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ARTICLE

Monetizing Animal Welfare Impacts for Benefit–Cost Analysis

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Abstract

Animal welfare is often ignored in decision-making, despite widespread agreement about its importance. This is partly because of a lack of quantitative methods to assess the impacts of policies on humans and nonhumans alike on a common scale. At the same time, recent work in economics, philosophy, and animal welfare science has made progress on the fundamental theoretical challenge of estimating the well-being potential of different species on a single scale. By combining these estimates of each species' well-being potential with assessments of how various policies impact the quality of life for these species, along with the number of animals affected, we can arrive at a framework for estimating the impact of policies on animal health and well-being. This framework allows for a quantifiable comparison between policies affecting humans and animals. For instance, it enables us to compare human QALYs to animal QALYs tailored to specific species. Hence, the intrinsic value of animal welfare impacts of policies can be monetized on the same scale as market and non-market impact for humans, facilitating benefit–cost analysis. Many challenges remain though, including issues of population ethics, political feasibility, and new complexities in addressing equity and uncertainty.

1. Introduction

Benefit–cost analysis (BCA) requires aggregating diverse consequences to make overall assessments about the net impacts of public actions. To compare costs and benefits across various situations, economists usually use money as a numeraire and have thus developed methods to monetize the value of non-market goods, such as impacts on human health and the environment. For many such goods, there are now established methods for their monetization.

Animal welfare, for example, has been monetized via familiar means for determining people's willingness-to-pay (WTP) for improvements to animal welfare – for example, the additional amount that consumers are willing to spend on cage-free eggs versus conventional eggs (e.g., Norwood & Lusk, 2011; Hsiung & Sunstein, 2007) or to save their pet (Carlson *et al.,* 2019).

However, it is not clear that humans' WTP provides the optimal and exclusive method for valuing animal welfare. "Animal welfare" does not refer to something that humans alone value. Animals, like humans, care about how well off they are, making efforts to improve their welfare and avoid negative welfare impacts. Therefore, while assessing humans' WTP for animal welfare may capture some of its value, allowing the welfare of animals to appear in the full accounting of a public action's consequences, it does not clearly capture all its value, as it overlooks the intrinsic value and disvalue of positive and negative welfare impacts to the animals themselves.

To appreciate this point, consider that anthropocentric WTP methods miss (i) welfare impacts where humans are mistaken about what is good and bad for animals, (ii) welfare benefits for which people are not willing to pay, and (iii) negative welfare impacts that people prefer, all things considered.

As an example of welfare impacts where humans are mistaken about what is good and bad for animals, note that humans are often willing to pay extra for products from smaller "family" farms. However, there is good evidence that animal welfare is not uniformly better on smaller farms and is sometimes considerably worse (Robbins *et al.,* 2016), as larger farms often have better systems for monitoring animals and treating diseases and injuries than smaller farms. In such cases, consumer WTP does not express the value of the state in question (Espinosa, 2023).

As an example of a benefit for which people are not willing to pay, consider that the USDA APHIS Wildlife Services program has been working with various partners to distribute oral rabies vaccination to wildlife in certain areas. This is done to protect human health, pets and livestock, and on the basis of these benefits alone, most economic assessments indicate that oral rabies vaccination programs can yield cost savings (Sterner *et al.,* 2009). However, none of these assessments incorporate the benefits to the wild animals that are vaccinated from rabies, even though those vaccinations spare foxes, coyotes, raccoons, and other animals from contracting a disease that seriously reduces welfare. These benefits are excluded because no one is paying for these programs to benefit wild animals: it is a foreseen but not-valued consequence of the program. Nevertheless, welfare benefits are real. By not counting this benefit, current economic assessments arguably underestimate the value of this policy.

As an example of circumstances where consumers prefer situations involving negative welfare impacts, all things considered, we observe that Americans are consuming much more chicken and much less beef than in the 1970s. Since chicken production emits much less carbon than beef production, this may imply that there has been a per capita reduction in carbon emissions due to shifts in consumer preferences. However, any comprehensive assessment of the value of this shift ought to incorporate the change in the total number of animals produced (as chickens are much smaller than cattle, so it takes many more of them to produce the same quantity of meat) and the welfare impacts on those animals (which is a concern here because chickens arguably have lower average welfare than beef cattle; Norwood & Lusk, 2011). By excluding animal welfare, an economic assessment misses factors that may overestimate the value of this change, where human preferences are satisfied but animal welfare is worse on the net.

It is important, therefore, to find ways to express the intrinsic value of animal welfare in monetary terms.[1] However, there are challenges to integrating the intrinsic value of animal welfare into BCA. Consider, for instance, that while there are quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs) and standard methods of monetizing them for BCA (Robinson *et al.,* 2021), there are no widely agreed-upon *animal* QALYs (AQALYs) and DALYs – and, as importantly, no widely accepted methods for converting between human QALYs and AQALYs (i.e., there is no common scale for translating from the one to the other). So, while it is possible to express some number of QALYs in dollars, it is not currently possible to express some number of AQALYs in dollars. However, if such tools were available, animal welfare impacts could be expressed in the same currency as human welfare impacts, environmental impacts, and economic impacts. This would allow for the straightforward expression of the true benefit or cost of a particular policy or practice, facilitating comprehensive assessments of the consequences of public actions.

Fortunately, just as methods have emerged to estimate the intrinsic value of environmental goods (McShane, 2018), methods are now emerging to estimate the intrinsic value of animal welfare, with recent work in economics, philosophy, and animal welfare science suggesting promising paths forward (Budolfson *et al.,* 2023; Fischer *et al.,* 2024; Kuruc & McFadden, 2023; Espinosa, 2023; Espinosa & Treich, 2023a; Budolfson & Spears, 2019). If the relevant methodological problems can be addressed, then one important barrier to including animal welfare in decision-making could fall. Therefore, while some existing studies have underscored the importance of integrating animal welfare into BCA (Norwood & Lusk, 2011; Stawasz, 2020; Leitzel & Shaikh, 2021; Espinosa, 2023; Sunstein, 2024), this paper builds on these recent emerging methods to explain one way that this integration can be accomplished. At the same time, it highlights some complexities and choice points associated with any such integration.

In Section 3, we highlight one method of monetizing animal welfare as a proof of concept, while also noting the availability of alternative types of approaches, and pros and cons of each. The method we feature in Section 3 is a method of extending existing methods for monetizing human QALY impacts. The key additions are two conceptual innovations: first, a method for generating AQALYs from traditional welfare assessment tools in animal welfare science; second, a method for converting AQALYs into human QALYs. With these tools in hand, it becomes possible to express the intrinsic value of animal welfare impacts in monetary terms.

Accordingly, the goal of this paper is to outline a research program that is analogous to early efforts to monetize human health impacts and non-market environmental impacts. This paper explains why it is important to monetize animal welfare, surveys some possible methods for achieving this end, explores one illustrative methodological example in more detail, and, in a concluding step, introduces a "master formula" that amalgamates the diverse

[1] We refer here to the *intrinsic* value of animal welfare as the importance of animal welfare for the animal itself. It is a value that animals have as individuals, not as instances of species or as dimensions of biodiversity. These other dimensions of value may be significant, but they are distinct. Moreover, it is akin to the value that human individuals have in that it is not conferred by other humans. It is therefore different from the use values that humans can derive from animals (e.g., meat, labor) or the non-use existence values that humans hold regarding animals (e.g., satisfaction from knowing that polar bears exist). It corresponds to the value of the welfare of the animal even if humans do not benefit from, do not think that they will benefit from, and do not care about the existence of the animal. See Bateman *et al.* (2011).

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components expounded earlier (Section 5). At the same time, and like those earlier, successful research programs, feasible methods face challenges and have limitations that should be clearly acknowledged. We highlight those challenges and limitations as we proceed and in Section 4, and suggest strategies for managing them.

2. Why monetize the intrinsic value of animal welfare?

Monetization is important because, in a world of limited resources, decision-makers face difficult tradeoffs. To avoid arbitrariness, decisions about those tradeoffs require evaluating the benefits and costs on a common scale. While other options may be available, money is the traditional scale for such purposes. Given the importance of monetization, there are two broad reasons why it is important to monetize the intrinsic value of animal welfare. First, there are powerful theoretical arguments that favor accounting for the intrinsic value of animal welfare and not just its value to humans. Second, *not* incorporating the intrinsic value of animal welfare appears to be inconsistent with standard economic assumptions.

2.1. Theoretical considerations regarding welfare

Animals experience welfare, even if their welfare can be different in important ways from human welfare. From the perspective of the theory of welfare, it is indefensible to assume that animal welfare only matters insofar as humans are willing to pay for it. If we consider that the social planner's objective is to consider either (a) all preferences or (b) all the positive and negative valenced states that individuals experience (depending on whether welfare is understood in terms of preferences or in terms of hedonic states), then both humans' and animals' welfare should matter directly. Given this, animal welfare is intrinsically valuable, implying that methods are needed such as those outlined in this paper for valuing animal welfare intrinsically. As one among many examples of arguments for the view that animal welfare matters intrinsically, consider the argument from species overlap (Horta 2014). In brief, it is very difficult to identify any trait that would explain why all human welfare has intrinsic worth, whereas animal welfare does not. There are, of course, many features that may explain why human welfare matters *more* than animal welfare, but that is not the issue at hand here. Instead, the question is whether there is any trait that could explain why, say, a dog's being in pain only matters insofar as a human cares about it, whereas that does *not* appear to be true for a human's being in pain. In particular, it is implausible that humans' WTP to avoid pain is the crucial trait, as, first, many humans have no WTP (infants, those with severe cognitive disabilities, people in comas etc.) and for any extended sense of "WTP," such as being willing to work to avoid pain, animals have WTP in that sense. Therefore, it seems like a mere prejudice – often called "speciesism" – to insist that human welfare matters intrinsically and animal welfare does not (see also Singer, 2023; Espinosa & Treich, 2023b; Blackorby *et al.,* 2005; Singer, 1975).

2.2. Internal consistency within economics, policy and benefit–cost frameworks

Second, apart from the concerns just listed, a fully anthropocentric position is dubious from within the logic of mainstream economics and policy. One way to appreciate this point is to recognize that many animals have preferences over outcomes, and there is nothing within

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economics that explains why the preferences of this subset of individuals should be ignored, just as there was never an economic logic to ignoring the preferences of people in an earlier time based on their race, gender, or other factors. (The same point applies if welfare is understood in terms of hedonic states.)

It may be tempting to argue that animals lack some feature that is necessary for having welfare in the sense that is relevant to economic analyses. For instance, someone might argue that animals have zero WTP – or cannot even entertain the question of their WTP – and so are not market agents. Therefore, one might conclude that animals do not meet an essential condition for having welfare. However, neither condition is relevant to having welfare. Just as analyses should include the health and well-being impacts to individual Americans who happen to have zero WTP (e.g., if they do not earn wage incomes at any point during their life), so too the health and well-being impacts to animals must also be included. Likewise, the needs of those with limited cognitive abilities cannot be dismissed simply on the grounds that those individuals are not market agents. In cost–benefit analyses, monetary units are only one of the possible numeraires that economists take for interpersonal welfare comparisons. While economists often use changes in WTP to assess changes in welfare, their primary objective is to assess changes in *welfare*, which both humans and animals experience. So, the well-being impact of our actions on animals should be monetized in a way that incentivizes us to respect the actual well-being value of harm to animals (Budolfson, 2023).

3. How might the non-anthropocentric/intrinsic value of animal welfare be monetized?

The aim of this section is to outline an emerging approach to monetize the non-anthropocentric/intrinsic value of animal welfare. This particular example extends existing methods for monetizing human QALY impacts (Robinson *et al.,* 2021).[2] The key additions are two conceptual innovations: first, a method for generating AQALYs from traditional welfare assessment tools in animal welfare science (Espinosa, 2023; Espinosa & Treich, 2023a); second, a method for converting AQALYs into human QALYs (Budolfson & Spears, 2019; Fischer, 2023). With these tools in hand, it becomes possible to express the intrinsic value of animal welfare impacts in monetary terms.

3.1. Animal QALYs

The objective of a QALY is to express two important dimensions of welfare with a single unit: namely, the quality and quantity of life. In the QALY framework, losing one QALY can be seen either as losing 1 year of perfect health or losing half of the maximum quality of life over 2 years, allowing for the straightforward conversion of one kind of welfare impact into the other. An AQALY has the same objective and provides the same expressive power. Such a tool is essential because human decisions affect both the quality of animals' lives and the

[2] As summarized by Robinson *et al.* (2021), "analysts typically derive the value per QALY from a VSL estimate. In particular, HHS recommends estimating the value per QALY by dividing its recommended VSL by the expected discounted present value of QALYs remaining for an individual at the mean age of the population studied. As noted earlier, in 2020 dollars at 2020 income levels, the recommended VSL estimate is $11.4 million. The value per QALY derived from this estimate is $580,000 if a 3% discount rate is used and $970,000 if a 7 % discount rate is used."

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total amount of life lived. For example, if chickens are bred to grow more slowly, they have lower incidences of keel bone fractures than conventional chickens (which are bred to reach slaughter weight very rapidly). However, precisely by virtue of being (relatively) slow-growing, such chickens spend more time in intensive rearing facilities. So, if a policymaker decides to incentivize rearing slow-growth chickens, it will improve some aspects of welfare, but it may set back other aspects of welfare and will alter the lengths of animals' lives. To express the total welfare impact of this policy change, therefore, we need to combine changes in the quality and quantity of life.

For example, QALY scores are in some cases based on surveys that employ a time tradeoff method. For instance, to assess the impact of a broken femur in terms of some quantity of life, respondents are asked when they would be indifferent between having a broken femur and sacrificing some amount of life at full health. If respondents would, on average, sacrifice 3 months of life to avoid this injury – 25% of a year – then, over the course of a year, the welfare of an individual with such an injury could be represented by 0.75 QALYs.

Animals, of course, cannot report the tradeoffs they would accept, which means that AQALYs cannot be computed via the same methodology. It is, therefore, a significant challenge to analyze animal welfare in a framework that is precise enough to make it implementable over a large set of situations but that is encompassing enough such as to take into account the specificities of different species. One first step is to adapt traditional animal welfare assessment frameworks. Espinosa (2023), for instance, demonstrates how the Five Freedoms framework – which is one of the most widely used models of animal welfare worldwide and is recognized by the World Organisation for Animal Health – can be used for this purpose. The Five Freedoms framework evaluates animal welfare along five dimensions: (i) freedom from hunger/thirst/malnutrition, (ii) freedom from fear/distress, (iii) freedom from physical discomfort, (iv) freedom from pain/injury/disease and (v) freedom to express normal patterns of behavior. Espinosa (2023) defines a scale of animal welfare that accounts for the number of violation points for each of these freedoms. Then, Espinosa and Treich (2023a) integrate the instantaneous welfare over the animal's lifetime on this scale to define AQALY scores for animals.

It would be possible to define similar AQALY scores using other animal welfare tools, such as Alonso and Schuck-Paim's (2021) pain-track method, which distinguishes four categories of animal pain and observable symptoms of their presence. With such a tool, it is possible to quantify the amount of time that animals spend in pain, to define tradeoff relationships between pain categories and then to define corresponding AQALY scores.

However, while widely used and historically significant, the Five Freedoms framework has some well-known limitations, the most frequently noted of which is that it limits attention to negative welfare states to the exclusion of positive welfare states. That is, the best welfare state that the framework acknowledges is one without the violation of any of the freedoms, which could still be a state that is far worse than the best welfare state available to the animal in question. The same problem afflicts the pain-track method, which focuses even more narrowly on pain, even to the exclusion of all other negative affective states. This particular limitation is usually understood as a reason to use the so-called Five Domains framework (Mellor & Reid, 1994) or the Welfare Quality framework (Blokhuis, 2008), the details of which are not important here, but both of which remedy this particular issue. The methods that Espinosa (2023) develop, however, can readily be adapted to such alternative welfare frameworks.

An attractive feature of the AQALY approach is that it allows researchers to explore welfare states that are considered worse than death (Weinstein *et al.,* 2009). As Espinosa and Treich (2021) show, many people believe that the lives of some animals in intensive production systems are not worth living. As a result, preventing those animals from coming into existence may improve social welfare overall. Policies that affect both the number and the quality of lives are difficult to discuss as they imply non-trivial tradeoffs discussed in population ethics (see Section 4.1). However, quantifying the welfare of animals on both positive and negative sides of a welfare scale can provide estimates that can be used to make these tradeoffs explicit.

Finally, a limitation is that this proposed AQALY framework attempts to measure animal welfare, encompassing aspects beyond health alone. Consequently, it is not entirely analogous to the QALY framework and rests on distinct foundations. In particular, QALYs are a health measure, not a welfare measure and health is just one component of welfare (i.e., it is possible to be at full health without being at full welfare). So, the value of an AQALY for a given species could be more precisely understood as a year of full human welfare adjusted by the welfare potential of that species. However, we have no measures of a year of full human welfare. So, for the sake of producing some estimate of the value of an AQALY (a welfare measure, of which health is one component), the methodology proposed here is to use the value of a QALY (a health measure). Since the value of a year of full human welfare is greater than the value of a QALY, this suggests that we are underestimating the value of an AQALY, that is, providing a conservative estimate. The examples below, which use the monetary equivalent of one QALY to assign monetary equivalents to the welfare of animals measured in AQALYs may therefore be more precisely interpreted as lower-bound estimates.

3.2. Welfare potential

Given AQALYs, the task now is to find a way to convert between AQALYs and (human) QALYs. The conceptual innovation here is to understand the link between these units using *welfare potentials.* An animal's welfare potential is a measure of how good and bad the life of an individual of a given species can be relative to a human; equivalently, it is a measure of the amount of welfare that the animal can generate relative to a human. More concretely, suppose that it is possible to assess a human's welfare on a 0-1 scale, as QALYs purport to do using health as a proxy, and that it is possible to assess an animal's welfare on a 0-1 scale.[3] A welfare potential is an estimate of the relationship between these scales: it is a means for expressing the relationship between, say, a 0.5 on the animal scale and some number on the human scale. Presumably, this variable will vary considerably by species based on their respective cognitive capacities, understood broadly to include, among other things, their affective and social abilities. Perhaps a 0.5 on a chimpanzee scale is within an order of magnitude of the same value on a human scale – that is, at least 0.05. However, perhaps a 0.5 on a gecko's scale is orders of magnitude lower – say, 0.00005.

Broadly, there are two methods that have been proposed for estimating welfare potentials. The first is an adaptation of the time tradeoff methodology that is used to estimate the impact

[3] This amounts to assuming interpersonal comparability, which is theoretically significant; moreover, it is normatively significant insofar it assumes that the 0 point (death) has the same value for all individuals.

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of various diseases on human health. In the health context, this involves surveying individuals to determine when they are indifferent between some amount of time with a health burden and living some number of years fewer than they otherwise would (Lugnér & Krabbe, 2020). In the present context, extending this method to animals would involve surveying people to determine when they are indifferent between an additional year of healthy human life and some number of years as an animal of a given species (Bruers, 2023). If people judge that it would take several years of life as a chimpanzee to be worth sacrificing an additional year of healthy human life, then this provides some reason to think that the intrinsic value of chimpanzee experience is lower than that of human experience by a corresponding amount.

There are, of course, challenges associated with this approach. For example, it is difficult to determine how, exactly, to interpret the tradeoffs that people report. For instance, to what degree do humans prefer being human for non-prudential reasons – that is, reasons unrelated to welfare, but due to, say, status quo bias, anthropocentrism or what Franz de Waal (1999) calls "anthropodenial," which is, roughly, the knee-jerk rejection of various cognitive capacities to animals? Since humans have never been pigs, they do not necessarily know how pigs experience the world; as a result, their self-reports may have little evidential value with respect to the intrinsic value of living as a pig versus alternatives.

Likewise, even if respondents limit their attention to prudential considerations, not all of them will be relevant to welfare potential, making it difficult to control for yet more possible confounds. For instance, if respondents are asked how many years of life they would sacrifice to avoid becoming a pig, they might reflect on the risk of swine flu, with the result that the incidence of that disease – and not just welfare potential – would be reflected in their answer.

Likewise, depending on how we interpret the tradeoffs that people report, it may be difficult to convert those tradeoffs into estimates of welfare potential. To continue with the example mentioned above, if it is plausible that status quo bias or "anthropodenial" explains some amount of people's preference to live human over animal lives, then the strength of such biases must be quantified so that the appropriate discount rate can be applied. Otherwise, the time tradeoff method will underestimate the animals' welfare potentials. By contrast, if it is plausible that anthropomorphism explains some amount of people's preference to live animal lives – where humans are mistakenly attributing human-like (and welfare-relevant) traits to animals – then the time tradeoff method will overestimate animals' welfare potentials. It could work out that such a bias is more prevalent for some animals than others; for instance, based on familiarity and affection, people may overestimate dogs' welfare potentials relative to pigs', despite there being few objective differences between these animals' cognitive capacities.

The second methodology bypasses these questions by focusing on proxies that, in one way or another, bear more directly on how well or poorly an animal's life can go. For instance, given the assumption that there is some important relationship between the increased functionality and processing power associated with larger brains and welfare potential, it is possible to define a function from neuron counts in certain brain regions to welfare potential, resulting in a single score per species that can be used to make interspecies welfare comparisons (Budolfson & Spears, 2019). Alternatively, it is possible to incorporate a wide range of neurophysiological, cognitive and behavioral traits into more complex multidimensional proxies that can be aggregated to produce a single

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overall welfare potential score (Fischer, 2024). These approaches parallel the way economists already try to capture complex phenomena by combining several proxies (e.g., assessing human development through proxies like education level, wealth and longevity).

There are predictable challenges here as well. First, proxy selection poses several problems. On a purely theoretical level, there is the difficulty of establishing a relationship between the proxy in question and differences in welfare potentials. Neuron counts, for instance, do not matter in themselves; they are important because they are associated with key intellectual and affective capacities that may bear on welfare potentials. However, the empirical evidence suggests that those capacities do not scale linearly with the total number of neurons that animals possess. So, it is important to specify brain regions and perhaps other proxies that bear closer relationships to the capacities of interest, as discussed in Budolfson and Spears (2019).

On a more practical level, there is the challenge of identifying proxies for which data are available across a sufficiently wide range of decision-relevant species. There is surprisingly little research on many species of clear relevance to decision-makers, as demonstrated by Fischer (2024). This makes it difficult to identify proxies that are both welfare-relevant and sufficiently well-studied to be of use to current decision-makers who need to make interspecies welfare comparisons.

Second, after the hurdle of proxy selection, there is the challenge of proxy aggregation. Again, on a purely theoretical level, there is the difficulty of establishing a relationship between sets of proxies and differences in welfare potentials. Consider a method for estimating welfare potentials that involves a wide range of proxies. The simplest aggregation strategy is additive: take the scores across all the proxies, sum them and divide by the total possible score to produce a welfare potential estimate. However, it could be that some nonlinear relationship between proxies and welfare potential estimates is more appropriate, requiring some more complex function.

Likewise, on a more practical level, there is the challenge of navigating uncertainties about proxy possession. How, if at all, should a proxy aggregation strategy correct for a lack of empirical clarity about whether animals possess certain cognitive traits, such as mental time travel (the capacity to replay past experiences and imagine hypothetical future experiences)? Any proposal will need to navigate this issue.

Though these challenges are hardly insignificant, they are not obviously worse than the ones that prior research programs have faced. In those cases, and presumably in this one, all methods require care in their development, interpretation and use. Moreover, they will often work better in tandem than alone, as agreement between them is one source of evidence that they are tracking genuine differences between the taxa of interest. (Indeed, it may be possible to combine their separate welfare potential estimates – each of which is sensitive to specific assumptions – into composite, "meta" scores that reflect our best "all things considered" judgments given various methodological uncertainties.) Finally, it is important to recall that these methods and others are primarily intended to provide inputs to sensitivity analyses, making it possible to determine whether decisions do, in fact, turn on the uncertainties involved in generating these estimates. In some cases, they will. In other cases, it may turn out that any plausible way of generating welfare potential estimates has the same practical implications, in which case decision-making is simplified.

3.3. A monetization method for animal welfare

Together, AQALYs and welfare potential estimates provide a method for monetizing animal welfare. Again, the method is to extend existing methods for monetizing human QALY impacts, where the key additions are two conceptual innovations: first, a method for generating AQALYs from traditional welfare assessment tools in animal welfare science; second, a method for converting AQALYs into human QALYs. With these tools in hand, it becomes possible to express the intrinsic value of animal welfare impacts in monetary terms.[4]

Suppose, for instance, that the lives of egg-laying hens in small conventional battery cages can be improved by switching to larger cages. If, for instance, the improvement in each hen's life from switching cages would be scored as 0.25 AQALYs, then welfare potentials can be used to convert that improvement into (human) QALYs. Consider one of the simplest welfare potential metrics – cortical neuron counts – where the ratio of the average number of forebrain neurons in a chicken brain to the average number of forebrain neurons in a human brain is taken to represent chickens' welfare potential (i.e., ~61M/~21B; Olkowicz *et al.,* 2016; Herculano-Houzel, 2009). Then, a year of egg-laying hen life in conventional battery cages is equivalent to ~0.0007 (human) QALYs (0.25 AQALYs × 0.0029 welfare potential score, representing the hypothesis that one fully healthy chicken life year = 0.0029 fully healthy human life year). This estimate can then be converted into a currency using standard methods. For example, assuming a human QALY is valued at $580,000, then the implied intrinsic animal welfare value of switching to the larger cages is $420.50 per chicken.

Note that policymakers might also be interested in capturing the heterogeneity in animal welfare within a single species when considering the policies to implement. As for humans, a policy can have heterogeneous effects on individuals because they live in different welfare situations. For instance, forcing farms not to slaughter their broilers before 80 days is beneficial for some animals and detrimental to others. As for QALY scores, animals might experience negative welfare such that additional days at the farm might be detrimental. On the contrary, chickens in some organic farms might experience positive welfare such that a longer lifetime would be associated with a greater lifetime overall utility.

This method could also be used in cost–benefit contexts to compute *break-even points.* Let us consider for instance the case of animal experimentation where a research team is willing to undertake an experiment on primates. If the medicine is successful, the researchers expect this medicine to save about one out of three persons affected by a rare disease. The team expects that X humans would take the medicine per year, which would add three QALYs per person. They consider that their experiment will necessitate 20 chimpanzees to appropriately estimate the medicine's effect size, and they believe that the experiment has ultimately 10% of being successful (i.e., a successful test on chimpanzees and then a successful test on humans). Last, imagine that the welfare of the primates taking part in the experiment would be substantially reduced and worsened by the experiment such that the welfare impact is estimated to be about −8 AQALY for each chimpanzee and that the utility potential of a primate is 0.85. A central question for the ethics committee is to decide whether the experiment is worth running. It must evaluate whether the benefits of running the project

[4] Note that we may also apply the method to the valuation of animal mortality risks, for instance, to explore the BCA of certain hunting practices. However, this extension prompts the question of whether the use of AQALYs would be suitable for valuing mortality risk.

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exceed the costs. The costs are given by: 20 (number of chimpanzees) times 0.85 (utility potential) times −8 (AQALYs per chimpanzee), which is equivalent to 136 human QALYs. The yearly expected benefits are 0.10 (chances of success) × 1/3 (chances of recovery) × X (number of humans that would take the medicine each year) × 3 (number of QALYs gained per cured human), namely 0.1 X human QALYs. Assuming a discount rate of 5%, the expected benefits are 0.1X/0.05 = 2X human QALYs. Thus, the ethics committee could decide to validate the experiment only if 2X > 136, that is, if there are strictly more than 68 humans that would take the medicine per year.

4. Challenges to the project of monetizing the intrinsic value of animal welfare

Despite the importance of monetizing the intrinsic value of animal welfare, any approach to this project faces a number of notable challenges. We review some of the more significant hurdles here.

4.1. Population ethics

Policies that influence animal welfare frequently have impacts on the total number of animals in existence. Consider policies related to meat consumption, animal testing, or biodiversity conservation, for instance – all these policies alter the sizes of different animal populations. Now, let us assume (as we do in this paper) that animals possess intrinsic value. When the number of individuals with intrinsic value varies, we are in a variable population case. In the population ethics literature, it is widely recognized that variable population cases can give rise to difficult moral dilemmas. Common social welfare functions (SWFs) like total utilitarianism have counterintuitive consequences under variable populations, the most famous of which is the so-called "repugnant" conclusion (Blackorby *et al.,* 2005; though see Zuber *et al.,* 2021). (Attempts to avoid such conclusions have their own problems – e.g., the so-called "sadistic" conclusion; see Arrhenius, 2000.)

The foundation of BCA lies in the Kaldor–Hicks principle – namely, the potential Pareto improvement concept. Yet, the Pareto concept typically operates within the framework of a fixed population. Similarly, the QALY or DALY approaches typically consider a fixed population as they do not assess the impact of adding or subtracting lives. More than two decades ago, Broome (2000) wrote: "What is the value of adding a person to the world? I know of no cost–benefit analysis in practice that has taken account of this value." The key point we aim to emphasize here is that integrating animal welfare into policymaking will only make it more important to confront the intricate issue of population ethics in BCA.

4.2. Equity

One of the primary challenges in BCA revolves around addressing equity concerns (Adler, 2012). The consideration of animal welfare introduces new dimensions to these equity issues. In practice, equity is often tackled through the use of equity weights that typically reflect disparities in income. However, considering that animals do not have income, we must adopt a different approach. One possibility is to calculate these weights as a reflection of differences in utilities and using an SWF. Yet, this raises several difficult questions. For instance, what axioms should guide the development of a multispecies SWF (Zuber *et al.,* 2023)? Which attributes should we consider when evaluating utilities? What does "priority for the worse-off" mean when comparing multiple species? How can we appropriately account for instances of negative well-being? The list of open questions in this domain is extensive.

Deeper challenges may even arise when comparing different species (Fleurbaey & Leppanen, 2021). While some animals like elephants and horses live for decades, many bird species live only for a few years. There are even smaller species with extremely brief lifespans. Comparing lifetime welfare, we risk undervaluing these short-lived creatures, which may seem unfair. So, should we normalize lifetime welfare to a species standard? Or should we accept that some kinds of animals can, by virtue of living longer, have better lives than others (Vallentyne, 2005; Kagan, 2019)? There is an additional complication here related to farmed animals, where it is unclear whether the "species standard" should be given by production timelines (i.e., the time to slaughter) or by the natural lifespan. If the former, then many farmed animals are not made worse off simply by having their lives cut short; if the latter, then raising and slaughtering animals for food results in significant losses of AQALYs.

4.3. Uncertainty

Another common challenge within BCA pertains to the treatment of uncertainty. Again, the consideration of animal welfare introduces another layer of complexity here. As highlighted in our earlier discussion, the subject of animal welfare is notably intricate, with numerous uncertainties yet to be resolved. The welfare potentials of many species remain unknown (Fischer, 2024), this is unlikely to change in the short-term, and there will still be high uncertainty about animals' welfare potentials for a long time. Uncertainty also concerns ethical aspects such as determining whether an animal's life is worth living or not. The main challenge here lies in explicitly incorporating this scientific uncertainty into the decision-making process and evaluation practices. For instance, some experts argue for the adoption of the precautionary principle when determining which species possess sentience (Birch, 2017). This seems sensible but, in practice, how can we account for this specific precautionary premium in BCA?

Nevertheless, it is easy to overstate the problem of uncertainty. In many cases, sensitivity tests will reveal that almost most reasonable estimates of the intrinsic value of animal welfare support a particular decision. And while it may not be obvious what range of valuations to use for various understudied species, reasonable extensions can be made from others where better information is available. In the human case, we should recall, high confidence is not required to justify using the outputs of various ways of monetizing health impacts. Instead, what matters is that these outputs are integrated into decision-making in appropriate ways (e.g., as inputs to sensitivity tests) and that the entire decision-making process has democratic legitimacy. If similar standards can be met when quantifying animal welfare, then uncertainties need not be barriers to incorporating intrinsic valuations into BCA.

4.4. Political viability and pure species discounting

The aim of this paper is to encourage research on ways of monetizing the intrinsic value of animal welfare. However, some methods for monetizing the intrinsic value of animal welfare – even if well-motivated and methodologically sound – may suggest that animal welfare is worth far more than the general population previously believed. This could result in cases where BCAs imply that animal welfare should be prioritized over human interests in ways that the public finds uncomfortable. If so, then we face difficult questions about the political prospects for public action based on non-anthropocentric valuations of animal welfare.

There are several points to make here. First, it is possible that many members of the public would be open to more animal-friendly policies than we might initially predict. For instance, a 2015 Gallup survey found that a full third of Americans said that animals should have the same rights as people (with 62% saying that animals deserve "some protection"; Gallup 2015). Surveys from Ladak and Anthis (2022) and Norwood and Murray (2018) showed substantial levels of support among US consumers for banning slaughterhouses (~39–43%); Dullaghan (2022) found less but still significant sympathy for this position (~8–20%). In the United kingdom, about 40% of the citizens hold that animal lives are worth the same as human lives (YouGov, 2021). In France, 95% of the citizens consider that animals have rights (IPSOS, 2020), and 93% of them support increased protection for animals (Harris Interactive, 2021). And perhaps most directly relevant to the question at hand, Johansson-Stenman (2018) conducted a survey that was fairly representative of the Swedish population where over 95% of respondents said that "animal suffering should be taken into account… in public decisions, even when no human beings suffer when knowing that animals suffer."[5]

Of course, even if the present public (in some country or region) is not willing to allow non-anthropocentric valuations of animal welfare to guide public action, that is not necessarily an argument against incorporating those valuations: some domestic BCAs completely ignore the impacts of public actions on the international community, but that is no evidence that those impacts are irrelevant to those BCAs. To the contrary, incorporating those impacts is one way, however modest, of encouraging the population to consider a wider range of consequences.

That being said, it is also possible to incorporate a pure species discounting parameter in BCA that reflects some population's view about the relative value of, say, chicken welfare to human welfare. This would be a simple multiplier that reduces the intrinsic valuation to some lower value (as proposed, essentially, by Kagan, 2019). Still, a pure species discounting parameter on an intrinsic valuation of animal welfare is still importantly different from a straightforwardly anthropocentric valuation approach: the former still allows *some* amount of animal welfare to outweigh human interests, while the latter may involve a function where animal welfare has diminishing marginal value to the point that, in relatively high stakes cases for humans, animal welfare never outweighs human interests. Applying a pure species discounting parameter is, therefore, a possible compromise between an intrinsic and an anthropocentric valuation that may improve political viability in the short run. At the same time, pure species discounting that is calibrated only to political feasibility would not have a fundamental social welfare justification. Instead, it would be motivated only by practical considerations, just as pure time discounting of future human welfare that is calibrated only to the political feasibility of climate change policy does not have a fundamental social welfare justification.

[5] Moreover, these views have been translated into action in some contexts. To give just a few examples, ballot initiatives have led to significant changes in animal welfare standards in several US states. In the EU, several initiatives have been launched over the past few years to improve animal welfare through Citizens' Initiatives (e.g., Fur Free Europe). And in Germany, animal protection has become a constitutional objective since 2002 (art. 20a).

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With this in mind, it may be normatively important to consider ways of incorporating animal welfare into democratic decision-making that more closely reflect its undiscounted value. Some work has already been done in this vein – for example, Zuolo (2020) and Magaña (2023), which represent different views about the relationship between the Rawlsian idea of public reason and animals' interests – but much more is still required.

5. A possible master formula

Overall, economists could use the following type of master formula for the SWF:

$$SWF = \sum_{s=1}^{S} \alpha_s \sum_{i=1}^{N_s} g_s(\phi_s u_{is})$$

where:

- S is the total number of species (including humans) and N_s is the number of individuals in species s,
- α_s represents the pure species (or political) discount factor associated with species s (i.e., what Espinosa and Treich (2021) call the level of antispeciesism, with α_s=1 for all species being antispeciesism and α_s=0 for all species but humans being anthropocentrism),
- ϕ_s represents the welfare potential of species s,
- u_{is} is the "standardized" utility of individual i in species s (i.e., what can be potentially estimated through QALYs and AQALYs; see the discussion above), and
- g_s is a transformation function that can possibly vary across species (with $g_s(u) = u$ being total utilitarianism, $g_s(u) = u - c_s$ being critical-level utilitarianism or $g_s(.) = g(.)$ increasing and concave being prioritarianism (see Zuber *et al.,* 2023).

As suggested by this paper, the calibration of this master formula requires extensive research. Moreover, note that there are tradeoffs in any proposed way of combining QALYs, WTP, BCA, and ultimately the SWF.[6] For instance, our approach to monetizing impacts involves using a WTP per QALY – a decision motivated, in part, by the existence and use of the WTP data per QALY, which makes real-world implementation in BCA possible. It is important to note, however, that a WTP per QALY approach has been critically discussed both in academia and in practice (Bleichrodt & Quiggin, 1999; Pinto-Prades *et al.,* 2009; Hammitt, 2013, 2017; ASPE, 2017; Robinson *et al.,* 2021). Moreover, while this monetization allows us to in turn monetize AQALYs through the welfare potentials, it remains unclear whether this method relying on humans' WTP is fully robust in our non-anthropocentric setting. For example, note that QALYs pertain to health while AQALYs pertain to welfare.[7] So, there may be difficult choices between theoretically optimal approaches and approaches that have political support and/or are supported by sufficiently robust data and method.[8]

[6] Note that adopting an SWF approach inevitably raises the issue of interpersonal comparability of utilities, even within species (Adler, 2019). In addition, we have in mind here an SWF approach where utils would be converted into monetary units.

[7] See the end of Section 3.1 for further discussion.

[8] Such tradeoffs remain even if one sidesteps the monetization step and adopts a cost-efficiency approach by directly using both QALYs and AQALYs to calculate an efficiency score. While theoretically elegant, this makes it difficult to know how to balance any given result with other goods that are often relevant in cases where human and animal interests are in tension, such as environmental benefits.

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We would like to offer a final comment regarding the master formula, specifically regarding parameters α_s and ϕ_s. In some settings, one could possibly merge the two parameters. Here, we clearly distinguish between the two parameters to reflect their different roles in evaluating social welfare. On the one hand, the parameter ϕ_s serves to translate AQALYs into comparable utility points.[9] This parameter may reflect some species' abilities and possibly be estimated empirically (for instance using the number of neurons). On the other hand, the parameter α_s represents the moral concern or political weight assigned to individuals of species. It reflects how much the social planner takes the utility score of the individual into account in their decisions. The distinction between ϕ_s and α_s mirrors Browning's (2023) differentiation between, respectively, the "empirical problem" and the "moral problem" in welfare comparisons between species.

6. Conclusion: Future directions and a growing interdisciplinary research program

Animal welfare is often ignored in decision-making, despite widespread agreement about its importance. This is partly because of a lack of quantitative methods to assess the impacts of policies on humans and nonhumans alike on a common scale. At the same time, recent work in economics, philosophy, and animal welfare science has made progress on the fundamental theoretical challenge of estimating the well-being potential of different species on a single scale. By combining these estimates of each species' well-being potential with assessments of how various policies impact the quality of life for these species, along with the number of animals affected, we can arrive at a framework for estimating the impact of policies on animal health and well-being. This framework allows for a quantifiable comparison between policies affecting humans and animals. For instance, it enables us to compare human QALYs to AQALYs tailored to specific species. Many challenges remain though, including issues of population ethics, political feasibility, and new complexities in addressing equity and uncertainty.

In sum, methods are emerging for monetizing the intrinsic value of animal welfare impacts on the same scale as the market and non-market impact for humans, facilitating BCA. The results have important theoretical implications for BCA, especially from the perspective of non-anthropocentric utilitarianism, and frameworks such as planetary health and OneHealth. The results also have important practical implications for policy analyses, including analyses of pro-social investments of time and money, sustainable intensification of agriculture that aims to take animal welfare into account (producing more food while reducing the overall impacts of agriculture) (Garnett *et al.* (2013)), optimal diets (Budolfson, 2015), climate change policy (Hsiung & Sunstein, 2007), wilderness protection policy, and other challenges related to market failures and resource management. In all of these cases, if the well-being of animals is taken more fully into account, then decisions by individuals and governments will become better on utilitarian grounds and more compassionate toward the plight of animals.

Last but not least, let us note that we discussed here exclusively what could be done should we decide to value animal welfare in our societies. How to get these numbers to really

[9] We interpret this parameter as a welfare potential, but note that this could also be understood in other ways. For instance, given the view that moral standing is grounded in agency rather than sentience, s could be interpreted as an *agency* potential.

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affect decision-making is beyond the scope of this paper but is a crucial question for these theoretical discussions to turn into reality. Because animals do not participate in the political process directly or indirectly (e.g., they do not have an *ombudsperson*), it is difficult to make their interest count when political decisions are taken. On the contrary, human beings who benefit from animal use are likely to lobby or put political pressure to prevent any policy change. Ultimately, an inclusion of the *intrinsic* value of animal welfare is likely to depend on the *altruistic* concerns for animals. Importantly, the consideration of animal welfare by policymakers is central insofar as standard solutions to solve market failures might not work. For instance, Coasian bargaining might not help compensate externalities imposed on animals as animals are not capable of bargaining or might not be able to compensate others since they are not economic agents in the usual sense (i.e., capable of producing wealth and transferring it). Market-based solutions such as label-based or nudge-based strategies might also be limited by standard economic and behavioral barriers (information constraints, free-riding, impure altruism etc.). In a nutshell, integrating animal welfare directly in cost–benefit analysis might face several obstacles but might be one of the most prominent solutions in the long term to have effective and efficient interventions when animals are involved.

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