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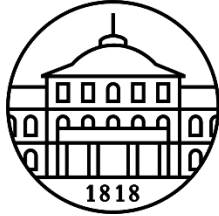
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**Animal Welfare In Non-Anthropocentric
Cost-Benefit Analysis And Social Welfare Functions:
A Critical Review To Guide Practical Application**

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Abbreviations

CBA.....	Cost-Benefit Analysis
CEA.....	Cost-Effectiveness Analysis
DALY.....	Disability-Adjusted Life Year
DEFRA.....	Department for Environment, Food & Rural Affairs (United Kingdom)
EU.....	European Union
LCA.....	Life Cycle Assessment
MAL.....	Morally-Adjusted Animal Lives
MCDA.....	Multi-Criteria Decision Analysis
SWF.....	Social Welfare Function
QALY.....	Quality-Adjusted Life Year
US.....	United States

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Abstract

Cost-benefit analysis and social welfare functions are two closely related methods to evaluate impacts of policies on humans (producers, consumers etc.) and animals. In cost-benefit analysis, the impacts on animals are currently either disclosed as intangible impacts or monetised from the human (anthropocentric) perspective through production costs, revenues and willingness to pay. Social welfare functions are more flexible to aggregate and trade-off impacts on animals, but they are not yet applied in practice. In the literature, advances have been made to monetise policy impacts from the animals' (non-anthropocentric) perspective and to include animals in social welfare functions. Yet, policy analysts who seek to implement any of these approaches in practice face substantial challenges because the available studies differ considerably in the methodologies and underlying normative assumptions. We conduct a critical review of the scientific and grey literature with the aim to synthesise the available material, to facilitate an informed debate on conflicting normative assumptions, and to eventually guide the practical application of non-anthropocentric cost-benefit analysis and social welfare functions. The results of the critical review are presented in the form of a checklist that allows to better comprehend key steps of the methodologies. Step-by-step, the checklist gives an overview of the alternative options and normative assumptions in the literature, and points to any remaining research gaps. Beside the academic debate, this is relevant for practical policy analysts who need to make methodological choices for their policy questions at hand.

Preface

« 'In a strict sense, I don't [literally] believe the numbers that pop out of the exercise I did,' Kuruc says. 'The hope of writing a paper like that is to put a wrong answer into the academic ecosystem and hope people swarm like piranhas, and tell me what's wrong with it...Because that's how we make progress on these things.' »

Kevin Kuruc, co-author of a groundbreaking study on animal welfare in social welfare functions (Kuruc and McFadden 2023b), interviewed by Sentient Media (2023)

In this critical review, we proceed as envisaged by Kevin Kuruc: We review the small but growing body of literature on how to include the animals' perspective in cost-benefit analysis and social welfare functions, while adopting a critical lens to detect any normative controversies. Such normative controversies may be explicit in the literature, when researchers specifically criticise other studies, or they may be implicit and become apparent only when several studies are carefully compared.

1 Background: Animal Welfare in Policy Evaluations

Animal welfare policies may have impacts on animals, producers, consumers, the environment, public health, food safety, and other entities. This critical review focuses on impacts on animals, which may materialise, for example, as changes in the resting behaviour of animals or in mortality rates.

For policymaking at the EU level, it is generally required to assess impacts on animals (European Commission 2023, p.139), and different methods are available for this purpose, drawing from methods to assess human health (*ibid.*, p.143, 282ff).

1.1 Cost-Benefit Analysis (CBA)

In classical CBA, impacts are expressed in monetary units and the simple sum across all affected entities determines which policy option is preferable (e.g., Adler 2019, p.30ff). In addition to these tangible impacts, there may be impacts that cannot be expressed in monetary units, despite significant efforts. Such intangible impacts should nonetheless be disclosed in CBA, so that they can be considered in decision making (e.g., Hanusch 2011, p.8ff).

In CBA for practical policy advice, impacts on animals are currently only monetised insofar as they affect producers, consumers, or other citizens who do not consume animal products. In other words, impacts on animals are monetised from the human (anthropocentric) perspective. For example, if a policy requires to provide straw bedding and if, as a result, animals show improved resting behaviour and a lower incidence of lameness, this may lead to lower costs for veterinary treatments or increased revenues due to lower premature culling rates (Figure 1: market-based monetisation). Multiple literature reviews have addressed impacts on producers (Niemi 2023; Fernandes et al. 2021; Dawkins 2017; Brouwer et al. 2011), and monetisation is regularly carried out in practical CBA, for example, at the EU level (Wieck and Dusel 2022), in Germany (Deblitz et al. 2021), and in the United Kingdom (DEFRA 2013). However, the scope of the analyses is limited in practice due to a lack of data on impacts on animals, and on how these impacts translate into production impacts (Dusel and Wieck 2023).

From the consumers' and citizens' perspective, impacts on animals may affect private consumption utility (e.g., perceived meat quality, warm glow from contributing to a good cause), and/or altruistic preferences i.e., the utility humans derive from knowing that animals are treated decently (e.g., Espinosa 2023; Eichner and Runkel 2022; Lusk and Norwood 2012; Marggraf et al. 2012). Private and altruistic preferences may translate into purchases of higher-welfare products with a price premium in limited market segments (recently reviewed by Maestre et al. 2022), but these price premiums are generally known to fall short of the willingness to pay elicited in research settings ('citizen-consumer gap'). The literature on human willingness to pay for animal welfare has been intensively reviewed (Yang and Renwick 2019; Clark

et al. 2017; Lagerkvist and Hess 2011; Cicia and Colantuoni 2010). Information on human willingness to pay regularly feeds into practical CBA (e.g., Wieck and Dusel 2022; DEFRA 2017) and plays a prominent role in the policy process (e.g., Eurobarometer 2023).

Humans' altruistic preferences may be more or less accurately aligned with animals' needs (Espinosa 2023; Treich 2022; McInerney 2004). The more these preferences are aligned, the more the degree of anthropocentrism in the monetisation of animal welfare decreases i.e., the more non-anthropocentric the monetary values become (Figure 1). Nevertheless, even if human altruistic preferences were fully congruent with animals' preferences, some degree of anthropocentrism will always be present when impacts on animals are monetised through human willingness to pay. If they could, animals might be willing to pay quite different values themselves (Stawasz 2020; Lusk and Norwood 2012). This is because altruistic preferences represent only one element in the human utility function, meaning that human willingness to pay is also influenced by preferences for other goods, constrained by household income, and does not encompass possible differences in the marginal utility per Euro between animals and humans (Lusk and Norwood 2012).

When impacts on animals are included for their own sake in policy evaluations i.e., from the animals' perspective and not through human production or human preferences, the evaluations can be considered non-anthropocentric or intrinsic.

In the USA, impacts on animals are not yet included from the non-anthropocentric perspective in practical CBA (Sunstein 2024; Leitzel and Shaikh 2023; Stawasz 2020). In other countries, this is already done, but the impacts remain intangible i.e., descriptive or expressed in various quantitative, non-monetary units. For example, Wieck and Dusel (2022) describe in an ex post CBA of EU animal welfare policies that "group housing of sows during gestation has the potential to increase AW [animal welfare] compared to confinement in crates because group housing is closer to the sows' physiological and social needs (e.g. free movement, social interaction with other sows)" (p.183). In another example, DEFRA (2010b) estimates expected benefits for laying hens due to the restriction of beak trimming to infrared techniques compared to a full ban: "Decreased incidence of injurious feather pecking is between 20 and 80 percentage points. Reduced mortality due to decreased cannibalism is between 0 and 20 percentage points [...]" (p.2). Both examples illustrate that the (intangible) impacts on animals can often only be broadly approximated because adequate data is lacking in practice (Dusel and Wieck 2023). Monetising these impacts from the animals' perspective represents an even greater challenge, also on theoretical grounds, as we will see in the course of this review. Why attempt to monetise these impacts then? Money appears to be a convenient unit because producers' costs due to animal welfare policies (e.g., labour costs to provide straw bedding) are readily available in monetary units. These costs feature prominently in political debates, and therefore,

it seems appealing to also express the benefits of the policies for animals in monetary units. By this, costs and benefits could be directly compared on the same scale (Budolfson et al. 2023). Scientific progress has been made on this issue, and scientists have recently called for better representation of this in practical policy evaluations (Budolfson et al. 2023; Kuruc and McFadden 2023a). In the political arena, the European Court of Auditors has formulated the demand “to develop a methodology to price-in animal suffering” (European Court of Auditors 2023, p.6). We consider it a first step towards these ambitions to critically review the emerging body of literature on monetisation of animal welfare from the animals’ perspective. Of note, as will become apparent in the course of this review, there always remains some degree of anthropocentrism in the monetisation of impacts on animals. Money is simply a human tool, and even the studies that claim to be non-anthropocentric, in the end, rely on human willingness to pay and other human metrics for monetisation.

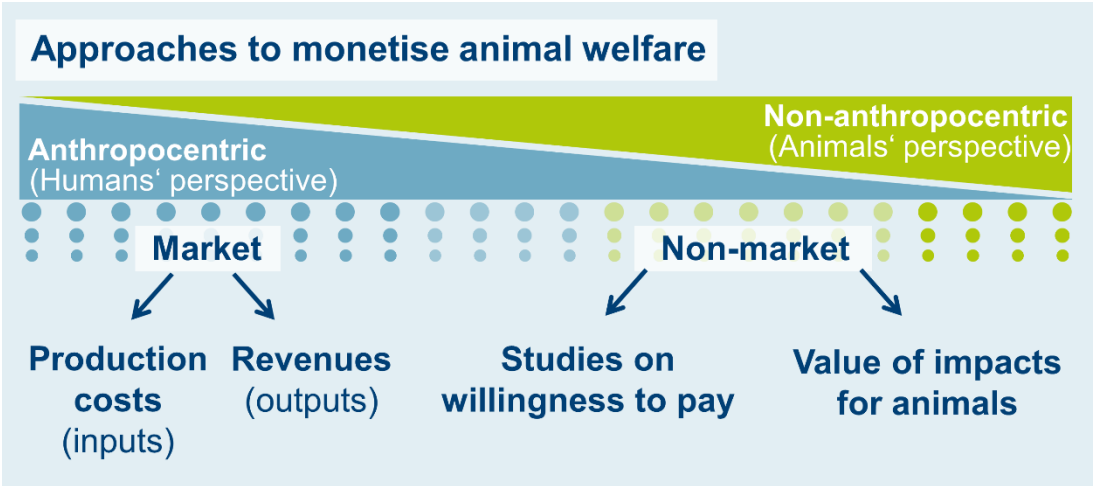


Figure 1: Approaches to monetise animal welfare in policy evaluations

1.2 Social Welfare Functions (SWF)

In view of the challenges associated with the non-anthropocentric monetisation of impacts on animals, an alternative is to assess these impacts on the same scale as impacts on producers (and other humans) by using ‘well-being units’ instead of monetary units. This is the basic principle of social welfare functions (e.g., Adler 2019, p.41ff). The well-being units may, for example, consist in quality-adjusted life years (QALYs). Notwithstanding, it is also possible to use money as a welfare metric in SWF but, in contrast to CBA, this is not imperative (Adler 2019, p.32)¹.

SWFs are not yet applied in practical policy evaluations, and the SWF methodology is not included in the EU’s Better Regulation Toolbox, a handbook with guidelines for policymaking at the EU level (European Commission 2023). However, as methods to include animal welfare

¹ In fact, as Adler (2019, p.37) points out, CBA with distributional weights can be considered an approximation of various SWFs.

in SWF gain traction in science (Budolfson et al. 2023; Kuruc and McFadden 2023a), we consider it the right time to explore the path towards practical application by critically reviewing these studies.

SWFs share some similarities with Life Cycle Assessments (LCAs) but LCAs, in contrast to SWFs, already feature in the EU's Better Regulation Toolbox (European Commission 2023, p.571ff). Few LCA studies have attempted to include animal welfare, and these have recently been reviewed by Lanzoni et al. (2023). In these LCA studies, animal welfare is usually comprised in the social dimension (Lanzoni et al. 2023), and evaluated along with other social aspects such as human health (Minetto Gellert Paris et al. 2024) and local communities (Zira et al. 2021). Because the goal of LCAs is to compare production systems or product footprints, whereas SWFs seek to assess aggregate well-being in society, the impacts on the different social entities in LCA do not necessarily have to be expressed on the same scale. This avoids the normative issues associated with constructing a harmonised scale for all social entities. In fact, there appears to be only one theoretical framework in the LCA literature that pursues welfare comparisons between humans and animals on the same scale (Scherer et al. 2018: morally-adjusted animal lives (MAL)). MAL were employed in a recent LCA case study by Minetto Gellert Paris et al. (2024) but only the impacts on animals were expressed in MAL, while the impacts on humans were assessed in 'minutes of healthy life gained' instead (although MAL could have been used). This means that impacts on humans and animals featured side-by-side in the study by Minetto Gellert Paris et al. (2024), without making the kinds of cross-species comparisons and aggregations that would be necessary for SWF.

1.3 Other Methods

As reviewed by Stawasz (2020), there also exist methods for the non-anthropocentric evaluation of animal welfare policies that do not require a common scale for humans and animals, such as cost-effectiveness analysis, breakeven analysis, and multi-criteria decision analysis. In cost-effectiveness analysis (CEA), the costs are monetised, but the benefits are expressed in a quantitative non-monetary unit. Based on this, the cost-effectiveness ratio (or vice versa) is computed (e.g., costs of straw provision divided by change in mortality rate), which serves as the decision criterion to compare policies (e.g., Boardman et al. 2018, p.512). In a sense, CEA is similar to CBA with intangible impacts. However, the scope of (intangible) CBA is much broader to capture all possible positive and negative impacts, whereas CEA tends to focus on specific costs and relies on a uniform quantitative metric for benefits to enable comparisons across policy options (Boardman et al. 2018, p. 519, 531). Hence, CEA can be considered as an analysis of "technical efficiency" (*ibid.*, p.531) rather than of aggregate welfare in society. In the EU, United Kingdom and Germany, there appears to be a focus on CBA with intangible benefits rather than on CEA, and we could not find any examples of CEA in practical contexts.

However, CEA does feature in the EU's Better Regulation Toolbox (European Commission 2023).

Breakeven analysis, according to Stawasz (2020), is a simplified version of CEA where the costs of policies are broken down, for example, per animal. Such breakeven analyses are regularly carried out in the EU (e.g., Rayment et al. 2010), the United Kingdom (e.g., DEFRA 2010a), and in Germany (e.g., Federal Ministry of Food and Agriculture 2024).

Multi-criteria decision analysis (MCDA) describes an array of different methods that serve to map impacts along different dimensions (e.g., Dean 2022; Stawasz 2020). MCDA features in the EU's Better Regulation Toolbox (European Commission 2023), and a comprehensive MCDA was recently carried out by Milieu (2023) to inform the impact assessment for the ongoing revision of the EU legislation on animal transport. Other than that, we could not find practical examples of MCDA because the focus in the field appears to lie on CBA. In the MCDA by Milieu (2023), an expert assessment was carried out and impacts on economics, animal welfare (non-anthropocentric), the environment, and social aspects were scored on a scale from 1 (least favourable) to 5 (most favourable). Milieu (2023) treat the results quantitatively and calculate the weighted mean across all impact dimensions to obtain an overall score per policy option. Although the impacts are formally expressed and aggregated on the same scale, the approach differs from CBA and SWF, where impacts on the welfare of different *individuals* must be assessed and aggregated on the same scale to obtain total impacts on society. Besides, as with any MCDA (Stawasz 2020), the question remains which policy option is preferable based on the mapping of impacts i.e., what is worth more, a score 3 for the environment or a score 4 for animal welfare?

In conclusion, although formally easier to apply, all three methods entail the disadvantage that costs to producers and benefits to animals cannot be directly compared. Hence, it remains unclear for which policy option the benefits outweigh the costs, and policymakers face difficulties to decide which policy option is preferable (Budolfson et al. 2023).

2 Research Questions, Hypotheses, and Research Objectives

This critical review aims to answer the following **research questions**:

- i)* Which approaches exist
 - to monetise impacts on animals from the non-anthropocentric perspective in CBA?
 - to include impacts on animals from the non-anthropocentric perspective in SWF?

- ii)* What are the normative assumptions of these approaches? Are they controversial?

When impacts of policies on the welfare of society (including animals or not) are studied, this will necessarily involve value judgments because certain methodological questions – e.g., how welfare should be defined, which proxies should be used to measure welfare, whether worse-off individuals should have a higher weight in society – just cannot be solved only empirically (e.g., Budolfson et al. 2023; Browning 2023; Visak 2022, p.112; Sebo 2022, p.142ff; Bruckner 2020).

As with anything that involves value judgments, **we hypothesise** that there will be normative controversies in the field, meaning that policy analysts who seek to implement any of the new approaches in practice will have to make normative choices for their policy questions at hand.

Hence, we pursue the following **research objectives**:

- to synthesise the available material on non-anthropocentric inclusion and non-anthropocentric monetisation of impacts on animals in CBA and SWF from the literature
- to make transparent any conflicting normative assumptions
- to display the results in a way that enables policy analysts to make informed normative choices for practical application
- to facilitate an academic debate on the normative controversies, and to point out any remaining research gaps

3 Methodology

3.1 Critical Literature Review

In a typology of literature reviews, Grant and Booth (2009) explain that critical reviews “‘take stock’ and evaluate what is of value from the previous body of work” (*ibid.*, p.93). Paré et al. (2015) describe in a meta-review of literature reviews that critical reviews serve “to reveal weaknesses, contradictions, controversies, or inconsistencies” (*ibid.*, p.189).

Based on this, we have chosen the format of a critical review because it fits our research objective to investigate normative controversies in the literature.

Drawing from the guidelines proposed by Wright and Michailova (2022) for critical reviews, we adopt the following frame of analysis:

- i)* **Authors’ own stance:** We approach the review process without a preformed normative standpoint.
- ii)* **Interpretation of “critical”:** By “critical”, we mean that we do not take any of the normative assumptions in the literature for granted but instead, try to challenge these assumptions as much as possible with counterarguments from the literature. In addition, we identify inconsistencies in the studies, and point out any remaining research gaps. We leave it up to the readers to form their own normative standpoint based on our critical review, and only in the conclusion, we explain how we would proceed ourselves in view of the results.
- iii)* **Engagement with the literature:** Normative controversies may be explicit in the literature, when researchers specifically criticise other studies, but this criticism may have got lost over time for no good reason other than lack of visibility. Other than that, normative controversies may be implicit and become apparent only when several studies are carefully compared. In both cases, we aim to synthesise the available material and to display it in parallel in order to make transparent which normative alternatives exist.
- iv)* **Purpose of the critical review:** As the non-anthropocentric monetisation in CBA, and inclusion in SWF, of impacts on animals is not yet applied in practice, the ultimate purpose of our review is to enable policy analysts to make informed normative choices for their practical policy questions at hand. Besides, we aim to facilitate the academic debate on these normative controversies, and to point out any remaining research gaps.

3.2 Search Process

The search process consisted of a database search in EconLit and Scopus, and a snowball search.

In **EconLit**, we used the following search terms:

AB animal welfare* AND AB (econom* OR polic* OR polit* OR (im-pact* AND assess*) OR (cost* AND benef*) OR (social AND welfare AND function))* → 285 results

AB animal welfare* AND AB monet** → 7 results

In **Scopus**, we had to further narrow down the search terms due to the broader coverage of different scientific disciplines:

(ABS (animal AND welfare*) AND ABS (((polic* OR polit*) AND evaluat*) OR (cost* AND benef*) OR ("social welfare function*")))*
→ 803 results plus 22 preprints

TITLE-ABS-KEY (animal AND welfare* AND monet*)* → 92 results
plus 1 preprint

All results and preprints were screened for inclusion according to title and abstract (inclusion criteria see below).

Similar to the methods described by Wohlin (2014) for systematic reviews, we adopted a multi-tier backward and forward **snowballing approach** in the scientific and grey literature. This covered, on the one hand, studies that were citing, cited, cited-by-cited etc., and on the other hand, searches for specific authors and conferences (Wohlin 2014). In addition, we included documents from the scientific and grey literature that we know from our own experience in practical policy advice (Niemi et al. 2023; Dusel and Wieck 2023; Wieck and Dusel 2022).

We consider it especially important to include the grey literature because *i*) preprints and working papers allow us to be up to date with the most recent scientific advances in this emerging research field, *ii*) practical policy documents published by governmental bodies or consultancies are particularly relevant for the research topic.

In total, the full texts of 73 publications were included in the critical review. Studies were included based on the following criteria:

- Language: English or German

And either:

- Theoretical or empirical contribution to the measurement of human and animal welfare on the same scale

Or,

- Theoretical or empirical contribution to the non-anthropocentric inclusion of animals in SWF

Or,

- Theoretical or empirical contribution to the non-anthropocentric monetisation of impacts on animals in CBA, SWF, or other contexts

No restrictions were applied regarding the year of publication and geographical location.

3.3 Limitations

Critical reviews are often criticised for being non-systematic and subjective because formal criteria to present methods and results, and to assess the quality of the included studies are lacking (Paré et al. 2015; Grant and Booth 2009).

Although not fully eliminated, we believe that these drawbacks are somewhat mitigated in this critical review because we approach the literature without a preformed normative standpoint, we explain in detail the methodology, and we adopt rather broad inclusion criteria. However, we do not formally assess the quality of the included studies. Instead, as Grant and Booth (2009) suggest, we focus on the conceptual contribution of each study, and determine whether the studies advance our understanding of the research topic.

4 Results: Checklist

The results of the critical review are presented in the form of a checklist that allows to better comprehend key steps of the methodologies and associated normative controversies. For each step in cost-benefit analysis and social welfare functions, the checklist gives an overview of the alternative options discussed in the literature, and points to any remaining research gaps.

4.1 How should welfare be measured?

4.1.1 Which fundamental concept of welfare should be adopted?

In the welfare economics literature in general (e.g., Adler 2019, p.10f), and in the studies on animal welfare economics (e.g., Browning 2023; Visak 2022, p.13f; Fleurbaey and Leppanen 2021; Schukraft 2020a; Horta 2018, 2017), three main concepts of welfare are distinguished:

- **Experientialism** (welfare is determined by what the individual experiences), **most common form: Hedonism** (feelings of pleasure or suffering determine welfare) **(4.1.1.A)**
- **Preferentialism** (fulfilment of the individual's own preferences determines welfare) **(4.1.1.B)**
- **Objective-good concept** (availability of certain goods determines welfare) **(4.1.1.C)**

Objective goods do not have to be preferred by the individuals themselves, and they are not limited to (but may comprise) experiences (Adler 2019, p.11). For example, objective goods may include resources like feed, or conditions like physical health (Visak 2022, p.25; Fleurbaey and Leppanen 2021). In the objective-good concept, these goods themselves constitute welfare, while in experientialism and preferentialism, these goods only contribute instrumentally to welfare (e.g., Fischer 2022; Sebo 2022, p.171; Visak 2022, p.13f; Fleurbaey and Leppanen 2021; Schukraft 2020a; Horta 2018). Similar to this, preference fulfilment may also be viewed as instrumental for experiences of pleasure and suffering in hedonism (Appleby and Sandøe 2002) or, vice versa, pleasure and suffering may be seen as instrumental to drive individuals towards preference fulfilment (Visak 2022, p.82). Following from this, objective goods (Visak 2022, p.65) including hedonic goods like pleasure or suffering, and preference fulfilment (Appleby and Sandøe 2002) can also be taken as **indicators (or proxies)** to infer welfare in the other concepts of welfare. Some studies, like Espinosa and Treich (2024b), lack conceptual clarity in this regard as they confound concept and indicators of welfare (see 4.1.1.B).

Multiple studies do not opt for a specific concept of welfare at all, but rather provide a general framework for non-anthropocentric CBA or SWF that would be compatible with multiple (Budolfson et al. 2024; Fleurbaey and Leppanen 2021) or all concepts of welfare (Rusman et al. 2023; Eichner and Runkel 2022; Zuber et al. 2022; Budolfson and Spears 2020; Johansson-Stenman 2018; Blackorby and Donaldson 1992). Further details are provided in the Appendix.

In animal science, where the focus is on practical issues of welfare assessment, the underlying concept of welfare often remains undefined (Visak 2022, p.65; Bruckner 2020). However, links can be drawn between typical animal welfare frameworks and welfare concepts (see 4.1.1.A-C).

In theory, it is possible to assume welfare **variabilism**, meaning that different concepts of welfare are applied, depending on the species, or welfare **invariabilism**, where the same concept is applied to all species (Schukraft 2020a). We could not find any studies in the literature that assume welfare variabilism across species i.e., all studies assume welfare invariabilism.

4.1.1.A Hedonism²

The most advanced studies in the field, those that include a parameterised example, rely on hedonism (Espinosa and Treich 2024b, 2024c; Espinosa 2023; Kuruc and McFadden 2023b; Fischer 2023). The study by Rusman et al. (2023) is an exception as it provides a parameterised example without specifying the underlying concept of welfare.

Fleurbaey and Leppanen (2021) criticise hedonism for being “partly anthropocentric” (p.271) because mental states matter a lot to humans, but this may not be true for other species. Hence, if only mental states count for welfare, humans receive implicit priority over other species (*ibid.*). On the contrary, Fischer (2022) argues that it would not make much of a difference to adopt an objective-good concept instead of hedonism because, even if other goods were included, hedonic goods (especially, freedom from pain) would be most important by far for all species. According to Fischer (2022), pain is such an intense experience that it cannot be outweighed by any other non-hedonic good. In particular, Fischer (2022) emphasises that individuals would not deliberately choose to undergo physical torture in order to obtain any other non-hedonic good. But this is not entirely convincing: First, there are examples of humans choosing almost certain torture by standing up against dictatorships to obtain goods like free press. Second, in the context of animals, Fischer’s own assumption that pain intensity likely differs between species makes it more plausible that other goods could be more important than pain for some species. This leads back to Fleurbaey and Leppanen (2021) who suggest to account for such differences between species by adopting the objective-good or preferentialist concept of welfare.

Espinosa and Treich (2024b) acknowledge the arguments against hedonism raised by Fleurbaey and Leppanen (2021). In response, Espinosa and Treich (2024b) adopt a “hybrid approach mixing the hedonistic and objective list approach” (p.19). However, we do not consider this theoretically consistent because we take the welfare concepts as mutually exclusive.

² In the context of animal welfare, hedonism is the only relevant experientialist concept of welfare in the literature.

Instead, based on Visak (2022, p. 65), we would characterise their approach as hedonism, using resource-based technical indicators to infer hedonic welfare states.

In animal science, subjective experiences play an important role (Gaffney et al. 2023), according to Visak (2022, p.63) even a dominant role. Browning (2023) sees hedonism as the most common concept underlying research in animal science. For example, the influential Five Domains Framework by Mellor (2016) can be ascribed to hedonism (Browning 2023; Visak 2022, p. 64). In contrast, Fleurbaey and Leppanen (2021) consider the objective-good concept, including hedonic goods, as the standard concept in animal science. This controversy is not surprising, given that studies in animal science often do not define the underlying welfare concept (Visak 2022, p.65; Bruckner 2020). Instead, concepts are assigned from the outside perspective, leaving room for interpretation how animal welfare frameworks and indicators can be linked to the welfare concepts.

4.1.1.B Preferentialism

Theoretical frameworks for preference-based non-anthropocentric CBA or SWF have been developed by Budolfson et al. (2024), Fleurbaey and Leppanen (2021), Lusk and Norwood (2012), and Marggraf et al. (2012). These frameworks are rather basic and not yet connected to actual findings from animal science where animals' preferences are tested experimentally (e.g., Ede et al. 2022).

Browning (2023) finds preference-based approaches “far less convincing for animals” (p.535) than for humans, mainly because she suspects self-harming preferences in animals that, unlike for humans (e.g., smoking), could not be accounted for by defining a set of idealised rational preferences. However, Browning (2023) does not provide convincing reasons why this should not be possible, she just posits that she cannot imagine idealised rational preferences could be defined for animals. Although Fleurbaey and Leppanen (2021) acknowledge the existence of problematic preferences in animals (as in humans), they consider it possible to account for them, only this work has not been done for animals yet.

4.1.1.C Objective-good concept

Visak (2022, p.21ff, 36ff) has critically reviewed the objective-good approaches by Kagan (2019) and McMahan (1996). She points out that these approaches may have very different implications, depending on whether goods are included that animals and humans can attain to the same extent (e.g., health), or not (e.g., playing the piano). In this context, Visak (2022, p.25) criticises the lack of commitment in the literature to any specific list of goods. Further, Visak (2022, p.71) criticises that many of the proposed goods are more plausibly instrumental for experiencing pleasure (i.e., for hedonism) than that they are ends in themselves.

Fleurbaey and Leppanen (2021) see the main advantage of the objective-good concept in its flexibility to account for differences between species (as compared to hedonism). The main challenge is the need to find weights for the different goods depending on how important they are for the different species (Fleurbaey and Leppanen 2021; Schukraft 2020c). As a solution, Fleurbaey and Leppanen (2021) propose that weights should be informed by species' own preferences over goods i.e., the animals decide themselves how to weigh the different goods. Fleurbaey and Leppanen (2021) consider the objective-good concept, including hedonic goods, as the standard concept in animal science, but this is controversial (see 4.1.1.A). Lists of indicators, as they are common in research on animal science, are easily assigned to the objective-good concept, although they may also be instrumental for welfare in the other concepts (Visak 2022, p.65). The animal welfare frameworks about natural living and biological functioning (Appleby and Sandøe 2002), and also the WOA definition of animal welfare and the Five Freedoms Framework (Fleurbaey and Leppanen 2021) have been linked to the objective-good concept of welfare.

Surveys on welfare concepts

Surveys are generally important for policymakers in order to get an impression of what the public expects from animal welfare policies. Bruckner (2020) has reviewed the very small body of literature on concepts of welfare held by the public. Based on this, it can be tentatively concluded that public beliefs are more in line with the objective-good concept rather than unidimensional concepts like hedonism. However, Bruckner (2020) stresses that even if certain beliefs are held by the public, this does not mean they should automatically be adopted in policy evaluations. Instead, public beliefs should rather serve as an input for reflective equilibrium on appropriate methods of policy evaluation, a work that still has to be carried out (Bruckner 2020).

4.1.2 Does the capacity for welfare differ between species?

We define 'capacity for welfare' similar to Schukraft (2020a) and Browning (2023) as the **span between the minimum and maximum attainable levels of welfare**. An alternative term used for this by Gaffney et al. (2023) and Fischer (2023) is 'welfare range'³. Budolfson et al. (2024) describe the same as 'welfare potential'.

The question whether the capacity for welfare differs between the species cannot be solved only empirically because it depends on the choice of welfare concept (see section 4.1.1), which is a normative choice (Visak 2022, p.58f; Bruckner 2020). Once the welfare concept is chosen,

³ Fischer (2023) uses the term 'capacity for welfare' to denote the product of 'welfare range' multiplied by lifespan.

the capacity for welfare can be investigated empirically (e.g., Browning 2023; Gaffney et al. 2023; Schukraft 2020b; Budolfson and Spears 2020, p.607ff). The metric for analysis may differ depending on the concept of welfare (Budolfson and Spears 2020, p.607).

Whether the capacity for welfare differs between the species is highly controversial in the literature:

- **Different capacity** (The minimum and maximum attainable level of welfare differs between species.) (4.1.2.A)
- **Equal capacity** (The minimum and maximum attainable level of welfare is the same across species.) (4.1.2.B)

4.1.2.A Different capacity

Presuming **hedonism**, differences in the capacity for welfare between species are often justified with the biological underpinnings of pleasure and suffering (Budolfson et al. 2024; Espinosa and Treich 2024b, 2024c; Espinosa 2023; Fischer 2023; Gaffney et al. 2023; Schukraft 2020b; Budolfson and Spears 2020). For example, Fischer (2023) and Schukraft (2020b) claim that different cognitive and/or emotional capacities of the species (e.g., capacity for mental time travel or romantic love) may be positively or negatively correlated with the capacity for welfare. In a large project, Fischer (2023) investigates one-by-one which cognitive and emotional capacities are present or absent in different species, and derives hedonic welfare capacities from this. Fischer's approach can be criticised for missing the point that different specialisations of species may mean that the presence or absence of capacities would not have the same relevance across species (Visak 2022, p.28; Fleurbaey and Leppanen 2021). For example, it does not seem plausible that solitary animals suffer because they do not engage in social behaviours like romantic love (Visak 2022, p.28; Fleurbaey and Leppanen 2021). In turn, from the perspective of a dog, the underdeveloped olfactory capacities of humans could be seen as a deficit reducing welfare capacity (Visak 2022, p.52). This makes Fischer's focus on cognitive and emotional capacities, in which humans are particularly specialised, appear arbitrary (Visak 2022, p.49). Fischer (2023) himself admits that his approach might rather map the variety of hedonic states than their intensity, and he leaves this for further research.⁴

A much simpler approach, relying only on the number of cortical neurons to estimate welfare capacities, is adopted by Espinosa and Treich (2024b), Espinosa and Treich (2024c), Espinosa (2023), Rusman et al. (2023)⁵, and Budolfson and Spears (2020). Neuron counts as a proxy

⁴ Of note, Fischer (2023) attempts to assess differences in the intensity of pain across species but finds too little data to proceed with the task.

⁵ Rusman et al. (2023) rely on the number of cortical neurons to calculate a "morally adjusted monetisation factor of a (human) DALY" (*ibid.*, p.65) but they do not specify whether this reflects different welfare capacities, weights and/or marginal utilities of money.

are generally compatible with all welfare concepts, but they feature most prominently in connection with hedonism (Fleurbaey and Leppanen 2021), for example in the study by Espinosa and Treich (2024b). Using neuron counts to infer welfare capacity is strongly criticised as too simplistic (reviewed by Shriver 2022), and even those who apply it, acknowledge major deficits. The **objective-good concept** is generally considered compatible with different capacities for welfare (e.g., Fischer 2022; Fleurbaey and Leppanen 2021; Schukraft 2020a), but Visak (2022, p.25) points out that, depending on the types of goods included, equal capacities would also be compatible (see also 4.1.1.C). It is less clear whether **preferentialism** is compatible with different capacities for welfare. Visak (2022, p.30, 48) argues that preferentialism must imply equal capacities for welfare because having one's preferences satisfied means the same thing across species, only the content of preferences may differ which she finds irrelevant at this point. In contrast, Schukraft (2020a) takes preferentialism as compatible with different welfare capacities because he hypothesises that strength, number, and complexity of preferences differ across species though empirical research on this is lacking to date.

If different welfare capacities are assumed, it is possible to either **normalise** measured welfare to the species-specific minimum and maximum levels, **or to compare absolute values** across species. In the literature, different terminology exists to describe normalisation: Fleurbaey and Leppanen (2021) call it the "maximum principle" (p.279), Gaffney et al. (2023) describe it as "species-relativized welfare impacts" (p.5), and Browning (2023) refers to normalisation as the "[s]imilarity in capacity assumption" (p.537). The latter wording seems to be counterintuitive but it encapsulates what Fleurbaey and Leppanen (2021) criticise about normalisation: normalisation wipes out differences between species because, even if absolute welfare levels differ vastly, two individuals may still be considered equally well-off if species-normalised values are used for comparison. Visak (2022, p.36ff) and Horta (2010) review specific methods for normalisation that differ with regards to which minimum and maximum values exactly are used (e.g., McMahan's (1996) native potential account). If these minimum and maximum values are chosen in a way that cements the status quo, normalisation can be considered anthropocentric because the suffering of other species is easier to ignore if it is presented in normalised terms (Fleurbaey and Leppanen 2021). Consider for example dairy cows: If the minimum and maximum values for normalisation are derived from the welfare capacities of current high-yielding breeds, the need for more robust breeds may seem less urgent because current welfare levels appear less concerning in relative terms.

4.1.2.B Equal capacity

Presuming **hedonism**, Browning (2023) and Visak (2022, p.87) consider equal capacities as the main view in animal science because pleasure and suffering emerged from shared

evolutionary pressures as a means to modulate behaviour, and are grounded in similar structures across species. Others consider hedonism compatible with different capacities for welfare, based on alternative lines of biological reasoning (see 4.1.2.A).

For **preferentialism**, Visak (2022, p.30, 48) argues on a conceptual level that this must be connected to equal capacities because welfare is determined solely by whether preferences are fulfilled, which has the same meaning across species – but this view is challenged (see 4.1.2.A).

For the **objective-good concept** of welfare, Visak (2022, p.25) points out that certain goods (e.g., physical health) may be attained by animals and humans to the same extent, which would imply equal capacities. However, with other goods, the objective-good concept of welfare is also compatible with different capacities for welfare (see 4.1.2.A).

Surveys on welfare capacity

Surveys are generally important for policymakers to get an impression of what the public expects from animal welfare policies. Public beliefs about the capacity for welfare of different species are only just beginning to be researched. Futureye (2018) conducted a representative survey among 1521 Australians and found that on average, respondents believed mammals (cattle, sheep, goats, pigs) were more sentient than chicken, followed by fish, and then, crustaceans. The Sentience Institute (2022) carried out a representative survey among 1532 US citizens and found that 85,4% of respondents at least somewhat agreed that farmed animals (without further specification of animal species) had roughly the same ability to feel pain and discomfort as humans. Similarly, preliminary results of a representative survey by Bruers (2024) among 112 Flemish-speaking Belgians reveal that the confidence-weighted median of respondents assign the same capacity for suffering as for humans to dogs, birds, and salmon, and a lower capacity to shrimp, followed by flies.

4.1.3 Which indicators should be used to assess welfare?

Compared to the sophisticated research in animal science, the indicators used in the studies on non-anthropocentric CBA and SWF are remarkably simple. Kuruc and McFadden (2023b) do not even use any animal welfare indicators in their study. Their quantitative results are based on mere assumptions about negative welfare states of farm animals, in combination with standard slaughter age and carcass weight.

- **Resource- or management-based indicators (4.1.3.A)**
- **Animal-based indicators: preferences (4.1.3.B)**
- **Animal-based indicators: other (4.1.3.C)**

4.1.3.A Resource- or management-based indicators

Eichner and Runkel (2022) use the inverse of the stocking density, approximated by land input per animal, as the animal welfare indicator for their General Equilibrium Model. Of note, this indicator does not relate to the actual space provided to the animals but includes land input for feed production.

In contrast, based on the methodology proposed by Scherer et al. (2018), Rusman et al. (2023) use i) stocking densities in the sense of space provided to the animals for broilers, laying hens, and pigs, ii) number of days on pasture for cattle, and iii) transport time for all four species, as animal welfare indicators.

The studies by Espinosa and Treich (2024b, 2024c), and Espinosa (2023) are based on the Five Freedoms Framework. For different husbandry systems, violations of the five freedoms are assessed by experts, and serve as indicators of animal welfare.

4.1.3.B Animal-based indicators: preferences

In the studies that adopt preferentialism, the welfare indicators consist of the animals' willingness to turn down feed for other resources (Lusk and Norwood 2012; Marggraf et al. 2012). However, to date, these studies only provide general frameworks and do not integrate actual findings from animal experiments.

4.1.3.C Animal-based indicators: other

The five-freedoms expert assessment approach by Espinosa and Treich (2024b, 2024c), and Espinosa (2023) implicitly includes animal-based information. Other than that, the classical animal-based indicators (e.g., lameness) have not yet been introduced into the economic frameworks for non-anthropocentric CBA and SWF. This is a severe drawback. Yet, in theory, all approaches would be compatible with animal-based indicators, just this has not been done yet. Of note, the complex indicator list by Fischer (2023) serves to estimate welfare capacities, not actual welfare at a specific point in time. Welfare capacities could be combined with resource-, management- or animal-based indicators to assess actual welfare.

4.1.4 Does the measurement scale cover positive, neutral, and/or negative welfare states?

The literature generally distinguishes between positive, neutral, and negative welfare states. The measurement scale does not have to be symmetric around the neutral point (Fischer 2023; Schukraft 2020b), and the neutral point does not have to coincide with the threshold below

which some assume that life becomes not worth living (Sebo 2022, p.171f).

- **Restricted scale (4.1.4.A)**
- **Full scale (4.1.4.B)**

4.1.4.A Restricted scale

The measurement scale is restricted to negative values in the studies by Eichner and Runkel (2022) and Kuruc and McFadden (2023b). Both studies give similar reasons: i) because the authors find it reasonable to assume that the welfare of farmed animals is generally negative, and ii) to avoid the undesirable consequence of their approaches that animal production would have to be increased if animal welfare was positive.

In contrast, Rusman et al. (2023) restrict the scale to non-negative values (i.e., zero or positive values) for ethical reasons, assuming that loss of life is generally not in the animals' interest. This is based on the methodology proposed by Scherer et al. (2018).

4.1.4.B Full scale

Most studies allow for positive, neutral, and negative welfare states (see Appendix for details). These studies either accept the consequence that animal production has to be increased if animal welfare is positive, and/or they find workarounds to avoid this consequence (for example, with specific aggregation rules see section 4.2.3). The question which consequences follow from negative values will also be discussed in detail in section 4.2.3.

4.2 How should the welfare of individuals be aggregated to determine which policy is optimal for society?

4.2.1 Should weights be used to give different ethical values to individuals or species?

Weights can be applied in addition to, and independently of, the assumptions in section 4.1. Essentially, the weights determine how much the welfare of different individuals or species, as measured in section 4.1, counts in society.

The application of weights is also referred to in the literature as the 'hierarchical' view on moral status, in contrast to the 'non-hierarchical' (also: 'unitarian') view without weights (e.g., Visak 2022, p.123; Schukraft 2020a; Kagan 2019, p.2f). The term 'status-adjusted' welfare refers to the product of measured welfare (from step 4.1) multiplied by weights indicating moral status, where moral status can be either the same across species (i.e., same or no weights 4.2.1.A), or different (i.e., different weights 4.2.1.B/C) (Schukraft 2020a; Kagan 2019, p. 108).

- **No, differences between species are already accounted for in the measurement steps (4.2.1.A)**

- **Yes, weights should be applied based on empirical reasoning (4.2.1.B)**
- **Yes, weights should be applied based on ethical deliberation (4.2.1.C)**

4.2.1.A No, differences between species are already accounted for in the measurement steps

It is passionately debated whether differences between the species should be accounted for in the measurement steps and/or whether additional weights should be used during aggregation (Visak 2022, p.123ff; Schukraft 2020a; Kagan 2019, p.54; Horta 2018, 2017, 2010). An important limitation of the reviewed literature is that none of the studies actually measure welfare across species, although methods have been proposed by Browning (2023) and Gaffney et al. (2023). Instead, at best, expert assessments as in Espinosa and Treich (2024b) are used to assess welfare states. Hence, to date, the parameterised studies in the field, except Kuruc and McFadden (2023b), rely on additional weights to depict differences between species.

4.2.1.B Yes, weights should be applied based on empirical reasoning

Weights based on the same empirical reasoning as for welfare capacities (section 4.1.2) are applied by Budolfson et al. (2024), Espinosa and Treich (2024b, 2024c), and Espinosa (2023). In fact, in these studies, the same weights are used twice: First, to infer differences in welfare capacities between species. Then, welfare levels are normalised to the different capacities, which wipes out any differences between species (section 4.1.2). But because the authors want to hold on to these differences, they apply the same weights again in the aggregation step. Due to the normalisation, this does not correspond to the double-discounting that Schukraft (2020a) warns of, but the 'back-and-forth' should be addressed more explicitly in such cases.

In the study by Rusman et al. (2023), a discounting factor is applied in the calculations but it is unclear whether this reflects differences in welfare capacities, an aggregation weight, or different marginal utilities of money (see sections 4.1.2 and 4.3.1).

An important criticism of applying weights during aggregation is that these weights can overrule anything from the previous steps, which means that equal interests of individuals from different species may not receive equal consideration (e.g., Schukraft 2020a; Kagan 2019, p.108; Horta 2018, 2017, 2016).⁶ Espinosa and Treich (2024b) realise this themselves and are dissatisfied that the same pain would be valued differently in their approach, depending on whether it is experienced by a pig or a human. They propose to apply equal weights to equal interests, but this is only a workaround to a problem that arises from the lack of actual welfare measurement, from the normalisation and the weighing in their approach (section 4.1.2).

⁶ As reviewed by Zuolo (2017), the principle of equal consideration of interests originally goes back to Peter Singer (1993) and has become very popular in animal ethics.

In contrast, Kagan (2019, p.55) does not find the hierarchical view on moral status problematic. He accepts that equal interests receive different weight depending on which species these interests belong to, and gives a striking example: If a mouse and a human are drowning (i.e., same interest at stake – survival), it would be very counterintuitive to flip a coin to decide who should be saved. Further, following from the concept of status-adjusted welfare (Schukraft 2020a; Kagan 2019, p. 108, see section 4.2.1), it would anyway lead to the same results if the same empirical reasoning serves to infer either weights for aggregation, or different welfare capacities in the measurement steps. Along the same lines, Blackorby and Donaldson (1992) point out that assigning different weights to the species is mathematically the same as assuming different utility functions of the species in the measurement steps.

4.2.1.C Yes, weights should be applied based on ethical deliberation

Several studies feature an additional weight to reflect the level of anthropocentrism in society i.e., humans' attitudes towards protecting animals in general (see Appendix for details). Such a weight could be determined based on ethical deliberation, including for example, public surveys⁷. It can be applied in addition to weights based on empirical reasoning.

According to the societal values reflected in current laws, animals generally have a lower weight than humans, otherwise they could not be used for food production (Francione 2010). Food production has been connected to the issue of assigning weights also in other studies. Sebo (2022, p.157f) notes that human self-care could justify giving somewhat lower priority to animals because humans need to sustain their own species first, before they can protect other species. In an expert survey by Bracke et al. (2023), some respondents indicate that the weights on animal lives should depend on whether animals are kept for reasons of healthy nutrition (lower weight), or for excessive consumption (higher weight to prevent overconsumption).

Schukraft (2020c) has reviewed several survey studies and comes to the tentative conclusion that the hierarchical view is common, i.e. many people assign lower weights to animals than to humans, and weights are differentiated by animal species. Two additional surveys by Johansson-Stenman (2018) and Lusk and Norwood (2008) are not covered in Schukraft's (2020c) review. Johansson-Stenman (2018) asked 1072 Swedish citizens in a representative survey about the weight animal suffering should have in public decisions. Respondents believe animal suffering, compared to human suffering, should count: equally (49.3%), less (43.5%), more (3.2%), only via human altruism (3.2%), should not count at all (0.8%). Lusk and Norwood (2008) conducted telephone interviews with 651 US citizens in a non-representative sample. On average, respondents equate the suffering of one human to the suffering of 8489 to 14310 farm animals. Of note, when the public are asked about the weights to be placed on animals,

⁷ Hence, the results of public surveys are also covered in this section.

it is not entirely clear whether respondents take these weights as merely ethical, whether they derive them from empirical reasoning, or whether they do not even see them as weights in the sense of this review but rather as differences in welfare capacities (Schukraft 2020c; Johansson-Stenman 2018).

Further, the study by Clarke and Ng (2006) makes clear that weights need to be determined not only for the present, but also for future generations of animals and humans. However, the (dis)counting of future generations of animals does not play a role in the literature yet.

Lastly, weights based on ethical deliberation can serve as a 'last resort' in policy evaluations when empirical information is not available (Browning 2023).

4.2.2 Which aggregation rule should be adopted?

The aggregation rule defines how individual welfare is aggregated to societal welfare. In addition to the weights in section 4.2.1, the aggregation rule may entail weighing based on how good or bad individual welfare is i.e., different degrees of priority may be given to worse-off individuals.

- **Utilitarianism** (The only matter of interest is overall welfare in society.) **(4.2.2.A)**
- **Prioritarianism** (Worse-off individuals receive priority, even if overall welfare was maximised by giving priority to better-off individuals.) **(4.2.2.B)**
- **Egalitarianism** (Inequalities in the distribution of welfare between individuals should be reduced, even if this neither maximises overall welfare nor prioritises the worse-off.) **(4.2.2.C)**

4.2.2.A Utilitarianism

Utilitarianism is about maximising the overall quantity of welfare in society, and there are different ways how this quantity can be calculated. Utilitarian aggregation rules are currently the most frequently used in the field. The Appendix contains an overview of the different forms of utilitarianism proposed for non-anthropocentric SWF in the literature. Of note, cost-benefit analysis with distributional weights can be considered an approximation of various utilitarian (and other) SWFs (Adler 2019, p.37).

In **total utilitarianism**, the most basic form of utilitarianism, the sum of individual welfare is maximised. An undesirable consequence of total utilitarianism is the so-called 'Repugnant Conclusion', first described by Parfit (1984) and often cited in connection with animal welfare (e.g., Espinosa and Treich 2024c; Visak 2022, p.133; Bruers 2022). The Repugnant Conclusion denounces that numbers beat quality in total utilitarianism i.e., that a huge population with individuals of very poor welfare would be preferable compared to a population with fewer individuals of higher welfare.

This is mitigated in **average utilitarianism**, where the mean of individual welfare is maximised. However, this version of utilitarianism also has important deficits, in particular the so-called ‘Sadistic Conclusion’, first described by Arrhenius (2000) and also often cited in connection with animal welfare (e.g., Bruers 2022; Zuber et al. 2022). The Sadistic Conclusion entails that, when average welfare is sufficiently high in a population, it would be preferable to add few individuals with negative welfare than many individuals with positive, but below-average, welfare.

In **critical-level utilitarianism**, individual welfare is first subtracted by a constant, positive threshold value and then, the sum of the remainders is maximised. Critical-level utilitarianism also leads to the Sadistic Conclusion (Arrhenius 2000) but Bruers (2022) offers refined versions, called ‘neutral-range utilitarianism’ and ‘variable critical-level utilitarianism’, to avoid this. Essentially, this works by excluding contingent individuals i.e., those who do not exist in all scenarios (Bruers 2022). The approach is similar to the ‘prior-existence utilitarianism’ defended by Visak (2016, 2011), where only those individuals count that either already exist or will exist independently of the policy choice under consideration. Besides, a number of refined aggregation rules (not only utilitarian) have been proposed by Zuber et al. (2022).

Of course, the refined approaches also have their own problems, but this goes beyond the scope of the review and details can be found in the respective studies. The further refinement of utilitarian aggregation rules is a continuous process, and the novel approaches still take time to be taken up in parameterised studies.

4.2.2.B Prioritarianism and 4.2.2.C Egalitarianism

Prioritarianism and egalitarianism are aggregation rules that take into account the distribution of well-being in society. Although they feature differences with regards to the degree of priority given to the worse-off (see 4.2.2), prioritarianism and egalitarianism often require the same actions to be taken (Horta 2016; Faria 2014). Both aggregation rules are discussed together because their standing in the literature is similar.

Prioritarianism and egalitarianism are currently only discussed on a rather general level in the field. Espinosa and Treich (2024c) briefly introduce a general framework of equations for prioritarianism but find it too challenging to parameterise at this stage, given strong normative choices that would have to be made. Fleurbaey and van der Linden (2021) formalise egalitarianism in the context of an anthropocentric SWF, taking animal welfare into account only through human altruism. The most detailed, though qualitative, explorations of non-anthropocentric prioritarianism and egalitarianism can be found in the studies by Horta (2016) and Faria (2014). Both conclude that prioritarianism and egalitarianism would entail giving priority to animals because they are usually worse off compared to humans. This would require, for

instance, veganism and a considerable shift of resources towards animals (Horta 2016; Faria 2014).

However, the circumstances under which animals can be considered worse-off compared to humans depend on the assumptions made in the previous steps, especially, on welfare capacities, normalisation, and weighing. As described by Horta (2016) and Faria (2014), a hierarchical weighing approach based on welfare capacity is proposed by Vallentyne (2005) to prevent excessive resource shifts towards animals in the egalitarian setting. Leaving aside the issue that Vallentyne's approach entails double-discounting (Schukraft 2020a; see section 4.2.1), Faria (2014) considers hierarchical weighing generally incompatible with egalitarianism. Horta (2016) is not so apodictic and merely stresses that welfare capacity should be all that matters in welfare economics. As Vallentyne's (2005) weighing is based on welfare capacity, it could be considered compatible with egalitarianism if it is combined with a normalisation approach to avoid double-discounting, and subsequent multiplication to produce status-adjusted welfare (see section 4.2.1).

4.2.3 What is the welfare impact of increasing or decreasing the number of animals kept for farming purposes?

It is controversially disputed which welfare impacts should follow from changing the number of animals kept for farming purposes (e.g., Visak 2022, p.103ff; 2011; Bruers 2022; Visak and Garner 2016). Nevertheless, this issue is currently only discussed as a side note in the most advanced studies in the field, such as Espinosa and Treich (2024b) or Kuruc and McFadden (2023b). These studies adopt the assumptions in 4.2.3.A but alternatives exist e.g., the assumptions in 4.2.3.B.

- **Societal welfare can be increased by removing animals with negative welfare** (i.e., preventing them from being brought into existence or killing them), **or by adding animals with positive welfare (4.2.3.A)**
- **Preventing individuals from being brought into existence, or adding individuals, does not affect societal welfare whereas killing does affect societal welfare (4.2.3.B)**

4.2.3.A Societal welfare can be increased by removing animals with negative welfare, or by adding animals with positive welfare

This assumption entails either an impersonal view on societal welfare where just the abstract quantity of welfare counts and different individuals can replace each other, or it entails comparing individual welfare with non-existence (Visak 2011, p.226, 236). Both situations are contested because either individual identity does not count, or because individual welfare is compared to a state in which the individual simply does not have welfare because it does not exist

(e.g., Holtug 2016; Visak 2016). In particular, there is strong criticism against setting the neutral welfare state (see section 4.1.4) equal to non-existence as practiced by Kuruc and McFadden (2023b), or equal to non-existence and death as practiced by Espinosa and Treich (2024b, 2024c). This is because the neutral welfare state is something the individual can actually experience while non-existence is not (Visak 2016), and death is again different because the individual existed before and ending its life will affect its welfare. Besides, as Treich (2022) acknowledges, it has been suggested by Ng (1995) that individuals feel neutral most of the time because positive and negative welfare states have high energy costs. Under this premises, life would be equal to non-existence or death most of the time, which seems counterintuitive.

When it comes to removing animals from the population under different policy options, it is generally distinguished between preventing to bring them into existence, or killing them (e.g., Visak 2011, p.230f; Blackorby and Donaldson 1992). Killing entails possible suffering due to a painful killing method, and/or the 'harm of death' which refers to the future welfare loss of the animals (Visak 2022, p.89). The extent to which animals experience harm of death is controversially disputed and relates, for example, to the species' degree of connectedness to their future in terms of future plans and desires (e.g., Bradley 2016; Belshaw 2016, and reviewed by Visak 2022, p.88ff and Schukraft 2020a).

In total utilitarianism, as adopted by Espinosa and Treich (2024b, 2024c) and Kuruc and McFadden (2023b), animals with negative welfare⁸ should not be brought into existence, or should be killed, while animals with positive welfare should be added and may be killed if replaced by other animals with positive welfare to compensate for the welfare loss (Visak 2011, p.227). Critical-level utilitarianism arrives at the same results as total utilitarianism if the critical threshold corresponds to the neutral welfare state (Kuruc and McFadden 2023b; Espinosa and Treich 2024b, 2024c). However, if the critical threshold lies above neutrality, there will be animals with positive welfare whose lives are worth living but who do not increase societal welfare (Espinosa and Treich 2024c; Blackorby and Donaldson 1991). In this case, if societal welfare is assessed separately for the situations with and without these animals, it would be required to either prevent the animals with positive but below-threshold welfare to be brought into existence, or to kill them without replacement (Blackorby and Donaldson 1991). In contrast, if societal welfare is assessed across both situations in a before-and-after setting, the individual welfare loss of the animals would be captured and it would only be required to prevent the animals from being born, but not to kill them (*ibid.*). In either case, it may seem troublesome to deprive individuals who would subjectively have a life worth living from being born, or even to kill them, just because they do not increase societal welfare (Holtug 2016; Visak 2016;

⁸ Numerous ethicists criticise when animals face negative welfare due to the way they are treated by humans in the first place (Visak and Garner 2016, p.12), meaning that this part of the debate is somewhat misguided because it implicitly accepts such mistreatment.

Blackorby and Donaldson 1991). The same results as for critical-level utilitarianism also hold for average utilitarianism, relating everything to the average instead of the critical threshold (Blackorby and Donaldson 1991).

In their studies, Espinosa and Treich (2024b, 2024c) and Kuruc and McFadden (2023b) only focus on farm animals with a negative lifetime welfare and hence, a life not worth living. From their total utilitarian framework, they conclude that the number of these animals should be reduced in order to increase societal welfare. However, if the political goal is to provide farm animals a life with positive welfare (i.e., a life worth living), the opposite holds. Then, animal numbers would have to be increased (Kuruc and McFadden 2023b), and animal farming would have to be subsidised (Espinosa and Treich 2024b, 2024c). This constellation is known, and criticised (see 4.2.3.B), as the ‘logic of the larder’ (e.g., Espinosa and Treich 2024b, 2024c; Visak and Garner 2016; Visak 2011). Kuruc and McFadden (2023b) try to somehow avoid these implications by writing that they find their framework less useful for the case of positive welfare in animal farming. Espinosa and Treich (2024c) briefly mention that critical-level utilitarianism could be a way to avoid producing farm animals with positive but below-threshold welfare, so that only farming with positive above-threshold welfare would be subsidised. Generally, the higher the critical threshold, the more difficult to increase societal welfare merely by adding animals, instead of improving their welfare levels (Blackorby and Donaldson 1992). Yet, as explained above, critical-level utilitarianism comes at the expense of other undesirable implications.

4.2.3.B Preventing individuals from being brought into existence, or adding individuals, does not affect societal welfare whereas killing does affect societal welfare

This assumption is in line with the person-affecting view where comparisons with non-existence are not possible, and individuals cannot replace each other (e.g., Visak 2022, p.104). Hence, the logic of the larder (i.e., animal farming has to be expanded if animals have positive welfare) is avoided under this assumption (Bruers 2022; Visak 2016).

Different refinements of person-affecting approaches have been proposed in the literature, each with their own advantages and disadvantages. These include, for example, ‘prior-existence utilitarianism’ (e.g., Visak 2016, 2011; see section 4.2.2), ‘neutral-range utilitarianism’, ‘variable critical-level utilitarianism’ (Bruers 2022; see section 4.2.2), and ‘saturating-counterpart person-affecting utilitarianism’ (Visak 2016). The latter maps individuals that exclusively exist in one of the scenarios to counterpart individuals in other scenarios (Visak 2016). Thereby, in certain desirable instances, the same conclusions are reached as with impersonal approaches, but the logic of the larder and other undesirable consequences are avoided (*ibid.*). As for assumption 4.2.3.B, death and killing affect the welfare of individuals in the person-affecting view. It constitutes a welfare loss if animals are deprived of positive experiences

because their lives end prematurely. There are several methods to account for this welfare loss.⁹ These include, for example, calculations in analogy to human disability-adjusted life years (DALYs) where premature death and years of suffering are combined in a single measure (e.g., Minetto Gellert Paris et al. 2024 and 2022 based on Scherer et al. 2018; Weathers et al. 2020; Teng et al. 2018). Further, critical-level utilitarianism based on lifetime welfare penalises early slaughter because older animals accumulate positive welfare and exceed the critical threshold more easily (Blackorby and Donaldson 1992).

In the opposite case, when animals face negative welfare, the person-affecting approaches neither recommend to prevent these individuals from being brought into existence, nor to do the opposite, because comparisons with non-existence are just not possible (Visak 2016). However, once the animals do exist, it can be required to kill them also under the person-affecting view in order to increase societal welfare (*ibid.*). Yet, as mentioned in section 4.2.3.A, situations where animals incur negative welfare should be prevented in the first place rather than only taking a reactive stance (see also Visak and Garner 2016, p.12).

Surveys on variable population size

Espinosa and Treich (2021) conducted a survey among 223 French experts (animal farming or animal ethics), students, and animal activists. Participants were asked whether, from the perspective of a broiler, life under different husbandry conditions is worth living, or whether it would have been better not to be born at all. This implies that comparisons with non-existence are possible (see sections 4.2.3.A&B). A key result of Espinosa and Treich's (2021) study is that farm-animal experts and frequent meat eaters evaluated the lives of broilers more positively compared to the other participants. Bruers (2023) carried out a representative survey among 301 Flemish-speaking Belgians, explaining to them the state of non-existence as a deep sleep without experiencing anything. Bruers asked how much participants would be willing to pay (or accept) to experience the lives of different animals during the deep sleep, instead of having no experiences at all. The monetary values indicate whether participants consider the lives of the animals worth living (Bruers 2023). Unfortunately, the robustness of the method is questionable because mean and median responses differ largely, extreme outliers are present, and the final results are sensitive to excluded values (*ibid.*). In a much simpler survey, Bruers (2024) asked 112 Flemish-speaking Belgians how they would rate the lifetime welfare of conventional broilers and wild birds on a scale from minus 10 to plus 10. In this more direct approach, participants rated broiler welfare on average at -2.1, with a median of -2.0, meaning they believed that conventional broilers have negative lifetime welfare. However, the

⁹ These methods can also be applied in connection with assumption 4.2.3.A but they are more relevant under assumption 4.2.3.B because the welfare loss cannot be compensated by bringing additional animals into existence.

consequences following from this i.e., whether it would be better that broilers were not born at all, or killed immediately, were not investigated in this study.

4.2.4 Should any additional constraints be applied?

It is possible to restrict the aggregation rules by applying constraints that reflect fundamental ethical convictions of society, even if these convictions go against the principles of the aggregation rules (e.g., Adler 2019, p.25ff; Budolfson and Spears 2020, p.611). For example, the current EU legal systems prohibit the killing of humans, even though killing may be required under some aggregation rules (Francione 2010). Hence, such constraints can also be seen as rights that protect individuals from certain consequences of welfarist policy evaluations (e.g. Kuruc and McFadden 2023b; Adler 2019, p.26; Francione 2010).

- **Additional constraints (4.2.4.A)**
- **No additional constraints (4.2.4.B)**

4.2.4.A Additional constraints

For some aggregation rules, the circle of individuals whose welfare counts is restricted. For example, some of the aggregation rules proposed by Visak (2016, 2011) and Bruers (2022) exclude individuals that do not exist in all policy scenarios (see section 4.2.2).

Other than that, the use of constraints is rarely discussed in the context of non-anthropocentric policy evaluations. Kuruc and McFadden (2023b) briefly mention that a ban on killing animals could be modelled in their approach as an additional cost, similar to a financial sanction for violations of the ban. Further, Bruers (2022) restricts the choice options available to individuals in order to avoid undesirable consequences like the Repugnant Conclusion.

4.2.4.B No additional constraints

An important reason against the application of constraints is that policy evaluations may no longer be impartial i.e., welfare impacts are evaluated differently depending on which individuals experience them (e.g., Adler 2019, p.25). For example, it may be considered partial, or even speciesist, that it is currently only prohibited to kill humans but not animals, assuming both have the same at stake (Francione 2010).

4.2.5 Should human altruistic welfare (from knowing that animals are treated in a certain way) be included in addition to animal welfare?

Humans are capable of altruism, meaning they may derive positive or negative welfare from knowing that animals are treated in a certain way. Anthropocentric policy evaluations, like Espinosa and Treich (2024a) or Fleurbaey and van der Linden (2021), account for animal welfare

only through human altruism. In non-anthropocentric policy evaluations, different positions exist as to whether human altruism should be included in addition to the animals' own welfare.

- **Do not include human altruistic welfare (4.2.5.A)**
- **Include human altruistic welfare in addition to animal welfare (4.2.5.B)**

4.2.5.A Do not include human altruistic welfare

The main reason raised in the literature against the inclusion of human altruism is that this would result in the double-counting of animals' interests (Espinosa and Treich 2023; Eichner and Runkel 2022; Marggraf et al. 2012; Lusk and Norwood 2012). Further, because human altruism is coupled to the animals' own welfare (i.e., altruistic welfare decreases if animal welfare decreases), the double-counting may lead to the undesirable situation that welfare gains for animals cannot be redistributed to humans without decreasing total societal welfare (Lusk and Norwood 2012; Marggraf et al. 2012). Lusk and Norwood (2012) conclude from this that human altruism should not be included in addition to animal welfare when determining whether a policy increases total welfare, or when assessing compensatory redistributions. In contrast, Marggraf et al. (2012) consider it a viable option to include human altruism because they do not think it is necessary that redistributions have to be possible without decreasing total welfare. Marggraf et al. (2012) only stress that it should be carefully assessed which redistributions from animals to humans actually happen in practice in order not to overestimate the positive impacts of animal welfare policies.¹⁰

4.2.5.B Include human altruistic welfare in addition to animal welfare

The main reasons to include human altruism in addition to animal welfare are i) that an important part of human welfare would simply be left out otherwise (Lusk and Norwood 2012; Marggraf et al. 2012), and ii) that human altruism can be considered as a new, separate welfare entity that should be included next to the animals' own animal welfare (Eichner and Runkel 2022 based on Ng 1999).

When including human altruism in addition to animal welfare, it can be distinguished between pure and impure altruism. Pure altruism can be defined as an exact representation of the animals' own welfare, mathematically expressed using the same term twice, with or without an additional weight to discount this term (Espinosa and Treich 2024c, 2021; Marggraf et al. 2012). In contrast, impure altruism can be defined as a distorted misrepresentation of animal

¹⁰ Redistributions from animals to humans can happen in practice for example, when an animal welfare policy increases costs in one area (e.g., space per animal) and producers react by saving costs in a different welfare-relevant area (e.g., feed quality) (Norwood and Lusk 2011, p.217; Marggraf et al. 2012).

welfare where humans misunderstand what animals actually need (Espinosa 2023; Marggraf et al. 2012).

Multiple studies feature the option to include pure altruism in addition to animal welfare, with or without weight, but do not take sides whether this would be desirable (see Appendix). Johansson-Stenman (2018) and Marggraf et al. (2012) provide general frameworks that would be compatible with pure or impure altruism. The most elaborate framework to date for human altruism in non-anthropocentric policy evaluations has been developed by Eichner and Runkel (2022). The authors model human altruism as a combination of *homo oeconomicus*, taking the level of animal welfare as exogenously given because individual food purchases are perceived as having negligible impacts on animal welfare, and of *homo kantianus*, making every food purchase according to what is the right thing to do and assuming that everybody was doing the same (*ibid.*). The framework by Eichner and Runkel (2022) can be categorised as pure altruism, with an additional weight.

Surveys on human altruism

The results of standard surveys on human willingness to pay for animal welfare capture a mix of human private welfare from consumption (e.g., taste of meat), human altruism towards animals (Espinosa 2023; Lusk and Norwood 2012), and even human altruism towards other humans (Espinosa 2023).

In a specifically designed experimental auction with a representative sample of 100 US citizens, Lusk and Norwood (2012) attempt to separate human altruism towards animals from human private willingness to pay for consumption. They find large deviations between mean and median altruistic willingness to pay, driven by few individuals with strong altruism.

4.2.6 Which units should be used for aggregation?

As introduced in section 1.2, impacts on producers (or other humans) and animals can be aggregated and compared in monetary units, or in other units that reflect welfare. Other units may either be taken directly from the measurements, or they may be derived from the measurements, bringing the measurements to the same scale, like QALYs.

- **Monetary units (4.2.6.A)**
- **Other units (4.2.6.B)**

4.2.6.A Monetary units

Multiple studies use monetary units to aggregate and compare impacts on animals and humans (see Appendix). Even when QALYs and DALYs are used as the basis for monetisation,

the focus may lie on the monetary values, like in the studies by Espinosa and Treich (2024b, 2024c; Espinosa 2023) and Rusman et al. (2023).

4.2.6.B Other units

Many studies do not specify the unit but rather provide a general framework for aggregation that would be compatible with any monetary or non-monetary unit (see Appendix).

Budolfson et al. (2024) use QALYs to compare impacts on animals and humans. In addition, the authors also monetise these impacts. Fischer (2023) relies on DALYs to compare welfare impacts across species, but he does not formally cover the topic of aggregation.

4.3 How should welfare units be converted into monetary units?

4.3.1 What is the basis for monetisation?

Converting welfare units into monetary units requires to define a reference point that connects both units. The following reference points have been used in the literature:

- **Value of a human QALY or DALY (4.3.1.A)**
- **International poverty line (4.3.1.B)**
- **Market price of feed (4.3.1.C)**

4.3.1.A Value of a human QALY or DALY

There is a large body of literature on the monetary value humans assign to one year of life in perfect health (QALY), or to avoiding the loss of one year of life due to death, illness or disability (DALY). These monetary values are based on humans' stated or revealed willingness to pay (reviewed by e.g., Stawasz 2020; Ryen and Svensson 2015; OECD 2012).

For animals, the human QALY and DALY values are discounted, either based on the reasoning that animals have lower capacity for welfare, lower weight in society compared to humans, and/or a lower utility of money (see Appendix).

Because the monetary values for animals are directly derived from human values of QALYs and DALYs, the approach entails some level of anthropocentrism (Stawasz 2020).

Table 1 provides examples of monetary values from two parameterised studies using QALYs and DALYs as the basis for monetisation. Details on further assumptions of these studies can be found in the Appendix.

Surveys on monetisation

Bruers (2023) asked survey participants how much they would be willing to pay (or accept) to experience the lives of different animals during a deep sleep, instead of having no experiences

at all (see section 4.2.3). This resembles the QALY/DALY approach for humans, but also entails some level of anthropocentrism because humans assign a monetary value to the situation of animals without any input from the animals themselves.

4.3.1.B International poverty line

The international poverty line of \$1.90/day¹¹ serves as the basis for monetisation only in the study by Kuruc and McFadden (2023b). In this study, it is assumed that the welfare of one farm animal is equivalent to the welfare of one human living on \$1.00/day i.e., below the international poverty line. Kuruc and McFadden (2023b) themselves note that this assumption is rather arbitrary and they see it more as a proof of principle, with the possibility to further differentiate between farmed species, farm types etc. in the future.

As for QALYs and DALYs, the human poverty line as a reference point implies some level of anthropocentrism because the value of \$1.00/day is arbitrarily chosen without input from animals, using a poverty scale that is determined entirely by human action on global markets.

Table 1 provides an example of a monetary value from the study by Kuruc and McFadden (2023b). Details on further assumptions of this study can be found in the Appendix.

Table 1 Monetary values for the welfare of chickens (conventional or organic)

	Espinosa and Treich (2024b)	Rusman et al. (2023)	Kuruc and McFadden (2023b)
Monetisation approach	QALY Value of one day in perfect health for a human: 402 €/d	DALY Compensation cost for loss of one day for a human: 291 €/d	International poverty line Chicken's life is equivalent to human life on \$1 per day (0.92 €/d)
Monetary value Example: chicken	Value of chicken's lifetime welfare per kg chicken meat: ¹² conventional $v_1 = -62.19$ €/kg $v_2 = -17.02$ €/kg organic $v_3 = -60.36$ €/kg $v_4 = -0.98$ €/kg	Compensation costs for conventional chicken's welfare loss per kg chicken meat: $c = 22.01$ €/kg	External costs for conventional chicken's lifetime welfare per kg chicken meat: ¹³ $c = 4106.89$ €/kg

¹¹ In 2022, the international poverty line was raised to \$2.15/day to reflect changes in prices (Worldbank 2022).

¹² We converted the values to €/kg (instead of €/head) without making any additional assumptions than the study itself. The values v_1 vs. v_2 and v_3 vs. v_4 originate from different assumptions by Espinosa and Treich (2024b) regarding the welfare level below which the chicken's life is no longer worth living.

¹³ We converted the values to €/kg (instead of \$ per 20g protein) under the additional assumption that 100g of chicken meat contain 27.3g of protein (USDA 2019) and with an exchange rate of 1\$ ≈ 0.92€.

4.3.1.C Market price of feed

When a preferentialist concept of welfare is adopted, the marginal welfare increase of animals can be inferred from the quantity of feed they are willing to forego in order to obtain certain resources. To monetise this welfare increase, the quantity of feed can be multiplied by the market price of feed (Lusk and Norwood 2012; Marggraf et al. 2012)¹⁴. The approach would also work with other proxies instead of feed that are used in analogy to money to determine the strength of animal preferences (Lusk and Norwood 2012; Marggraf et al. 2012). For example, drawing from the study by Eichner and Runkel (2022), land prices would be an option if animals' preferences could be measured in the amount of land they are willing to give up for different resources.

The main advantage of the approach is that it uses animals' actual preferences and their marginal rates of substitution between goods to inform monetisation. However, only humans interact on markets and determine market prices. Hence, unless a "liquid interspecies market" (Keeler 2016, p.721) can be put in place, monetisation based on market prices will entail some level of anthropocentrism.

To date, this monetisation approach has not been adopted in a parameterised example.

4.3.2 Does the marginal utility of money differ between species?

When welfare units are converted into monetary units, it has to be decided whether the exchange rate (i.e., marginal utility of money) should differ between species. Similar to humans whose marginal utility of an additional Euro differs depending on their income, the marginal utility of money may differ between species (Lusk and Norwood 2012).

- **Different marginal utility of money (4.3.2.A)**
- **Same marginal utility of money (4.3.2.B)**

4.3.2.A Different marginal utility of money

Lusk and Norwood (2012) believe that the marginal utility of money is higher for animals than for humans because they consider it plausible that, for example, an additional \$100 represents a small welfare increase for a middle-class human but a large welfare increase for a pig.

Kuruc and McFadden (2023b) place animals on the steep, and humans on the flat, segment of the same utility function of income, meaning animals have a higher marginal utility of money compared to humans. This also implies that animals could reach the same welfare level as humans if they received enough money.

¹⁴ Although not explicitly mentioned, this approach would also be compatible with the study by Blackorby and Donaldson (1992).

As described in section 4.2.1, weights are used in the studies by Budolfson et al. (2024), Espinosa and Treich (2024b, 2024c), and Espinosa (2023). These weights also discount the value of money for the different species because of the way they are included in the multiplication formula, resulting in a higher marginal utility of money for animals compared to humans. However, the authors do not comment on this and hence, it remains unclear whether it is actually intended that the same figures as for welfare capacities and aggregation weights simultaneously also determine utility of money.

Similarly, Rusman et al. (2023) use a “morally adjusted monetisation factor of a (human) DALY” (*ibid.*, p.65) to convert welfare units into monetary units, resulting in a larger utility of money for animals compared to humans, but they do not specify whether this is actually intended or rather reflects different welfare capacities and/or aggregation weights.

4.3.2.B Same marginal utility of money

Johansson-Stenman (2018) assumes for simplicity that animal welfare is converted into monetary units with the same marginal utility of money as human welfare (also the same across human individuals).

Marggraf et al. (2012) and Blackorby and Donaldson (1992) do not explicitly address marginal utility of money but from their formulas it becomes clear that they assume the same marginal utility of money across and within species.

Lusk and Norwood (2012) are more in favour of different marginal utilities of money but for Kaldor-Hicks transfers between species to be possible, they have to assume the same marginal utility of money across and within species.

5 Discussion and Conclusion

In this critical review, we present the current state of knowledge on the non-anthropocentric inclusion and monetisation of animal welfare in CBA and SWF. We synthesise material from a variety of studies, each contributing to different steps in the process of non-anthropocentric CBA or SWF. The results reveal numerous normative controversies, and a checklist was developed to summarise the alternative options and assumptions from the literature. In the following, we discuss the results and present our conclusions in chronological order according to the checklist.

The three concepts of welfare (hedonism, preferentialism, objective-good) all appear workable, though preferentialism has not been tested in a parameterised study yet.¹⁵ Whichever concept is adopted, there is currently a gap in the literature when it comes to connecting the capacity

¹⁵ Neither has the objective-good concept but this seems less of an issue. Welfare indicators can easily be interpreted as determinants of welfare under the objective-good concept (Visak 2022, p.65).

for welfare to actual measurements on animals. Even the most advanced empirical study on welfare capacity by Fischer (2023) cannot draw a connection between the cognitive and emotional capacities of different species and the actual *relevance* of these capacities for the species' hedonic welfare capacity. This aspect has to be criticised, drawing from arguments by Visak (2022, p.28) and Fleurbaey and Leppanen (2021). Fischer (2023) himself also acknowledges this deficit, leaving it to further research.

The results show that currently, in non-anthropocentric CBA and SWF, the assumption prevails that the capacity for welfare differs between species. Likewise, Visak (2022, p.9) observes that the assumption of different capacities is dominant among philosophers. Yet, we believe that the arguments in the literature in favour of equal capacities are just as strong. Hence, similar to Browning (2023) and Visak (2022), we do not consider this question as settled.

The welfare indicators in the studies on non-anthropocentric CBA and SWF are currently too simplistic. Future efforts should better integrate the elaborate body of research from animal science on animal welfare indicators (especially, animal-based indicators), and these indicators should be used for actual measurements on animals. Official monitoring and reporting on the population of farmed animals will have to be expanded for this (Dusel and Wieck 2023).

This critical review provides the first overview of the different terminology used in the literature to describe the normalisation of (measured) welfare states to species-specific welfare capacity. This will help other researchers to recognise more easily when normalisation is carried out. Further, we identify cases in the literature where different welfare capacities are assumed but then, normalisation is carried out, which essentially equalises capacities. Because of this, weights have to be applied in the aggregation step to re-introduce differences between species. This process is somewhat unexpected and should be more explicitly explained and justified in the literature.

A key contribution of our critical review is to highlight the parallels between capacity for welfare, weights in aggregation and utility of money. All serve to discount animals compared to humans which is necessary if animals should continue to be used in food production. Otherwise, under equal capacity, weight and utility of money, Singer's principle of equal consideration (e.g., Singer 2014, p.86) would imply that animals' interests in not being eaten outweigh humans' interests in consuming animal products. Following from the concept of status-adjusted welfare (Schukraft 2020a; Kagan 2019, p. 108), it makes no difference for the final result if the same empirical reasoning is used to infer capacities or weights. In contrast, discounting based on utility of money means that all species could in theory reach the same welfare levels, just the amount of money they need for this would differ. The latter can be observed in particular in the study by Kuruc and McFadden (2023b).

We consider it important to distinguish between empirical and ethical weights, and to include both weights in the analysis (like multiple studies already do). This makes transparent on what basis animals are discounted.

When it comes to the aggregation rules, the novel refined specifications should be taken up in parameterised examples because the standard aggregation rules entail undesirable consequences like the Repugnant Conclusion or the Sadistic Conclusion.

We believe that negative animal welfare should be reduced primarily by improving husbandry conditions rather than by decreasing animal numbers¹⁶ because we are not convinced by the impersonal view on societal welfare, or by comparisons with non-existence that imply for example that “the beneficiaries [of an animal welfare levy] are the non-existing animals that would have existed without the policy” (Espinosa and Treich 2024b, p.12). Comparisons with non-existence also imply the logic of the larder i.e., that animal numbers have to be increased if animal welfare is positive. This undesirable consequence is currently not adequately addressed in the literature. Espinosa and Treich (2024b) briefly mention the logic of the larder, and then focus on the scenario with negative animal welfare. Similarly, Kuruc and McFadden (2023b) stress that they are less confident about the applicability of their framework under the assumption that animals’ lives are worth living. Eichner and Runkel (2022) even restrict the scale to negative values, allowing their model to improve animal welfare only within the negative range. Hence, there is currently a gap in the literature when it comes to accounting for positive animal welfare, and more attention should be paid to parameterising some of the novel refined specifications that avoid the logic of the larder.

Additional constraints are a useful tool to modify aggregation rules in a targeted manner according to certain ethical convictions in society that could otherwise not be reflected. Such constraints are currently rarely applied but they could aid in avoiding undesirable consequences like the logic of the larder. However, this comes at the expense of losing the impartiality of pure welfarism (e.g., Adler 2019, p.25).

We follow the argumentation presented in section 4.2.5.B that human altruism should be included in addition to animal welfare. Ideally, both human altruism and animal welfare should be measured on humans and animals respectively. If there is a deviation between both figures (i.e., impure altruism), this could be taken as a call for action to educate the public about what animal welfare means from the animals’ perspective.

Money is an appealing unit for aggregation because producers’ costs to adjust barns etc. are already measured in Euro. If instead, QALYs or DALYs are used, producers’ costs would have to be converted into QALYs or DALYs in order to balance them with impacts on animals. This is presumably why many studies that use QALYs or DALYs as a basis for monetisation focus

¹⁶ Notwithstanding, there are many good reasons to reduce animal numbers in high-income countries, like health and climate.

on money when it comes to aggregating and assessing welfare impacts across species. However, the monetisation of animal welfare is currently still in its infancy. QALYs and DALYs appear to be most established as a basis for monetisation, with parameterised studies by two different groups of researchers. A major disadvantage of monetisation based on QALYs and DALYs is that the approach is rather anthropocentric (Stawasz 2020), currently simply discounting human willingness to pay with the neuron counts of different species. A promising and less anthropocentric alternative is the combination of feed prices with animals' preferences, but this has not been tested in parameterised examples yet. The international poverty line as a basis is currently rather arbitrary, as Kuruc and McFadden (2023b) note themselves. The monetary values in the literature differ considerably (Table 1), reflecting the disparities in the underlying normative assumptions.

When monetisation is carried out, the assumptions on utility of money should be reported. Currently, these assumptions often remain implicit so that the process of discounting animals is not entirely transparent.

For some steps in non-anthropocentric CBA and SWF, a limited number of public surveys are available in the literature. These surveys give insights into normative standpoints among the public but the scope of the surveys is currently limited, and some methodological challenges remain.

In view of the manifold options to carry out non-anthropocentric CBA or SWF, we endorse the use of sensitivity analyses to explore the impacts of different assumptions, like others have also suggested (e.g., Budolfson et al. 2024; Budolfson et al. 2023; Stawasz 2020).

Finally, while we see the potential merits of assessing impacts on humans and animals on the same scale, making these methods fit for practical application – given the current controversies – should not hold up progress in animal welfare policymaking. Using the (limited) available data to describe the benefits of animal welfare policies in words or in quantitative non-monetary units, as already practiced in intangible CBA (see section 1.1), can also provide a reasonable basis for decisions.

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Appendix

Table A1 Assumptions of key studies on non-anthropocentric CBA and SWF

	Concept of welfare	Welfare capacity	Normalisation	Indicators	Scale	Weights	Aggregation	Population size	Human altruism	Unit for aggregation	Utility of money	Monetisation	Parameterised
Blackorby and Donaldson (1992)	–	–	–	Utility from feed consumption	Positive, neutral, negative	Possible, not further specified	Critical level utilitarianism	Impersonal view, comparison with non-existence, above critical threshold: logic of the ladder	Not included	Not specified	Same	Compatible with market price of feed	No
Browning (2023)	Hedonism	Different or equal	Possible	Not specified	Not specified	Ethical possible	–	–	–	–	–	–	No
Bruers (2022)	–	–	–	–	Positive, neutral, negative	–	Neutral-range utilitarianism, variable critical-level utilitarianism, minimax net-complaint theory	Person-affecting view	–	Not specified	–	–	No
Budolfson et al. (2024)	Hedonism or preferentialism	Different	Yes	–	Positive and negative, no remark on neutral values	Empirical and ethical	Not specified, general framework compatible with e.g., total utilitarianism, critical-level utilitarianism, prioritarianism	Not specified	Not included	QALY or money	Different	Value of human QALY	No
Budolfson and Spears (2020)	–	Different	–	–	–	Empirical	Total utilitarianism	Impersonal view, comparison with non-existence, logic of the ladder	–	Not specified	Different	–	No
Eichner and Runkel (2022)	–	–	–	Inverse of stocking density approximated by units of land input per animal	Only negative	Ethical	Total utilitarianism	Impersonal view, comparison with non-existence, logic of the ladder	Optional: Pure altruism (combination of homo oeconomicus and homo kantianensis) with weight	–	–	Compatible with land prices	No
Espinosa (2023)	Hedonism	Different	Yes	Five Freedom violations	Positive, neutral, negative	Empirical and ethical	Total utilitarianism	Impersonal view, comparison with non-existence, logic of the ladder	Altruism (unspecified) with weight	Money	Different	Value of human QALY	Yes
Espinosa and Treich (2024c)	–	Different	Yes	Five Freedom violations	Positive, neutral, negative	Empirical and ethical	Total, average, critical-level, number-dampened utilitarianism, prioritarianism	Impersonal view, comparison with non-existence, logic of the ladder	Optional: Pure altruism with weight	Money	Different	Value of human QALY	Yes
Espinosa and Treich (2024b)	“hybrid approach mixing the hedonistic and objective list approach” (Espinosa and	Different	Yes	Five Freedom violations	Positive, neutral, negative	Empirical and ethical	Total utilitarianism	Impersonal view, comparison with non-existence, logic of the ladder	Not included	Money	Different	Value of human QALY	Yes

	Concept of welfare	Welfare capacity	Normalisation	Indicators	Scale	Weights	Aggregation	Population size	Human altruism	Unit for aggregation	Utility of money	Monetisation	Parameterised
	Treich 2024b, p.19) ¹⁷												
Faria (2014)	–	–	–	–	–	–	Prioritarianism, egalitarianism	–	–	–	–	–	No
Fischer (2023)	Hedonism	Different	Possible	–	Positive, neutral, negative	Empirical	–	–	–	DALY	–	–	Yes
Fleurbaey and Leppanen (2021)	Objective-good with preference-based weights	Different or equal	No (monotonicity principle, preference principle)	Not specified	–	–	–	–	–	–	–	–	No
Gaffney et al. (2023)	Hedonism	Different or equal	Yes, but comparison based on absolute levels	Not specified	Positive, neutral, negative	–	–	–	–	–	–	–	No
Horta (2016)	Hedonism	Not specified	–	–	Positive and negative, no remark on neutral values	Empirical	Prioritarianism, Egalitarianism	–	–	–	–	–	No
Johansson-Stenman (2018)	–	–	–	–	–	Weights in general	Total utilitarianism	Impersonal view, comparison with non-existence, logic of the ladder	Optional: Pure and impure altruism with weight	Money	Same	–	No
Kuruc and McFadden (2023b)	Hedonism	Not specified (equal treatment of equivalent experiences)	–	None	Positive, neutral, negative possible but focus on negative	Ethical	Total, critical-level utilitarianism	Impersonal view, comparison with non-existence, above critical threshold: logic of the ladder	–	Utils or money	Different	International poverty line (\$1.90/day)	Yes
Lusk and Norwood (2012)	Preferentialism	Not specified (but different marginal utility of money)	–	Willingness to turn down feed	Not specified	Ethical	Total utilitarianism	–	Optional: Pure altruism with weight	Money	Different (but framework also compatible with same utility)	Market price of feed	No
Marggraf et al. (2012)	Preferentialism	Not specified (but different marginal utility of money possible)	–	Willingness to turn down feed	Positive, neutral, negative	Weights in general	Total, average, critical-level utilitarianism, Rawlsian SWF	Not specified	Optional: Pure and impure altruism with weight	Money	Same	Market prices of feed or other resources	No
Rusman et al. (2023)	Not specified	Not specified (see marginal utility of money)	–	Number of days on pasture (cattle), stocking density (broilers, laying hens, pigs)	Only non-negative values	Not specified (see marginal utility of money)	Total utilitarianism	–	–	Money	“morally adjusted monetisation factor of a (human) DALY” (p.65)	Value of human DALY	Yes

¹⁷ Although Espinosa and Treich (2024b) describe their approach as 'hybrid', we do not consider this theoretically consistent (see Section 4.1.1). Instead, based on Visak (2022, p.65) we would characterise their approach as hedonism, using resource-based technical indicators to infer hedonic welfare states.

	Concept of welfare	Welfare capacity	Normalisation	Indicators	Scale	Weights	Aggregation	Population size	Human altruism	Unit for aggregation	Utility of money	Monetisation	Parameterised
				Transport time (cattle, broilers, laying hens, pigs)							based on number of cortical neurons		
Visak (2022)	Not specified	Equal (plus review of different)	Not specified	Not specified	Positive, neutral, negative	Not specified	Not specified	Impersonal vs. person-affecting view (review)	–	–	–	–	No
Visak (2011)	Not specified	–	–	–	Positive, neutral, negative	Not specified	Total utilitarianism, prior-existence utilitarianism	Impersonal view and comparison with non-existence vs. person-affecting view (review)	–	–	–	–	No
Zuber et al. (2022)	–	–	–	–	Positive, neutral, negative	Ethical	Additively-separable generalised total utilitarianism, various refinements of axioms and functional forms	Various refinements of axioms and functional forms	–	–	–	–	No

Symbol: – not addressed

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