Wilting rationalism in technical decision making

Marc A. Maes
Prof. em. in civil engineering, University of Calgary, Canada

Yves Heroes
Independent analyst, former VP Business Intelligence, Kem One, Belgium

ABSTRACT: Certain modernistic attitudes catalyzed by shifting value systems and changing socio-economic preferences, are impacting on the way technical decisions are made. These attitudes include ultracrepidarianism, uberization, recklessness with facts and figures, juvenilization, financialization, bounded rationalism, as well as excessive rationalism. Case studies and examples illustrate how such attitudes can result in poor decisions. A Bayesian framework potentially accounts for and/or reconciles specific attitudes in technical decision making.

1. INTRODUCTION

In engineering decision making (DM-ing) – ranging from technical risk analysis and design to the development of risk-informed policies that impact on technology and society – the requirement of rational thinking and systematic analysis is fundamental.

New age thinking has shifted many of the distinctive features of rational DM-ing, with the unfolding of certain "modernistic attitudes" which are discussed in Section 2 of this paper.

In Section 3, we present a case study to illustrate that the impact on DM-ing for both short-term and long-term technological and environmental questions can be significant.

Section 4 outlines a Bayesian framework for capturing the effect of specific "attitudes" in decision making. This framework is based on the calibration of posterior information about such attitudes based on "stated" decisions in a multi-decision-maker context. Such analysis may stimulate insight into the assessment of the quality of decisions with respect to key attitudes and helps re-assess shaky decisions and offer resolution between conflicting decisions.

2. MODERNISTIC ATTITUDES

It is well documented that technical DM-ing is affected significantly by a wide range of both cognitive and noncognitive biases (Khaneman et al. 1982; Zhong 2011), in addition to socio-economic preferences and communication issues.

In this section we highlight four types of "modernistic" attitudes that – in our opinion and, as evidenced by the case studies in Section 3 – are becoming increasingly prominent in driving new-age DM-ing.

2.1. Ultracrepidarianism (UC)

The UC attitude refers to sacrificing science, research, and – in extreme cases – best practice, in favour of strongly held opinion. The Latin expression *sutor, ne ultra crepidum* (shoemaker, not beyond the shoe) warns us not to intervene in decisions beyond our domain of expertise. Modernistic thinking, however, promotes the art of speaking with "authority" about issues we know little or nothing about (Klein 1996). As pointed out by Avisrur-Ṭurḳiz and Frankfurt (2005), bullshit has become a greater and more believable enemy of the truth than lies. Rational DM-ing aims to know the truth (science) or to search for it (research); UC aims to proclaim half-truths and judgements based on apprehension, popularity, or self-interest. This aggravates the cognitive bias (Dunning 2011) whereby people with low expertise or experience are completely unaware of their own ignorance, and, as a result, overestimate their ability to make proper decisions. Minimal information about technical problems – typically limited to

consequences associated with everything that can and "will" go wrong – seems sufficient to claim an expert seat at the DM-ing table.

2.2. Changing value systems

The following modernistic attitudes have a significant impact on the value systems that affect DM-ing systems and preferences:

2.2.1. Uberization of DM-ing

The trend to provide (on-demand) services for as many as possible carries the undesirable side-effect of diminishing the role of the essentials. The focus tends to shift from technical issues to side objectives such as wrapping solutions in fancy mobile technology, enhancing the feel-good experience of stakeholders by enabling access to useless subsystems.

2.2.2. Bounded rationalism

Today's thinking promotes the present and demotes the past. By paying exaggerated attention to recent experience, we also diminish the impact of the long-term. We discount the future at rates that make little economic or ecological sense (Meadows 2008). We block out information that does not fit our mental models. The rational *homo economicus* becomes a blundering "satisficer" acting with a kind of "bounded rationalism" to satisfy immediate needs barely well enough before moving on to the next decision (Simon 1957).

2.2.3. Fake news and doomsday prophecies

The spreading of misinformation and partial truths is a prominent sign of our times (Nielsen et al. 2019) and it has a significant impact on value systems in DM-ing (Maes 2019).

2.2.4. Juvenilization and favoritism

These well recognized sociological trends are akin to uberization. People have come to embrace both Disney-style and TripAdvisor-like rankings for almost any need, service, or objective. Unjustified simplification, blatant promotion of preferences, digital shielding, etc., stand in the way of rational DM-ing.

2.2.5. Excessive financialization

Value systems in DM-ing become distorted if financial systems and elites gain increasing influence over technical DM-ing (Sawyer 2022).

2.3. Hypercaution

The rise of the precautionary culture is well documented; however, the precautionary principle is set to become a standalone objective rather than a principle. In the extreme, such an attitude leads to paralysis in DM-ing (Graham 2001).

2.4. The flip side: excessive rationalism (ER)

On the flip side, the modernistic counter-attitude of ER suggests that irrationality, emotive, and intuitive thinking constitute some sort of misbehavior. Such an attitude may cause the DM-er to be unmoored and ill at ease to point out uncomfortable alternatives. Thus, ER can itself become a source of bias. This is an important root cause of mass irrationality, as the world becomes frustrated by systems conceived by Spock-like DM-ers ("Mr Spock, your rational calculations fail to account for the irrationality of other people", Star Trek).

3. CASE STUDY: CLIMATE CHANGE AND RENEWABLE ENERGY DM-ING

The impact of improper attitudes on scientific and rational thinking is nowhere as visible as in DM-ing for global environmental issues. One would expect solid scientific consensus to be the basis for all policy issues in this field. However, more often than not decisions are taken rashly and prematurely. To a large extent this is due to the fact that so many scientific disciplines are involved, each with their own experts, but with few, if any, mastering them all. Many natural phenomena are not fully understood, let alone the interactions between their assumed driving forces. Tentative and highly fragmented models are proposed but need constant adjustment to the delight of the critics.

While this is to some extent expected in a due scientific process, personal, ideological and economic interests start to interfere and prevail

as soon as the public at large gets involved. At that time, experts in communication – media, politicians, activists, and eventually businessmen – get the upper hand in the scientific debate. These are ultracrepidarians who claim to have the right answers while catering to their own interests, and using tools such as fake news, doomsday scenarios, hypercaution, and recklessness to pile up public support.

On top of that, commercial interests, political credulity, and the increased influence of both external pressure groups and internal ESG departments further aggravate the bias in rational DM-making. Ultimately, DM-ers come to accept the condition described by Walter Lippmann as one "where all think alike, no one thinks very much".

Climate change has been in the news for decades and extreme weather has forever been a pet topic of discussion. While witchcraft and divine intervention have long ceased to serve as their explanation, the general mindset has not changed: industrial and chemical activity has become the prime — and evil — suspect.

The contribution to global warming and the precise role and effect of anthropogenic greenhouse gases, particularly CO2, are still far from clear (Lindzen and Lewis 2022), making it difficult to assess the likely impact of expected meteorological changes based on current projections. So far, scenarios linking global warming to a catastrophic increase in weather related disasters have not been confirmed by facts (Alexander 2021). In fact, based on Arent et al. (2014), economic growth, including greater concentrations of people and wealth in periled areas and rising insurance penetration, is the single most important driver of increasing losses; loss trends have not been conclusively attributed to anthropogenic climate change; and, most such discussions are not based on scientific attribution methods" (Arent et al. 2014).

Climate projections are potentially biased if they involve erroneous or manipulated historic data. Complacency of the reporter/analyst and financial interests add to the inability to provide quality support for DM-ing. As an illustration, independent scientific studies based on long term observations (1892-2000 and 1901-2015) found that the precipitation in Zimbabwe has not been affected by global warming (Mazvimavi 2010; Chifurira 2018). The Zimbabwe Ministry of Environment (2016) provided graphs and comments in line with those findings. But in 2021 The Climate Change Knowledge Portal of the Worldbank (2021) reported a systematic decline in average precipitation in the country since 1901. Their results are not substantiated. One can only surmise that pressure from the Worldbank subsequently led the Zimbabwe Ministry of Environment (2021) to publish a revised report that briefly and vaguely expresses "uncertainty" about rainfall projections.

In the face of uncertainty and confusion, one would expect that public authorities regulate carefully and award investments, subsidies, and grants on the basis of sound DM-ing processes. Unfortunately, it appears that ideological excitement rather than reason and knowledge has often come to guide their decisions. Not only politicians act under pressure from media and business lobbies, but leading academics increasingly possess an ideological agenda: in the words of former U.S. Senator T. Wirth "We've got to ride this global warming issue; even if the theory of global warming is wrong, we will be doing the right thing in terms of economic and environmental policy" (Bell 2013); and to quote IPCC official O. Edenhofer "One has to free oneself from the illusion that international climate policy is environmental policy. Instead, climate change policy is about how we redistribute de facto the world's wealth" (Bell 2013).

Lindzen and Lewis (2022) point out that current policies designed to achieve this {reducing CO2 emissions} at breakneck speed seem likely to cause considerably more harm than good. This typically results in the development of fragmented regulations that are geared toward small pieces of the puzzle, potentially creating conflict and confusion. For

instance, the objective of the European Commission to restore at least 25,000 km of rivers into free-flowing rivers by 2030 by removing horizontal and longitudinal barriers goes against centuries of hydraulic engineering and could easily backfire (European Commission 2022).

Returning to CO2 emissions, the recent and reluctant classification of nuclear as a green source of energy was prompted by tied hands rather than by common sense and rational analysis. In a similar policy U-turn, methane also got a green label from the cornered Commission. Interestingly, the methodology currently used for assessing greenhouse gas balances is often unjustifiably encouraging the harvesting of forest wood as a green source of energy (Robinson et al. 2022).

In another example, the renewable energy transition plans totally underestimated the infamous *dunkelflaute* (periods without sun/wind) requiring additional back-up gas powered units, though their intermittent output makes them uneconomical, leading to additional subsidies in order to secure a permanent supply. However, this is only part of the answer since the existing grid is unable to cope with the erratic supply patterns of clean energy. On top of the large investments required to construct windmills and solar panels, some 34-39bn€ per year will need to be found by 2030 to adapt the European grid according to Eurelectric president Birnbaum (Hancock 2022).

In the private sector, there is hardly any company that does not claim to save the planet. Clever marketeers have understood that image building has become an important part of the game, of which the corporate CDP sustainability scoring is but one example. In annual reports the carbon footprint now gets at least as much attention as profit & loss accounts, cash flow and balance sheets. What is usually missing, though, is the cost of the reported CO2 savings for each initiative. Surely, everything is well intended, but not everything can be worthwhile.

The same is true for new products and new technologies as illustrated in Fig. 1 which, among other things, shows that now is not the right time to launch generous tax incentives for electric vehicles, despite the fact that cars account for more than 10 % of the global CO2 emissions. Nothing wrong with developing the technology, but at this stage it is unwise from a DM-ing point of view to impose and subsidize their introduction. Instead, the focus should be on power generation, and on the energy efficiency of buildings, HVAC, and insulation systems. Policy making should account for their relative ease of development, for local conditions, and for the economies of scale.

A common misgiving in energy DM-ing that leads to unrealistic and overly ambitious projections is the illusion that renewable power generation has no limitations. While its potential supply is virtually infinite, its added annual capacity is not even covering the annual incremental demand (IEA 2022). The same is true for hydrogen: replacing the current supply of "dirty" hydrogen with green hydrogen made from renewable energy would require 143% of all the wind and solar installed globally to date (Liebreich 2022). Most of the projects that involve hydrogen as an intermediate step disregard the inefficiency of the electricity-to-hydrogen-to-electricity cycle. The most audacious plans start from scratch in the Namibian desert and depend on expensive and hazardous shipping of hydrogen to the Benelux and Germany; the challenges are huge (von Oertzen 2021) and so are the amounts involved. At best long delays can be expected, the energetic efficiency is bound to be low, hence the ROI needs to be rescued by subsidies.

4. FRAMEWORK TO ASSESS THE IMPACT OF ATTITUDES

4.1. The myth of the rational decision maker

In the strictest sense of its meaning, "rational" DM-ing requires adherence to the principles of the von Neumann-Morgenstern (VNM) maximum expected value DM-ing framework

(von Neumann and Morgenstern 1944; Savage 1954).

This presumes that DM-ers act in good faith and possess no hidden agenda. That they make fair decisions serving a clearly stated objective. That they are willing and able to estimate probability and consequence models needed for their analysis. That they use the most complete information at their disposal. That they bypass personal or professional bias and overconfidence, and that they are well aware of model and epistemic uncertainty, using Bayesian updating tools to their advantage.

It is clear that this depicts the highly idealized world of a robotic DM-er: in reality, DM-ing includes a high degree of subjectivity and operational adherence to the VNM framework is difficult to assess, let alone discuss.

4.2. Same options, same context, yet…

The myth of the perfect DM-er is further debunked by considering a group of DM-ers: it is observed that when facing the same alternatives, they do not necessarily end up making the same decisions (Maes and Faber 2006).

Numerous factors can cause or combine to cause such divergence: DM-ers have different views regarding the appropriate space of uncertain quantities influencing the consequences; they develop and select different models for these uncertain variables and processes; they appraise specific consequences in different ways: not just direct $ losses, but also consequences such as inconvenience, disruption, impact upon quality of life or the environment; they ignore certain long-term and/or follow-up consequences, or possess "boxed-in" models of the system or the market; and, they aggregate different types of consequences in different ways.

It is crystal clear that each and any of the modernistic attitudes raised in the preceding sections, can impact on each and any of the above factors.

A potential mine field pops up if we start to argue that certain DM-ers are not consistent, do not respect the basic VNM rules, or lack expertise. We could dismiss their analysis as non-optimal, lacking depth, or flawed. But this won't resolve any issues. Instead, a non-confrontational approach will expose flaws, differences, and inappropriate or extreme attitudes. The following Bayesian framework has the potential to do just that, and it is bound to provide insight, compromise, and reconciliation.

4.3. Bayesian framework

In the basic scenario of a single DM-er, the distinct alternatives a in a decision space A and the state of nature described by random variables X, result in a utility $u(\boldsymbol{x}|a)$ associated with each combination of outcome $\boldsymbol{x}$ and alternative a. The expected utility of alternative a is expressed by the real-valued preference functional $V(a)$

$$V(a) = \mathrm{E}(u(\boldsymbol{x} \mid a)) \tag{1}$$

It allows for a VNM preference ordering of all the alternatives in the space A. The optimal alternative $\hat{a}$ is the one possessing the largest $V(a)$ and the remaining alternatives can be ranked in decreasing order of preference. To denote preference of one course of action over another, we use the symbol $\succ$ so that the following two statements are equivalent for any pair of indices (i,j):

$$a_i \succ a_j \quad \Leftrightarrow \quad V(a_i) > V(a_j) \tag{2}$$

Consider several DM-ers facing the same alternatives subject to the same state of nature, as shown in Fig. 2(a). Each DM-er's "behaviour" is characterized by a vector of attitude variables $\boldsymbol{\omega}$, taking on real values in the space Ω of all attitudes.

The components of $\boldsymbol{\omega}$ may include direct measures of specific attitudes, e.g., degree of expertise, degree of systematic bias, degree of caution, …, expressed on a scale from 0 to 100%; as well as specific parameters in consequence, preference, or utility models that can be mapped unto specific attitude(s) scales.

The joint pdf of the $\boldsymbol{\omega}$ variables captures the current global attitude within a group or population of DM-ers. It is itself uncertain and in order to allow Bayesian inference, we use

hyperparameters $\boldsymbol{\theta}$ having a joint pdf $f(\boldsymbol{\theta})$. The attitude pdf can then be expressed as the conditional pdf $f(\boldsymbol{\omega}|\boldsymbol{\theta})$. The normal form of decision analysis is shown in Fig. 2(b). The attitude functional (1) is now conditional on $\boldsymbol{\omega}$ and $\boldsymbol{\theta}$:

$$V(a|\omega,\theta) = \mathrm{E}(u(\boldsymbol{x}|a,\boldsymbol{\omega},\boldsymbol{\theta})) \tag{3}$$

This formulation allows for the updating of the attitude pdf based on stated preferences by individual DM-ers. It can also be used to contrast and quantify perceived differences between two or more groups/populations of DM-ers, based on stated choices/rankings. The idea is to first use stated preferences (SP) to perform a posterior anchoring of the joint attitude pdf based on the likelihood *L* of such preferences.

$$f(\boldsymbol{\theta}|\mathrm{SP}) \propto L(\mathrm{SP}|\boldsymbol{\theta}) f(\boldsymbol{\theta}) \tag{4}$$

We now consider 2 ways in which such preferences are expressed: a ranking of alternatives in a discrete set *A*; and, a preferred solution $\hat{a}$ in a continuous set *A* of alternatives.

4.4. Ranking of n alternatives

If a complete ranking of alternatives is provided as follows $a_{[1]} = \hat{a} \succ a_{[2]} \succ \cdots \succ a_{[n]}$ then, within a group of *m* DM-ers, each selected ranking can be treated as an "observed" random variable in a hierarchical Bayes analysis (Maes and Dann 2007). In essence, the "reduced" set-up of Fig. 2(c) applies. The attitude space Ω can be partitioned into $\Omega_{[i]}$ for each permutation $[i]$ of the *n* alternatives, as illustrated in Fig. 2(d) in the case of *n*=3. The conditional probabilities of a specific permutation $[i]$ is equal to:

$$p_{[i]}(\boldsymbol{\theta}) = \int_{\Omega_{[i]}} f(\boldsymbol{\omega}|\boldsymbol{\theta}) d\boldsymbol{\omega} \quad (i = 1, \dots, n!) \tag{5}$$

Conditional upon $\boldsymbol{\theta}$, the number of stated preferences for each of the *n*! rankings of the alternatives can be collected in the set ($m_{[1]}$, …,$m_{[i]}$, …, $m_{[n!]}$) where the sum of all votes is equal to the number *m* of DM-ers in the group under investigation. This is a multinomial vector with the probabilities $p_{[i]}$ given in (5), so that the likelihood of the rankings in the updating rule (4) is the following function of $\boldsymbol{\theta}$:

$$L(m_{[1]}, \dots, m_{[n!]}|\theta) \propto \prod_{[i]\,=\,1,n!} \left(\int_{\Omega_{[i]}} f(\boldsymbol{\omega}|\boldsymbol{\theta}) d\boldsymbol{\omega} \right)^{m_{[i]}} \tag{6}$$

4.5. Preferred solution in a continuous set of alternatives

When the space *A* of alternatives is continuous, then the basic chance/decision tree reduces to the one shown in Fig. 2(e). The optimal choice $\hat{a}$ is the $a \in A$ that maximizes the preference functional $V(a|\boldsymbol{\omega},\boldsymbol{\theta})$. Whereas a given set of preference attitudes $\boldsymbol{\omega}$ yields a unique selection $\hat{a}(\boldsymbol{\omega})$, the inverse may not always hold as shown in Fig. 2(f), which shows iso-$\hat{a}$ lines in a 2D attitude space Ω; all combinations of $\boldsymbol{\omega}$ on a contour will result in the selection of the same $\hat{a}(\boldsymbol{\omega})$ as the optimal decision parameter. On a given contour, we can identify the most likely attitude $\hat{\omega}$ as the one maximizing $f(\boldsymbol{\omega}|\boldsymbol{\theta})$, allowing a unique attitude combination $\hat{\boldsymbol{\omega}}(\hat{a})$ for any stated choice $\hat{a}$. If *m* DM-ers provide their preferred solutions $\hat{a}_1$, …, $\hat{a}_m$ the following likelihood (4) applies:

$$L(\hat{a}_1, \dots, \hat{a}_m|\boldsymbol{\theta}) \propto \prod_{i=1,m} f_{\boldsymbol{\omega}}(\hat{\boldsymbol{\omega}}(\hat{a}_i)|\boldsymbol{\theta}) d\boldsymbol{\omega} \tag{7}$$

4.6. Example

Consider the following hypothetical application of 4.4 for two groups of 14 DM-ers each. We intend to find out if there is a significant difference between Group I and Group II with respect to two latent attitudes that impact on their decision making – and if so, we wish to quantify this difference –:

- ω_1: scaled from –1, totally principled DM-ing focused on the essentials, to +1, uberization, short-term gratification of the masses, and technically unprincipled
- ω_2: scaled from –1, excessive caution, to +1, total lack of caution

Both groups are requested to provide rankings for *n*=3 alternatives in a technical decision which after analysis and simplification can be approximated as follows:

$$a_1: V(a_1|\boldsymbol{\omega}) = v + \omega_2 + \omega_1$$
$$a_2: V(a_2|\boldsymbol{\omega}) = v + \omega_2 \quad (8)$$
$$a_3: V(a_3|\boldsymbol{\omega}) = v$$

where v is a constant. Assume (ω_1,ω_2) are iid and normal with means (θ_1,θ_2) and the same standard deviation. The joint posterior pdf of the hyperparameters, using a diffuse prior, is based on (4) and (6) which requires integration over the n!=6 sections $\Omega_{[i]}$ shown in Fig. 2(d), each section representing outcomes with a different ranking.

To avoid confusion, assume that both groups' top choices for alternatives 1, 2, and 3, are the same: 3, 6 and 5; however, the ranking associated with a_2 as the preferred choice differs between groups I and II, defined in part (a) of Table 1.

The joint posterior has the posterior means (also shown by the 2 green dots in Fig. 2(d)), posterior standard deviations, and posterior correlation coefficient listed in part (b) of Table 1. The evidence provided by the preferences expressed by both groups appears to have a significant impact on the chief posterior attitudes within groups I and II; see part (c) of Table 1. To further illustrate this point, the posterior probabilities that, for the same DM-ing context, alternative a_2 would be selected in the future is different for groups I and II, as shown in Table 1(d), even though the prior evidence the preference for $\hat{a}_2$ was identical.

5. CONCLUSIONS

The paper stresses that we need a fresh re-evaluation of rationalism in the context of DM-ing. The emphasis has shifted away from the paradigm ethical contrast between rational DM-ing – i.e., adherence to reason, method, and principles – versus irrational DM-ing – i.e., action in response to emotions, feelings, mainstream, and intuition.

A Bayesian framework for "attitudes" has the potential to provide valuable insight into not only the DM-ing process, but also into risk perception and into the different stakes associated with different outcomes. It also provides subsequent DM-ing with the potential to re-calibrate and/or justify attitudes.

At the end of the day, however, "rationality" remains somewhat of a vague principle, but one that cannot be bypassed as it plays an essential role in quality DM-ing.

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Table 1: Data and results for the example in Section 4.6: (a) number of preferences for each ranking (with ijk shorthand for the ranking $i \succ j \succ k$) for groups I and II; (b) moments of the posterior pdf of the hyper-parameters; (c) mean posterior attitudes for each group; (d) posterior probability that alternative 2 is selected.

	(a)						(b)					(c)	(d)
Group	123	132	231	213	312	321	$\hat{\theta}_1$	$\hat{\theta}_2$	σ_{θ_1}	σ_{θ_2}	ρ_{12}	Posterior	Pr($\hat{a}_2$|.)
I	2	1	1	5	4	1	-0.39	0.47	0.40	0.34	-0.23	Moderately principled, imprudent	0.36
II	2	1	5	1	4	1	-0.71	0.07	0.33	0.40	-0.19	Very rigorous, neutral wrt caution	0.40

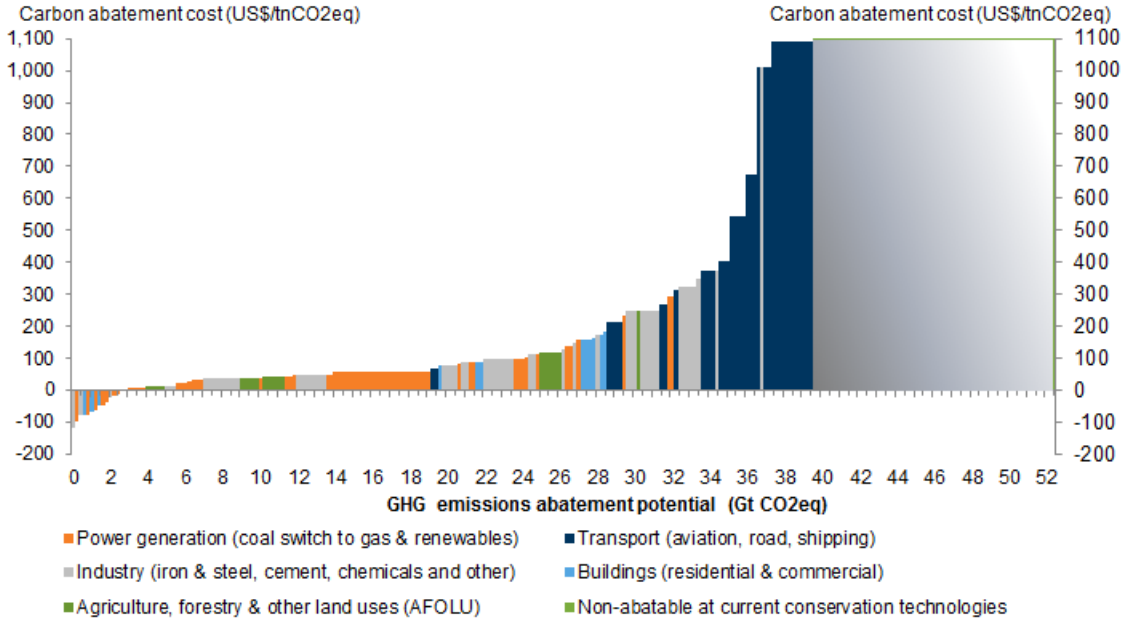
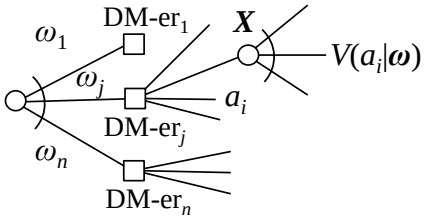
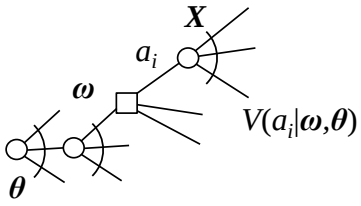


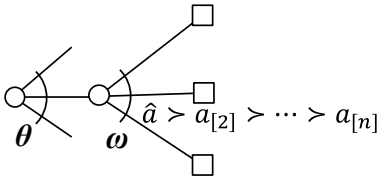
Figure 1: Marginal CO2 abatement cost worldwide (US Economist Analyst 2020).



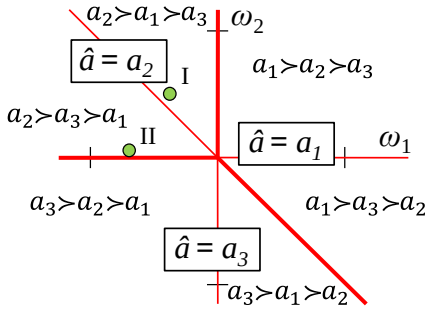
(a) Several decision makers DM-ers ($\boldsymbol{\omega}$ are attitude variables)



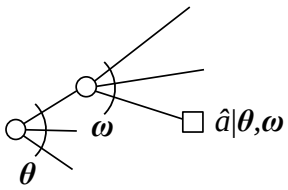
(b) Normal form of analysis ($\boldsymbol{\theta}$ are hyper-parameters)



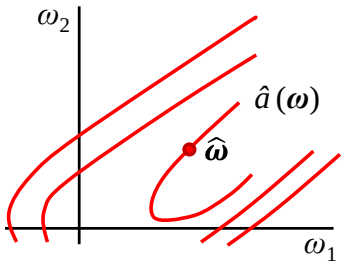
(c) Reduced decision tree corresponding to (b) in the case of ranked preferences $a_{[i]}$



(d) Partitioning of the attitude space Ω, for the example in Section 5.6 (2 attitudes, 3 ranked alternatives); the posterior mean for groups I and II is indicated by green dots



(e) Reduced decision tree corresponding to (b) in the case of a continuous set of alternatives



(f) ISO-lines of optimal alternative $\hat{a}$ in a 2D attitude setting

Figure 2: Framework for assessing attitudes.