certificates (Stiglitz & Weiss, 1990; Schieg, 2008). In the current calculation and assessment method, screening is performed by asking for a verification certificate. A verification certificate ensures that the MKI value is calculated conform the Determination Method.

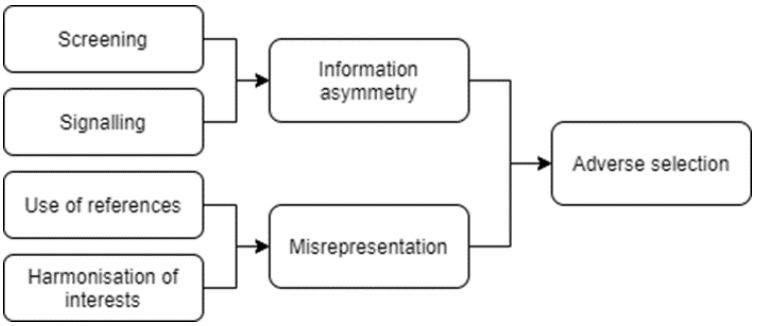

Figure 3 Methods for mitigating the risk of adverse selection

Information asymmetry can also be decreased through signalling (Stiglitz & Weiss, 1990). Signalling methods are used by a contractor to inform a contracting authority that he is suitable and fit to carry out the project. Important in signalling is that the benefits from signalling are higher than the costs for a suitable contractor, but lower for an unsuitable contractor (Spence, 1978). Contracting authorities should enable the possibilities for suitable contracts to distinguish themselves from unsuitable contractors. Otherwise every contractor, suitable or unsuitable, could signal itself as a suitable contractor (Schieg, 2008).

The third method is the harmonisation of interests between the contracting authority and the contractor, which can be used to decrease the opportunities for misrepresentation. When interests are harmonised, the incentive for the contractor to exploit the information asymmetry in disadvantage of the contracting authority is decreased. In the Dutch infrastructure industry, the common method for harmonising the interest is by inserting a bonus/malus system in the contract where contractors are rewarded or punished conform their performance (Hosseini, Windimu, Klakegg, Andersen, & Laedre, 2018).

The fourth method is the use of references. References can be used to decrease the chance of falling for the inside view. In order to make realistic references, the amount of assumptions will need to be decreased. The assumptions need to be replaced with data. Only with decreasing the amount of assumptions needed to set up references, a realistic

estimation of the projects performance can be made (Flyvbjerg, Hon, & Fok, 2016).

3. Methods

The goal of the research was to get an overview of possible measures that can be taken to mitigate the risk of adverse selection. This was done by evaluating the current calculation and assessment method of the MKI.

3.1. Data collection

The first step in the in the empirical study was conducting interviews. Interviews were conducted with six different experts on the application of the MKI. Two sustainability experts (who are generally involved in tendering at contractors), one expert of a consultancy firm which advises contracting authorities in the use of the MKI, and three experts from different contracting authorities, who are involved with using the MKI in contracts. The objective of these interviews was to determine which factors influence the calculation and assessment of the MKI, and to develop an overview of proposed measures to mitigate the identified factors.

Semi-structured interviews were used to give the interviewer the opportunity to go deeper into the answers and remarks made by the interviewee (Weiss, 1995). Furthermore, the number of responders was of such a size that interviews are efficient and applicable (Boeije, 2005). To give direction during the interviews, an interview protocol was used. This interview protocol is presented in Appendix I. The interviews consisted of five stages.

The interviews started with introductory questions, to get to know the experiences of the interviewee with the MKI.

In the second stage the interviewees were asked about their experiences with information asymmetry and the opportunities for misrepresentation. The interviewees were asked what factors impact the information asymmetry and opportunities for misrepresentation, and what measures could be taken to decrease the impact of these factors.

The third stage went into the application of the methods for mitigating the risk of adverse selection. The interviewees were asked how they apply these methods, what factors impact the application of these methods and what could be done to mitigate the impact of the factors.

In the fourth stage the interviewees were asked to imagine themselves in a different role. The experts from contracting authorities were asked what they would do if they were contractors, and the contractors were asked what they would do if they were contracting authorities. In this way a more detailed view could be created on the factors and possible measures. Furthermore, experts may propose measures against factors that they may withheld during the interviews.

The last stage of the interviews was the validation of the answers given in previous interviews. The interviewees were asked to what extent they agreed with the answers from previous interviews.

3.2. Data analysis

The data analysis started with unravelling and ordering the data (Boeije, 2005). The interview data was ordered into the different factors and different proposed measures mentioned by the interviewees. This resulted in an overview of the data from the different interviewees per identified factor and proposed measure.

The second step was working out the data and find what is important. In this step the factors directly impacting the calculation, assessment, and application of the MKI have been identified. Following this step, the most important factors have been found.

The third step was finding patterns between the identified factor, the proposed measures, and methods for mitigating the risk of adverse selection. This step combines the theoretical framework with the outcomes of the empirical study. This resulted in preliminary recommendations.

3.3. Validation of the interview results

The last step in the research was validating the identified factors and proposed measures. The factors and measures have been validated through a focus group. The focus group has been used for two reasons (Boeije, 2005). First, with a focus group it was possible to interview many people within a short period of time. Second, within a focus group there would also be social interaction between the participants The combination of the social interactions and short period of time could be used to discuss the results and create consensus regarding the proposed measures (Kitzinger, 1994).

The focus group consisted of seven experts on the calculation and assessment of the MKI. Three experts from two different contracting authorities, and four experts from three different contractors. In this way the addressed topics could be discussed from different points of view.

The focus group has been used to discuss the identified factors and to discuss the proposed

measures. The protocol used during the focus group meeting is presented in Appendix II. The goal of the focus group was to get an overview of the impact of the different factors and proposed measures, and how these measures would suit the current practice.

4. Results

The results of this research are separated into two sections. The first section provides the identified factors and proposed measures by the interviewees. The second section provides the results from the validation by the focus group.

4.1. Interview results

The interview results are divided in two. First, the identified factors that impact the calculation and assessment of the MKI. Second, the proposed measures to decrease the impact of these factors.

Identified factors

The interviews identified five main factors impacting the calculation and assessment of the MKI. The identified factors are shown in Figure 4. The five factors will be discussed separately.

Variation in assumptions in the calculation method

The process of determining the MKI value is based on predictions and assumptions. The interviewees moreover noted that the calculation method is inaccurate. The Determination Method is composed for the entire construction sector. Therefore, the assumptions made are broad. Furthermore, the assumptions made by different verifiers differ. These differences cause variation in the MKI value depending on the verifier, leading to opportunities for unintentional misrepresentation.

Moreover, the interviewees noted that verifiers of LCA are selected by the composer of the LCA. Therefore, composers of the LCA could select a verifier favourably. This gives contractors the opportunity to misrepresent strategically, and also hamper the use of screening methods.

Differences between contracting authorities in the use of the MKI in procurement

Contracting authorities differ in the way they applicate the MKI in the procurement procedure. The interviews showed that contracting authorities differ in the determination of the scope of the life cycle from which they require the MKI value. These differences emerge since some contracting authorities only ask the MKI value over life cycle stage A, while other contracting authorities ask for the MKI value of all the life cycle stages.

In addition, contracting authorities differ in the relative number of products for which they require the MKI value. Contracting authorities may ask for an MKI value which includes all products used, including products with presumably minimal environmental impact. Yet other contracting authorities

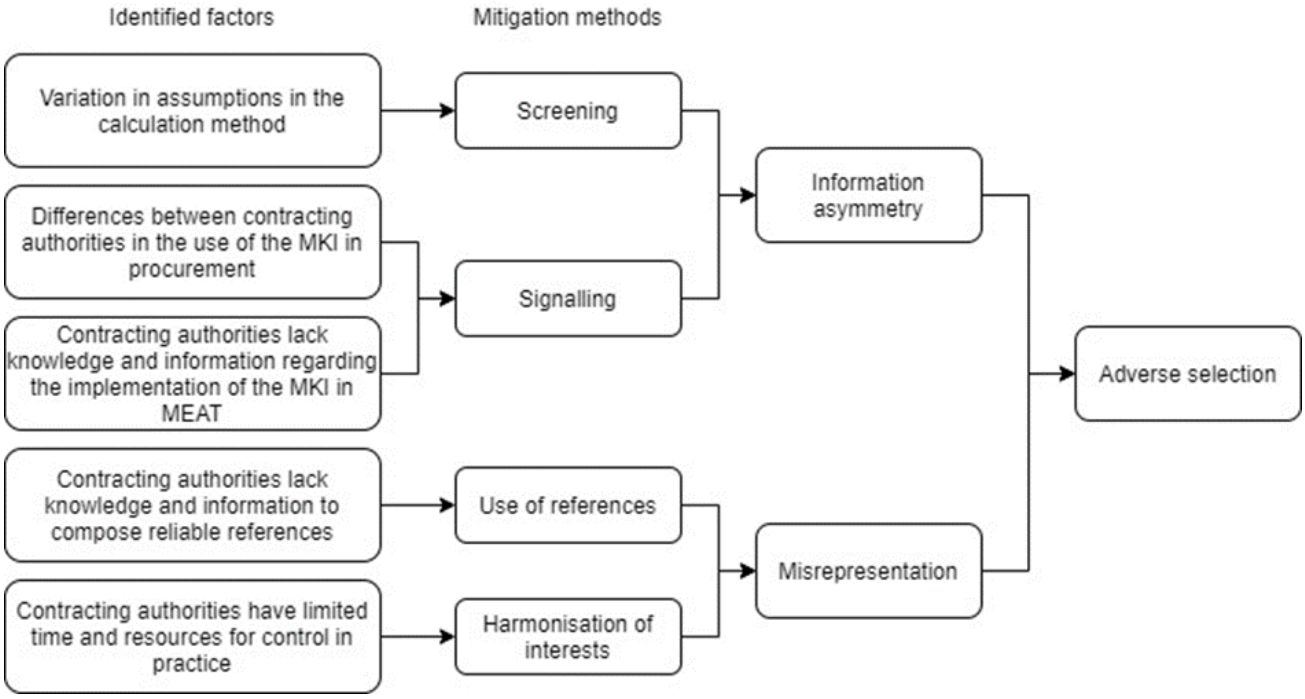

Figure 4 Identified factors

only ask for the MKI value of a few products, which presumably heave the most environmental impact.

Besides the differences in the scope in products and life cycle stages, the contracting authorities also differ in the discount contractors can receive for a low MKI value. Some contracting authorities reward a low MKI value with much more discount than other contracting authorities. Also, the MKI value for which the maximum discount can be received is much more challenging at some contracting authorities than at others.

These differences have two implications. First, the differences hamper the incentive for contractors to innovate. The differences cause contractors to reinvent the wheel for every tender they would like to compete in. Consequently, contractors are not able to decide on a focus for their innovation strategy. This impacts the signalling method. Since suitable contractors are not sure if they will distinguish themselves in future tenders. Second, due to a lack of consistency between contracting authorities it is harder for them to learn from each other and from comparable projects.

Contracting authorities lack knowledge and information regarding the implementation of the MKI in MEAT

The lack of knowledge and information impacts the application of the MKI in MEAT. Contracting authorities have problems finding the right balance between the price and the rewards given for a low MKI value. In addition, contracting authorities have problems finding the right MKI value for which the maximum reward is given. The interviewees noted that contracting authorities determine the MKI value for a maximum reward too high. Consequently, the limit is easily achievable and not challenging. Therefore, contracting authorities are not able to apply signalling methods in such a way that they are able to distinguish suitable contractors from unsuitable contractors.

Contracting authorities lack knowledge and information to compose reliable references

Contracting authorities lack knowledge due to limited experience they have with the MKI. The interviewees from contracting authorities stated that most of the contracting authorities only had done a few projects with the MKI and that consequently the experience was rather limited. Therefore, contracting authorities are not able to rely on their experience when composing references.

Furthermore, contracting authorities lack information because they depend on the data in the National Environmental Database. The interviewees underlined that the National Environmental Database is limitedly filled and mostly includes unreliable data. Due to the limited information and knowledge of contracting authorities there is an information asymmetry and contracting authorities are not able to compose realistic references.

Contracting authorities have limited time and resources for control in practice

The fourth factor impacting the calculation and assessment method is the process of control in practice. Interviewees mentioned the determination of the scope as an important factor in the control in practice. The scope can be determined on the life cycle stages and the products. The interviewees noted that the duration of construction projects only takes place in life cycle stage A. Since the other life cycle stages take place after construction, these are hard to monitor.

In addition, contracting authorities ask for the MKI value of too much products within the project. The interviewees stated that contractors require extended time and resources to calculate these MKI values. Also, contracting authorities require extended time and resources to check the MKI values. The limited time and resources of contracting authorities for control in practice impact the application of harmonisation of interests.

Proposed measures

The interviewees have proposed measures against the identified factors. The proposed measures from the interviews have been defined per identified factor. A schematic overview is shown in Figure 5.

Variation in assumptions in the calculation method

To decrease the impact of the variation in assumptions on the screening method, two measures have been proposed by the interviewees. The first measure is the implementation of the product category rules (PCR) if possible. Contracting authorities have to obligate contractors to calculate their MKI value conform the PCR. The application of product category rules will decrease the broadness of the assumptions made in the determination of the LCA and the calculation of the MK, because the product category rules are tailor-made and specific for one type of product.

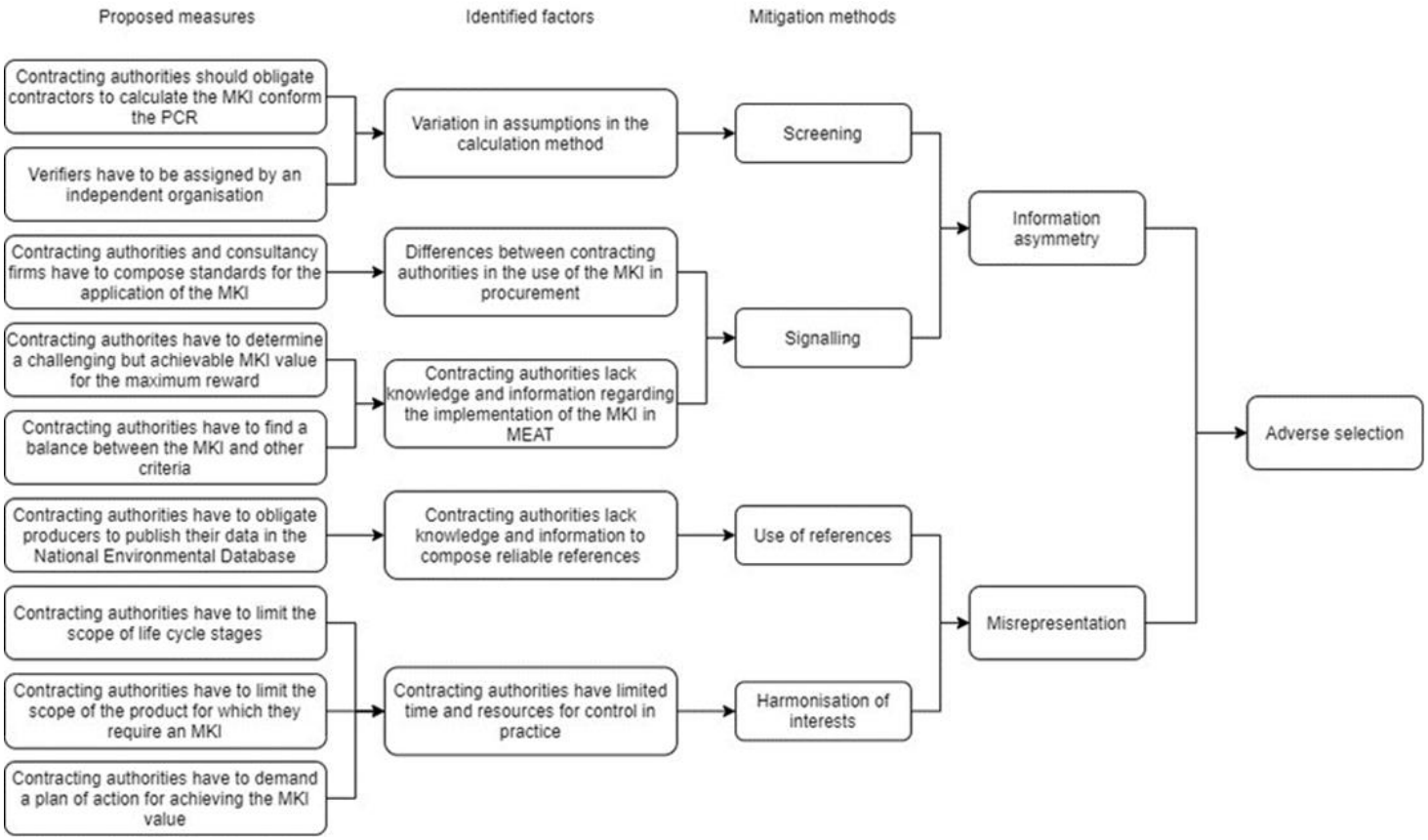

Figure 5 Proposed measures

The second measure is assigning verifiers independently. When verifiers are assigned independently, the opportunity for favourable selection will be eliminated. One of interviewees suggested that the verifiers may be selected by the organisation that manages the National Environmental Database. In this way they can ensure that all data in the National Environmental Database is verified independently.

Decreasing the impact of the assumptions and assigning the verifiers independently is advocated. These will decrease the opportunity for both unintentional and strategic misrepresentation. Hence, these measures foster the use of screening methods.

Differences between contracting authorities in the use of the MKI in procurement

To decrease the differences between contracting authorities, the interviewees proposed to compose standards. Contracting authorities and consultancy firms should combine their knowledge and experience in composing these standards. According to the interviews, the standards should include information for determining the scope of the products and life cycle stages. This information should help contracting authorities in determining the scope in relation to the goal of the project and the time and resources available. Standards should also be developed for the determination of the maximum reward given for a low MKI value. Besides, standards could help in determining the MKI value for which the maximum reward is given. The interviewees indicated that it may be useful to have standard ratio for every product between the price and the reward for a low MKI.

Standardisation of basic processes in the application of the MKI in procurement will decrease the time and resources needed for contracting authorities to get acquainted with the MKI. Moreover, standardisation will decrease the differences between contracting authorities.

Contracting authorities lack knowledge and information regarding the implementation of the MKI in MEAT

The interviews revealed that contracting authorities lack knowledge and information regarding the implementation of the MKI in MEAT. Contracting authorities still have limited experience with the MKI. To gain more knowledge, the interviewees suggested that contracting authorities should exchange experiences and knowledge amongst each

other. The knowledge that is exchanged should be the experiences contracting authorities have in determining both the maximum reward for the MKI and the MKI value for which the maximum reward will be given.

Determining the right balance between the reward for the MKI and other criteria will increase the incentive for contractors to invest in innovation and sustainable development. Besides, determining the MKI value for which the maximum reward will be given should be challenging but achievable. This will help contracting authorities to be able to distinguish suitable contractor from unsuitable contractors.

Exchanging experiences will help contracting authorities. They will be able to apply signalling methods more accurately and decrease the information asymmetry.

Contracting authorities lack knowledge and information to compose reliable references

For composing realistic references contracting authorities require reliable information. At this moment this reliable information is not available through the National Environmental Database. The interviewees suggested that contracting authorities should obligate contractors and producers to publish their MKI value in the National Environmental Database. When contractors publish their data in the National Environmental Database the database will be filled with reliable data. This data can be used by contracting authorities to compose reliable references and detect misrepresentation.

Contracting authorities have limited time and resources for control in practice

The interviews showed that contracting authorities have limited time and resources for control in practice. For contracting authorities to able to accurately control in practice, it is proposed to limit the scope of the life cycle stages to only stage A. This is suggested since life cycle stage A is the only stage which takes place during the construction project. The other stages take place after the project and are thus harder to control. Besides, the determination of the MKI value in stages B, C, and D is very uncertain in comparison to A. This creates opportunity for misrepresentation.

Besides limiting the scope of the life cycle stages, the interviewees also noted that the number of products for which the MKI value has to be calculated should be limited. The interviewees stated that in most projects only a few products have a major impact on the environmental effects of the project. The interviewees therefore stated that the contracting authorities should limit number the products for which they require an MKI value to only those products with a presumably major environmental impact.

Limiting the number of products and the scope will decrease the time and resources needed for both contracting authorities and contractors. Contractors will need less time to calculate the MKI value of all required products, and contracting authorities will need less time and resources to control the MKI value of these products.

In order to control whether the contractor will achieve the promised MKI value, the interviewees proposed to require a plan of action. Contracting authorities should require a plan of action from the contractors in which they state how they are going to achieve the promised MKI value. During the project, the contracting authority will then be able to track the progress on the contractor and will be able take measures in time if needed.

4.2. Validation of the results

This section presents the changes made after validation of the interview results by the focus group. The validation results are presented per identified factor. An overall overview of the identified factors and proposed measures after validation is shown in Figure 6.

Variation in assumptions in the calculation method

The focus group participants shared the concern with interviewees regarding the differences between LCAs and MKI values from different verifiers. The interviews already suggested to have the verifiers assigned independently. The focus group participants pointed out the differences between the verifiers, and that they should be assigned independently. Although, they were not sure if the organisation which manages the National Environmental Database had the resources to be able take this responsibility.

The focus group participants added the suggestion to calibrate the LCAs from the different verifiers. In this way the difference between the verifiers can come to light and be decreased. Calibration can be applied even if verifiers are not assigned independently. Through calibration, the differences in assumptions will be slightly decreased and therefore the opportunity for misrepresentation.

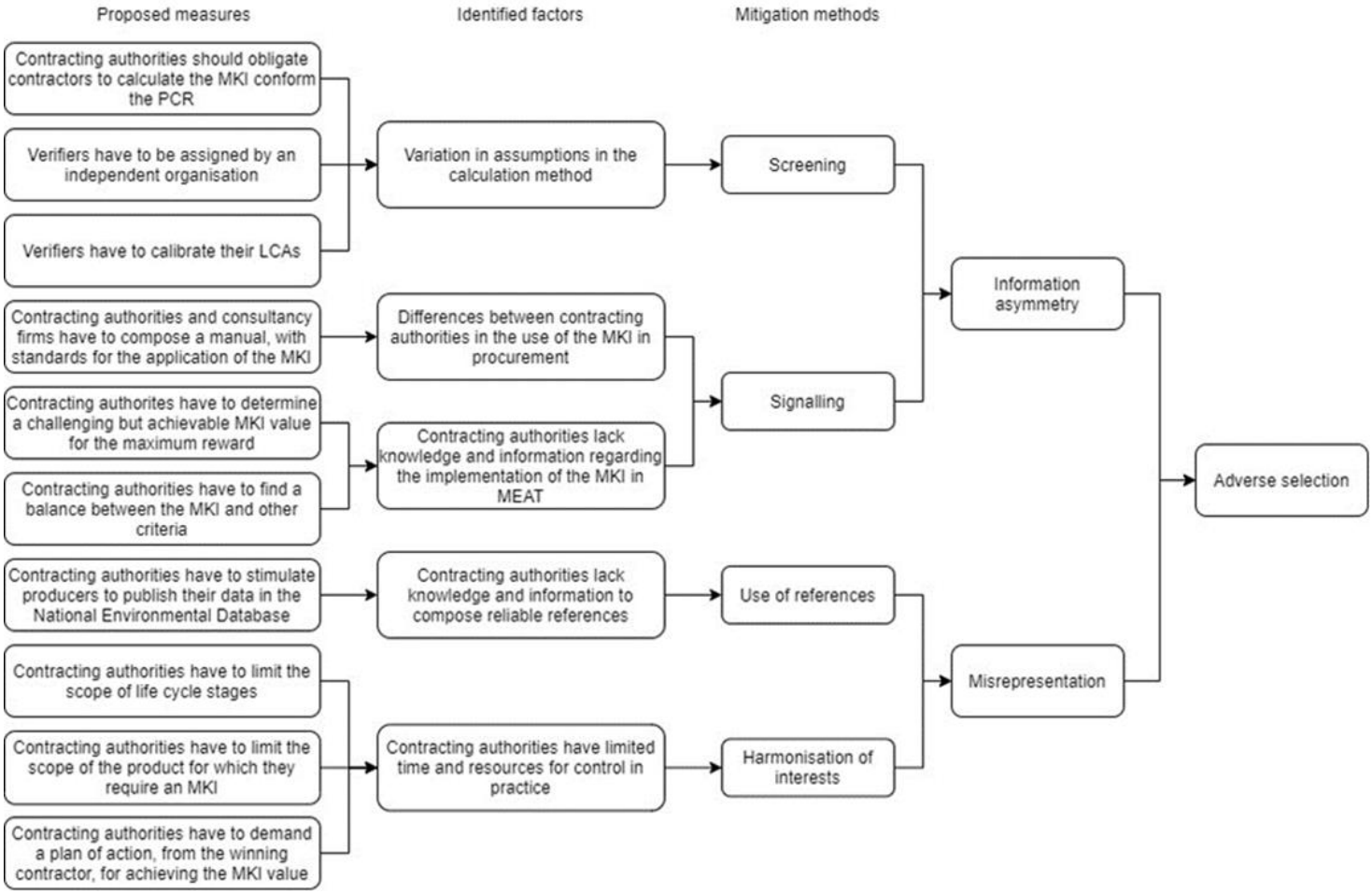

Figure 6 Proposed measures after validation

Differences between contracting authorities in the use of the MKI in procurement

The difference between contracting authorities in the application and the control of the MKI were also a thorn in the eye of the focus group participants. The focus group participants stressed the need for standardisation of the application of the MKI in procurement. They further suggested that contracting authorities and consultancy firms should bundle their knowledge and experience and compose a manual with the standards for applicating the MKI. A detailed manual would secure contracting authorities of necessary information for the use of MKI in MEAT.

Contracting authorities lack knowledge and information regarding the implementation of the MKI in MEAT

The representatives of the contracting authorities in the focus group stated that for them it was also challenging to find the right balance between the rewards for the MKI and the price. They additionally stated that contracting authorities are cautious in determining the lowest MKI value. Most contracting authorities first want to have sufficient experience, and choose to be on the safer side with a higher MKI value. Consequently, contractors are not able to distinguish themselves on the basis of MKI, and contracting authorities will not receive the desired result.

The focus group participants noted that exchanging knowledge and experience could help but is not always feasible. At this moment, the contracting authority with the most experience is Rijkswaterstaat. However, their procurement methods, the contracts they use, and the size of their projects are not comparable with of other smaller contracting authorities. These differences between the contracting authorities makes knowledge and information exchange difficult.

Contracting authorities lack knowledge and information to compose reliable references

The focus group participants confirmed that the lack of reliable information hampers composing reliable refences. Filling the National Environmental

Database with reliable data would help contracting authorities in composing more reliable references. The interviewees suggested that contracting authorities should obligate contractors to publish their MKI value in the National Environmental Database. Although, the focus group participants argued that obligating may not fall within the possibilities of the contracting authorities. That is why instead of obligated, contractors should be stimulated to publish their data in National Environmental Database voluntarily.

Voluntarily publishing MKI values could even be considered a signal method. Suitable contractors profit from voluntarily publishing their data in de National Environmental Database. The higher reliability of data will help contracting authorities in distinguishing realistic tenders from overly optimistic tenders, and so distinguishing suitable contactors from unsuitable contractors.

Contracting authorities have limited time and resources for control in practice.

The focus group participants stressed that the life cycle stages and the number of products which for which the MKI is required should be limited. However, the situation might occur in which a contracting authority still wants to reward contractors in efforts made in products or life cycle stages that would fall outside scope. The focus group participants suggested to apply additional quality criteria. In this way the controllability of the MKI is ensured, but also the additional wishes of the contracting authority are considered.

The focus group participants also underlined the need for a plan of action. In order to decrease the time and resources needed for both contractors and contracting authorities, it was suggested to only require a plan of action from the winning contractor. In that case the losing contractors would not have to put time and resources in composing a plan of action beforehand, and the contracting authorities would not have to assess all these plans of action. With the plan of action from the winning contractor, the contracting authorities will be able to control the progress of the contracting authority, with for example random sampling.

5. Discussion

This section shows the implications of the risks of adverse selection when implementing an assessment tool in MEAT, regarding previous literature. This study contributes to research on innovation-friendly procurement and research on information asymmetry and misrepresentation. Additionally, the research limitations will be discussed, and suggestions will be made for future research.

Research on innovation procurement suggested rationales for innovation-friendly procurement. Two of these rationales are: increasing the value-for-money of procured products received by the contracting authority, and enhancing the competitiveness between contractors (Lenderink et al., 2019).

In contrast, this research indicates that contracting authorities may not increase the value-for-money of procured products. Since the risk of adverse selecting is too high, contracting authorities may not select the tender with the highest value-for-money. Furthermore, since investments in sustainable development are not rewarded, competitiveness based on sustainable is not enhanced. Due to the risk of adverse selection, competitiveness may even be enhanced in gaming the system.

Research on innovation procurement mentions another rationale for innovation-friendly procurement. It is suggested that contracting authorities will be able to satisfy to future agency and social needs with limited time and resources, when innovation-friendly procurement is used (Lenderink et al., 2019; OECD, 2011). In addition, since innovation-friendly procurement only requires limited time, resources, and minor changes in the procurement strategy, it can stimulate innovation on a large scale (Knutsson & Thomasson, 2014; Lenderink et al., 2019).

This research has shown that a contribution to the social need of sustainability can be made with the implementation of the MKI. While theory suggests that innovation-friendly procurement requires low time and resources, this research on the other hand, has demonstrated that time and resources are still a limiting factor in the implementation of the MKI. The limited time and resources are mostly reflected in the lack of knowledge and information at contracting authorities. The lack of knowledge and information of single contracting authorities limit the application of the stimulation of innovation. Therefore, it is suggested that knowledge and information of contracting authorities is bundled through knowledge exchange and standardisation in manuals. This research indicates that standardisation of the application of a new tool for the assessment and comparison of different tenders is needed. This will decrease the time and resources needed for contracting authorities to implement the tool and increase the stimulation of innovation on a large scale.

A method the theory suggests for stimulating innovation through innovation-friendly procurement is the use of MEAT (Knutsson & Thomasson, 2014). Contracting authorities lack knowledge and information on how they should apply the MKI in MEAT. Contracting authorities find it hard to determine the reward which they will give for a low MKI value. Moreover, they find it hard to determine the lowest MKI score for which the maximum reward will be given given. As a result, this research indicates that successful implementing the MKI in MEAT is a challenge for contracting authorities.

Public procurement can be an important instrument for stimulating innovation procurement (Lenderink et al., 2019). Consequently, contracting authorities can have major influence on stimulating innovation through procurement (Lember, Kalvet, & Kattel, 2011). This research supports the conclusion that contracting authorities can play an important role in the stimulation of the innovation. However, with this role comes responsibility. This research has shown that contracting authorities will not be able to take responsibility as long as the risk of adverse selection is too big.

Besides the research on innovation-friendly procurement, this research also contributes to research on information asymmetry and misrepresentation. Winch (2009) described the relationship between contractor and contracting authority as a typical situation in which information asymmetry occurs. This research confirms this, as it shows the asymmetry in information and knowledge between contracting authorities and contractors regarding the calculation and assessment of the MKI.

This research shows that besides time and costs, the environmental impact of projects may be also misrepresented. Previous research has shown that misrepresentation of time and costs of a project can be a powerful weapon when competing for scarce funds (Wachs, 1990; Flyvbjerg et al., 2009; Liu et al. 2014). Research furthermore states that opportunities for misrepresentation can be decreased when assumptions are replaced with data (Flyvbjerg et al., 2016). Additionally, this research confirms the negative impact of assumptions on opportunities of misrepresentation and that environmental impact also may be misrepresented. Since the interest in sustainability at contracting authorities is growing, the impact of misrepresenting the MKI increases.

Limitations and suggestions for future research

This research proposes various suggestions for future research. The suggestions for future studies are discussed as a result of the limitations of this research.

The limited experience form smaller contracting authorities has been a limitation to this research. Although this research suggests improvements to the current way contracting authorities apply the MKI, because of the limited experience and knowledge at smaller contracting authorities, their vision could not be included in this research. In future research it is suggested to include visions of smaller contracting authorities. Such research could contribute to refining the proposed knowledge exchange and detailed manual. Future experiences of small contracting authorities could be valuable input for refinement and the content of the knowledge exchange and manual.

In addition, this research focusses on the asphalt paving industry in particular. Although the characteristics of the risk of adverse selection are general, the in the research proposed measures are specific for the asphalt paving industry in the Netherlands. In order to expand the applicability of this research, further research is suggested which takes into the account the entire infrastructure industry.

Moreover, this research shows the implications of adverse selection when using the MKI in procurement. However, adverse selection may emerge when using other criteria as well. It is proposed that future research focusses on the risk of adverse selection when using other sustainability or quality criteria.

Another limitation of this research is the research only displays a qualitative insight in the risk of adverse selection. Whereas, the extent to which adverse selection actually occurs has not been part of the research. A further study focussing on the quantity of adverse selection is therefore suggested.

One of the proposed measures of this research is stimulating the producers and contractors to publish their data in the National Environmental Database. However, this research does not give direction what method should be used to stimulate contractors and producers. Therefore, future research is suggested to explore the possibilities for stimulating producers and contractors to publish their data.

Last, future research is also suggested to enlarge the possibilities to predict the future performance of asphalt. Currently, the prediction of the performance of lifecycle stages B, C, and D houses too much risk of adverse selection. However, without including all life cycle stages in the calculation of the MKI, the potential of the MKI as a quantitative and objective way to compare sustainability performance of tenders is not fully utilized.

6. Conclusion

This research gives handles to contracting authorities to mitigate the risk of adverse selection. Information asymmetry between contractors and contracting authorities, and opportunities for misrepresentation are defined as the key sources for the risk of adverse selection. To decrease information asymmetry and misrepresentation four methods have been distinguished. Literature showed that information asymmetry can be decreased by the application of screening and signalling methods. Whereas the opportunities for misrepresentation can be decreased by harmonising the interests between contracting authorities and contractors, and the use of references by contracting authorities.

The data has been collected conducting interviews and a focus group session. The interviews identified factors impacting the use of the MKI in procurement, and proposed measures against these factors. The results from the interviews where then validated through a focus group. Resulting in the final outcomes of this research.

This research has identified five factors that impact the calculation and assessment method of the MKI. These factors are: the variation in assumptions in the calculation method, differences between contracting authorities in the application of the MKI in their procurement method, lack of knowledge and information at contracting authorities regarding the application of MKI in MEAT, a lack of knowledge and information at contracting authorities for composing references and, last, contracting authorities have limited time and resources for control in practice. In order to decrease the risk of adverse selection the impact of these factors has to be decreased.

This research has presented measures that are recommended to be implemented in order to decrease the impact of the identified factors. The research proposes the following measures:

- Verifiers have to be assigned by an independent organisation.
- Contracting authorities have to obligate contractors to calculate their MKI conform the PCR.
- Contracting authorities and consultancy firms have to compose a manual, providing standards for the application of MKI in tenders.
- Contracting authorities have to exchange knowledge with regard to making contractors be able to distinguish themselves.
- Contracting authorities have to exchange knowledge with regard to composing references.
- Contracting authorities have to stimulate producers to publish their MKI in the National Environmental Database.
- Contracting authorities have to determine the scope of products and life cycle stages in balance with their time and resources.
- Contracting authorities have to demand a plan of action form the winning contractor for achieving the MKI value.

In conclusion, taking the proposed measure will decrease the information asymmetry and opportunities for misrepresentation. Adopting these measures will mitigate the risk of adverse selection and increase the success of implementation of the MKI in innovation-friendly procurement. This will be a step forward in securing contracting authorities to receive the desired results, stimulating contractors to invest in innovation and sustainable development, and stopping the poker game of sustainable selection.

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Appendix I Interview protocol

The interview protocol is composed to give direction during the interviews. The interviews will be semi-structured, so the interviewer may deviate from the questions in this protocol. However, it is the task of the interviewer to ensure that all questions are answered.

Introduction
The goal of this section is to get to know about the experience of the interviewee and the organisation they are working for with the MKI.

What is your function within the organisation?

What is your experience with the MKI?

How often do you, and the organisation you work for, work with the MKI?

Information asymmetry
The goal of these questions is to get to know if the interviewee experiences information asymmetry between contracting authorities and contractors.

Do you think contracting authorities lack information to applicate the MKI correctly?

If yes, why do contracting authorities lack information?

Do you think there is difference in knowledge between contracting authorities and contractors?

If yes, why do you think there is difference in knowledge?

Misrepresentation
The goal of these questions is to get to know if the interviewee experiences opportunities for misrepresentation in the current calculation and assessment method.

Is it possible to achieve a lower MKI through gaming the system?

If yes, what makes this possible?

Methods for mitigating the risk of adverse selection
The goal of this section is to get to know how the methods for mitigating the risk of adverse selection are applicated in the current way of calculating and assessing the MKI, which factors impact the methods and what measure could be taken to reduce the impact of these factors.

Signalling
How is it at this moment possible for a contractor to distinguish himself and prove that his tender is more sustainable than the tender of other contractors?

Does the reward that can be received for tendering with a low MKI value weigh up against the costs?

What can be done to improve the working the of signalling methods?

Screening
Is the Determination Method at this moment used correctly?

Is the Determination Method accurate enough?

If no, what should be done to improve the accuracy of the Determination Method?

Are there other methods that are used for screening contractors?

Harmonisation in of interest
What are the current experiences with the use bonus/malus system to harmonise the interest regarding the MKI?

What are the current experiences with the control in practice?

What measure could be taken to improve the control in practice?

Use of references
Can the National Environmental Database be used for composing reliable references?

What factors impact the reliability of the data in National Environmental Database?
What could be done to decrease the impact of these factors?

Change of roles
The goal of this section of the interviews is to get insight in the vision from interviewees. They were asked to imagine themselves as contractor or contracting authority. This way it could be tracked down what problems the interviewers face when working with the MKI and what actions they would like to be taken by other stakeholders.

To an interviewee for a contracting authority: What would you do to win a tender on the basis of the MKI if you were working at a contractor?

To an interviewee from a contractor: What would you do to select the contractor with the tender with the lowest environmental impact?

Validation from previous interviews
The last questions in the interview are about the answers given in previous interviews. The interviewees shall be asked what their vision is on the answers and remarks given in the previous interviews.

Conclusion of the interview
Before ending the interview, the interviewees are asked if they have any additional questions or remarks regarding the research or the interview. The interview will be concluded with a short statement regarding the further process of the research and what will be done with the results from the interviews.

Appendix II Focus group protocol

The focus group protocol is composed to give direction to how the focus group will be organised and what will be discussed during the focus group. During the focus group the results from the interviewees will be validated.

Introduction
The introduction will start with small elaboration on the research. The focus group leader will explain the goal of the research, the goal of focus group and what is expected from the focus group participants.
After the introduction, an introduction round will be held, questions asked during this round are:

What organisation do you work for?

What is your function within this organisation?

How do you have to deal with sustainability and MKI?

Validation of the interview results

To validate the interview results the focus group participants are asked to discuss the identified factors and the proposed measures by the interviewees. To do so distinction is made between the different methods that can be used to mitigate the risk of adverse selection, the factors that impact these methods and the proposed measures to decrease this impact.
The results will be discussed per method for mitigating the risk of adverse selection. Per method the focus group participants will be asked to what extent they agree or disagree with the identified factors, and if they identify other factors impacting the methods. Next, they will be asked to what extent they agree or disagree with the proposed measures, and if the propose other (additional) measures.

Signalling
Factors influencing the signalling methods

Contracting authorities lack knowledge in applicating the MKI in performance-based tendering. As a consequence the reward given for a low MKI is limited and the MKI for which the maximum reward will be given, is not challenging.

Due to inconsistencies between contracting authorities, contractors are not stimulated to invest in innovation, since they cannot be sure if the investment will pay off in future projects.

Proposed measures to decrease the impact of these factors
Contracting authorities lack knowledge in applicating the MKI in performance-based tendering. Consequently, the reward given for a low MKI is limited and the MKI for which the maximum reward will be given, is not challenging.

- By sharing experiences regarding the application of the MKI with other contracting authorities and consultancies, contracting authorities will be able to gain more knowledge in a short time.
- Create standard reward for the MKI per product of product type, which is applicable on every project.
- By being careful with determine the MKI too low, contracting authorities will be able to gain experience with the MKI before setting MKI to a challenging and decisive limit.

Due to differences between contracting authorities, contractors are not stimulated to invest in innovation, since they cannot be sure if the investment will pay off in future projects.

- Contracting authorities must agree on standards on how to procure with MKI, so the differences between the contracting authorities will decrease and contractors will be able invest more accurately in innovation.

Screening
Factors influencing the screening method
The calculation method is inaccurate due to the amount and the broadness of the assumptions that must made.

Different verifiers make different assumptions, consequently contractors or producers may select verifiers favourable.

Proposed measures to decrease the impact of these factors
The calculation method is inaccurate due to the amount and the broadness of the assumptions that must made.

- Contracting authorities must obligate contractors to calculate the MKI conform the PCR when possible.

Different verifiers make different assumptions; therefore, contractors or producers may select verifiers favourable

- Verifiers must be selected independently, by the organisation managing the National Environmental Database

Harmonisation in of interest

Factor influencing the harmonisation of interest:
Control in practice by contracting authorities is inadequate and in limited

Proposed measures to decrease the impact of this factor:
Control in practice by contracting authorities is inadequate and in limited

- Contracting authorities must define the scope of the products and the life cycle stages in balance with the project and the time and resources available.
- Contracting authorities must require a plan of action for achieving the proposed MKI from the contractors.

Use of references
Factors influencing the use of references:
Contracting authorities have limited access to reliable information, because the data in National Environmental Database is mostly unreliable.

Contracting authorities have limited knowledge on composing references, since they have limited experience.

Proposed measures to decrease the impact of these factors:
Contracting authorities have limited access to reliable information, because the data in National Environmental Database is mostly unreliable.

- Contracting authorities must obligate contractors, producers and suppliers to publish their MKI values in the National Environmental Database, this will increase the reliability of the data in National Environmental Database.

Contracting authorities have limited knowledge on composing references, since they have limited experience

- Contracting authorities should share their knowledge and experience regarding composing references.