

The Reference Class Problem for Credit Valuation in Science

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Abstract: Scholars belong to multiple communities of credit simultaneously.

When these communities disagree about a scholarly achievement's credit assignment, this raises a puzzle for decision and game theoretic models of credit-seeking in science. The reference class problem for credit valuation in science is the problem of determining to which of an agent's communities – which reference class – credit determinations should be indexed for any given act under any given state of nature. I will identify strategies and desiderata for resolving ambiguity in credit valuation due to this problem and explain how pursuing its solution could, ironically, lead to its dissolution.

1. Introduction

Within the scientific community, there is a common understanding that its reward system drives problematic behavior linked to publication patterns, pipeline retention, hypercompetitive scientific cultures, and reproducibility. Conversely, there is also a shared sentiment that, in order to change these cultures and behaviors in ways that would improve science, the scientific community must coordinate across institutions to change how credit is assigned at the level of the individual scientist (Alberts et al. 2014, Nosek et al. 2015, Aalbersberg et al. 2017, National Academies of Sciences 2018, National Science Foundation 2015, Blank et al. 2017). The hope is

that increasing individual researchers' incentives towards increased transparency and openness will improve the integrity, reproducibility, and accuracy of the published record.¹

Analogously, philosophers working in the “credit economy” tradition adopt the working assumption that there is some amount of credit that agents can accrue for different acts under different states of nature. This assumption allows them to use decision and game theoretic tools to model how credit-seeking among individual scientists can give rise to behavior and norms that support or thwart the achievement of community-wide goals. When, in the aggregate, individual credit-seeking cuts against collective ends, their approach can explore how changes to individuals' incentive structures can nudge and redirect individual behavior (Bruner and O'Connor 2017, Rubin and O'Connor 2018, Bright 2017, Heesen 2017, Kitcher 1990, Strevens 2003, Zollman 2018). Different philosophers make different assumptions about the norms by which credit gets allotted – for example, whether credit is best thought of as all-or-nothing (Strevens 2003, Bright 2017, Heesen 2017) or as something that may come in degrees (Bruner and O'Connor 2017, Rubin and O'Connor 2018, Zollman 2018). However, the general approach assumes that there is some precise way to assign credit to different acts under different states of nature – an assumption that allows these philosophers to model credit-seeking behavior and the emergence of scientific norms in formally tractable ways.

But, how much credit gets assigned to any given act under any given state of nature? Just as each of us simultaneously belongs to multiple social categories, each of which is tied to implied social hierarchies (Macrae, Bodenhausen, and Milne 1995, Crenshaw 1989), each

¹ Institutions can also experience incentives that promote or thwart scientific ends (Lee and Moher 2017).

scholar simultaneously belongs to multiple communities of value with implied social hierarchies for assigning credit. To which of an agent's communities – which reference class – should credit determinations be indexed and why?

In this paper, I will use examples from the current context of science's complex and dynamic culture to motivate and illuminate what I will call the *reference class problem for credit valuation in science*. I will identify a few strategies and desiderata for solving ambiguity in credit assignments due to the reference class problem. And, I will say a bit about how developing the resources needed to solve it could ultimately sow the seeds for its own dissolution.

2. The Reference Class Problem for Credit Valuation in Science

The contours of this puzzle about the “coin of recognition” (Merton 1968, 56) become visible when one moves beyond thinking about credit in generic, abstractions of scientific communities towards the heterogeneous communities we find today. I start from this more concrete perspective because prestige requires recognition *by individuals and forums* that are themselves valued by credit-seeking scholars (Zuckerman and Merton 1971, Lee 2013): credit worthiness in science is a function of the individuals and systems designed to assess, allocate, dispute, and enforce it. Although some aspects of Zuckerman and Merton's narrative about the origins of the normative structure of science have been contested by historians (Csiszar 2015, Biagioli 2002), we see the social dynamics Zuckerman and Merton proposed clearly at play in contemporary science. For example, Nature Publishing Group recently found that – for the 18,354 authors in science, engineering, and medicine surveyed – the reputation of a journal is the primary factor driving choices about where to submit their work, where reputation is primarily

determined by the journal's impact factor and its standing "as the place to publish the best research" (Nature Publishing Group 2015).² Factors associated with a journal's ability to archive and disseminate research – things like a journal's time from acceptance to publication, indexing services, or Open Access options – are much less important.³

Within academia, each of us simultaneously belongs to multiple communities of value. The reference class problem arises when these different communities of value disagree about the amount of credit an agent accrues for different acts under different states of nature. Although I take this problem to be general, for the sake of clarity and simplicity in presentation, I will focus my examples on communities that can be described as having a nesting structure: for example, individual scholars belong to specific sub-disciplines, which are nested within disciplines, which are nested within a more general population of scholars. A sub-population that is nested within a population can have a credit sub-culture whose valuations differ from that of the population, whose valuations can differ from that of the super-population. In these cases, changing how

² Note that using journal impact factor to measure an individual article's importance is both old-fashioned and problematic: citation distributions within journals are so skewed that it is statistically improper to infer the impact of an individual article on the basis of the impact factor of the journal in which it is published (San Francisco Declaration on Research Assessment 2013, Hicks and Wouters 2015, Wilsdon et al. 2017, Larivière et al. 2016, Wilsdon et al. 2015).

³ Some decision theorists, especially those working outside of philosophy, may reject or remain agnostic about attributing mental states such as beliefs to agents (Okasha 2016). However, because I understand credit and credit-seeking as sociological phenomena involving status beliefs, I am committed to attributing beliefs to agents.

narrowly or broadly one draws the boundaries of an agent's community of valuation can change the amount of credit assigned to a scholarly accomplishment, just as changing how one gerrymanders the boundaries of a voting district can change its election outcomes. This gives rise to the *reference class problem for credit valuation in science*: to which of the agent's communities – which reference class – should credit valuations be indexed when determining the amount of credit the agent accrues for different acts under different states of nature?

There are many examples across academia where nesting community structures can give rise to paradoxes and pathologies in credit assignments. For example, a scholar's individual sense of what counts as quality work – their individual credit assignments – may deviate from what is endorsed in their sub-discipline's or discipline's status hierarchy (Correll et al. 2017, Centola, Willer, and Macy 2005, Willer, Kuwabara, and Macy 2009). A puzzle that has cachet in a sub-discipline may be of peripheral importance within that discipline: for example, a more accurate technique for measuring how temperature cools with elevation considered critical in mountain meteorology and mountain ecology (Mindner, Mote, and Lundquist 2010) may have less visibility, despite its relevance, to the larger discipline of hydrology (Livneh et al. 2013).⁴ A question, technique, or approach that is thought to have high impact *across* fields may have less prominence *within* each of those fields. For example, consider a hypothetical scenario involving an interdisciplinary project whose authors and content represent a set of non-overlapping

⁴ Indeed, savvy scholars can rebel against their field's disciplinary and sub-disciplinary boundaries to form an "unruly alliance" as a new field, as in the example of solid state physics, which was formed principally to serve the interests of applied physicists by linking their work to related abstract physical research within a new sub-discipline (Martin 2018, 199).

disciplines. Let's imagine that scholars in each of these disciplines prefer purely disciplinary projects over the interdisciplinary project; however, when these scholars' preferences are aggregated, their collective preference is for the interdisciplinary project over any single purely disciplinary project (because they prefer interdisciplinary projects over purely disciplinary projects that originate from outside their own fields). Imagine now that this project gets published in a journal, valued by those disciplines, that seeks papers of interest *across and beyond disciplines* (not just within disciplines) – this is one way to interpret, for example, *Science's* mission to publish papers that “merit recognition by the wider scientific community and general public. . . beyond that provided by specialty journals” (Science).⁵ Which reference class would be most relevant in evaluating the value of the interdisciplinary project (and why)?

There are other ways of dividing scholarly communities into nesting structures that create tensions in credit assignments. The pressures a scholar may feel from the incentive structure impacting her department/school may be slightly different from the incentive structure impacting her university. A coarse but concrete way to see this is to think about the prestige structure reified and reinforced by ranking systems (Espeland and Sauder 2012, 2016, Sauder and Espeland 2006), which transform “the ways professional opportunities are distributed” within organizations (Espeland and Sauder 2016, 7). Imagine that an untenured business school professor with a potentially high impact manuscript needs to burnish her prestige in the eyes of

⁵ Note that, at its inception in 1869, *Nature* also aimed to share scientific advances “of general interest” with working scientists and the general public (Nature 1869); and, as early as 1893, scholars saw *Nature* as a place where they could reach audiences “across increasingly sharp disciplinary boundaries” (Baldwin 2015, 72).

both her dean and her provost, since both will evaluate her tenure case. If her provost is working to gain stature on the Academic Rankings of World Universities [ARWU], the professor should submit her manuscript to *Science* or *Nature*, since the ARWU ranks universities by their publications in these journals (Academic Ranking of World Universities 2018). However, if her dean is trying to gain stature on the *Financial Times* International ranking of MBA programs, she should submit to one of the fifty business, economics, or psychology journals by which the FT ranking system evaluates business school prestige – notably, the journal list does not include *Science* or *Nature* (Ormans 2016). What should the business school professor do?

Finally, credit assignments can vary depending on how long a time window a scholar keeps in view. A coarse but concrete way to think about this is by looking at how metrics for evaluating scholarship change over time. Journal impact factors are becoming less useful measures for evaluating an individual's scholarly contribution: since the advent of the digital age, the most elite journals (including *Science* and *Nature*) are publishing a decreasing percentage of the top cited papers (Larivière, Lozano, and Gingras 2013); the relationship between journal impact factor and paper citations has declined over time (Lozano, Larivière, and Gingras 2012); and, the citation distributions between journals “overlap extensively” (Larivière et al. 2016). The current wisdom is that if quantitative indicators are to be used to evaluate research, it is more useful to use article-level metrics such as citations as well as alternative metrics such as downloads and views (San Francisco Declaration on Research Assessment 2013, Hicks and Wouters 2015, Wilsdon et al. 2017). On the horizon, there are now calls for creating new metrics that can encourage researchers and journals to be transparent and open in their reporting practices (National Academies of Sciences 2018, Wilsdon et al. 2017, Aalbersberg et al. 2017), where the rise of such metrics – as well as the growing meta-research literature that

ranks journals by the replicability (Schimmack 2015) or sample size and statistical power of their published results (Fraleley and Vazire 2014) – makes it possible for a journal’s impact factor and epistemic credibility to come apart (Fang and Casadevall 2011). Analogously, these new metrics, if assigned to individual researchers, may also reveal ways in which traditional markers of prestige (e.g., journal impact factor, citations, institutional rank) and epistemic credibility can also come apart. Other dynamic considerations can also give rise to the reference class problem: for example, the community to which a junior scholar aims their accomplishments (e.g., related to hiring within a disciplinary department or professional school) may be different from the audience they wish to command as a senior scholar.

Decision theorists and game theorists capture the risky nature of individual choices by allowing for uncertainty about which states of the world will come to be; and, when the probabilities attached to different outcomes are understood subjectively, these models permit a kind of subjectivity in estimates of expected credit for different acts. However, I hope the examples throughout this section animate genuine *ambiguity in credit* due to the reference class problem for credit valuation in science.

3. Strategies and Desiderata for Solving the Reference Class Problem

How might decision theorists and game theorists try to solve the reference class problem? One possible approach argues for the “correctness” of using one community rather than another.⁶

⁶ Note that indexing credit valuation to a particular community need not prevent scholars from outside that community from understanding the relative value of that contribution: for example, if one were to adopt the old-fashioned and problematic assumption that an article’s impact can be

For example, it might be tempting to argue that all prestige is discipline-based since many scholarly prizes are distributed for excellence in particular disciplines (e.g., Nobel prize, Fields prize, academic society prizes); and, even when research is funded or published in interdisciplinary contexts, it may be primarily evaluated on the basis of its disciplinary excellence (Lamont 2009, but see Lee et al. 2013). Because this strategy for addressing the reference class problem relies heavily on identifying the “right” community, defending the centrality of the chosen community as opposed to others is critical. For example, some may challenge the idea that disciplines should be the sole arbiter of credit. After all, the awarding of some scientific prizes reach across disciplinary conceptions of excellence (e.g., consider winners of the MacArthur Genius Prize and the psychologists who have won the Nobel Prize in Economics).

Another possible approach creates an algorithm that calculates the credit value of a scholarly contribution by summing the credit valuation of multiple communities. This approach would need to identify exactly how much to weight each community’s valuation – with a rationale for why – since different weightings could lead to different overall credit valuations.⁷

measured by the impact factor of the journal in which it is published, and one recognizes that citation rates vary across disciplines, one could use field-normalized percentiles to understand a paper’s impact in a metric that is legible across fields (Hicks and Wouters 2015).

⁷ On the face of it, this may seem like a form of commensuration because it involves summing values to calculate an overall score (Espeland and Stevens 1998). Note that the process of commensuration requires combining values across *qualitatively* different domains of value. As such, this would only count as commensuration if we moved to a pluralistic account involving

Note that some scholars take this style of approach when trying to measure the relative prestige of journals: in particular, the Eigenfactor score rates journals according to the number of its incoming citations, where the “relative importance” of each incoming citation is contextualized by the frequency with which the citing journal is itself cited (West, Bergstrom, and Bergstrom 2010).

Those who may wish to model the implications of different approaches for solving the reference class problem may try to do so by setting up hypothetical communities that assign community boundaries and credit assignments in *de facto* ways to see what kinds of behaviors and norms emerge. This work could reveal interesting insights into how different ways of gerrymandering intellectual populations – by shifting sub-disciplinary and disciplinary lines, journal scope, and grant agency program areas/panels – could change the kinds of projects and areas that “win.”

However, to solve the underlying *conceptual* problem, one must provide theories of community and credit that address two fundamental but vexing questions. How should one define and gerrymander the boundaries of the relevant communities invoked in the proposed solution? And, how does one determine the amount of credit those communities would assign to different acts under different states of nature? These questions may not be independently answerable. The boundaries of a community may need to be defined in terms of patterns of shared lore among its members about how credit is accrued – shared beliefs that coordinate credit-seeking and enforcement behavior in cases where status beliefs are internalized as norms

summing heterogeneous kinds of credit. For a more straightforward example of commensuration in scientific evaluation, see Lee (2015).

(Merton 1973) and in cases where they are not (Willer, Kuwabara, and Macy 2009, Ridgeway and Correll 2006). Conversely, in recognition that some community members can have more influence than others on the content of reigning status beliefs, a community's credit assignments may need to be defined with some reference to the causal patterns of interaction among specific individuals and clusters of individuals – including status judges who wield “social control through their evaluation of role-performance and their allocation of rewards for that performance” (Zuckerman and Merton 1971, 66). However, answers to these questions should not *exclusively* inform each other. In particular, we must be careful not allow the size of a scholarly population and/or the power of its status judges to fully determine the intellectual value of the questions pursued by any particular partition of the scholarly universe.

4. Conclusion

Scientific credit – the “coin of recognition” (Merton 1968, 56) – is assessed, allocated, disputed, and enforced by many different communities and institutions within science that support and sustain a multiplicity of status hierarchies. This gives rise to what I have called the reference class problem for credit valuation in science. Solving this problem requires developing rich theories of community and credit that are based on fine-grained information about the structure and status systems of complex scholarly networks.

The irony of this assessment is that such investigation towards solving the reference class problem could ultimately sow the seeds for its own dissolution. In particular, such study can render friable a critical assumption for both the reference class problem and for decision theory models: namely, that communities, once defined, assign determinate amounts of monistic credit for different acts under different states of nature – that credit “can vary quantitatively but not

qualitatively” (Anderson 1993, xii).⁸ Contrary to this, recent policy papers call for moving away from narrowly conceived measurements of research excellence towards broader ones that are sensitive to the diversity of research missions among individual researchers, programs, and academic institutions (Hicks and Wouters 2015, Wilsdon et al. 2015). Such work can include community-engaged scholarship that creates, disseminates, and implements knowledge in coordination with the public to identify social interventions, change social practice, and influence policy (Hicks and Wouters 2015, San Francisco Declaration on Research Assessment 2013, Boyer 1990, Escrigas et al. 2014). From the perspective of these efforts, plurality in our notions of scholarly excellence and credit – and differences in valuation and prioritization practices between individuals and communities – may be best conceived, not as a logical problem to solve, but as a starting point for theorizing.

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⁸ Note too that, for formal reasons, the assumption that individual credit assessments could be aggregated into a collective one is questionable given the challenges of combining individual preferences into collective ones (Arrow 1950).

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