The Reference Class Problem for Credit Valuation in Science

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. Solving this problem requires developing rich, mutually-informed theories of community and credit that are sensitive to the structure and status systems of complex, heterogeneous scholarly networks.

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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 replicability. 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, replicability, 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

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

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 (Crenshaw 1989, Macrae, Bodenhausen, and Milne 1995), each 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*. Those familiar with the generality problem for reliabilist epistemologies (Feldman 1985) will recognize some structural commonalities: in both, the valuation of a token case depends on the type to which it is assigned; however, because there is no determinate way to identify how narrowly or broadly those types should be

characterized and because different characterizations lead to different valuations, we are left with indeterminacy in the valuation of token cases. To close, I will identify desiderata, strategies, and challenges for solving ambiguity in credit assignments.

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

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[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.

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 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).[4]

[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).

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 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 – a journal valued by those disciplines – that seeks papers of interest *across and beyond disciplines* (not just within disciplines), akin to the mission statements found at *Science* and *Nature*.[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

[5] *Science's* mission to publish papers that "merit recognition by the wider scientific community and general public. . . beyond that provided by specialty journals" (Science). 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).

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 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 (Ormans 2016), 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*. 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 (Fraley 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 not only reward transparent and open research (Moher et al 2019), but 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 audience to which a junior scholar aims their accomplishments (e.g., related to hiring within a disciplinary department or professional school) may differ 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. Desiderata, Strategies, and Challenges for Solving the Reference Class Problem

How might decision theorists and game theorists try to solve the reference class problem for credit valuation in science? In order 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 in a way that would be normatively and descriptively apt?

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, credit-allotment, and enforcement behavior in cases where status beliefs are internalized as norms and in cases where they are not (Merton 1973, 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 to 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.

Strategies that try to address the reference class problem by tackling one question without reference to the other simply underscore their mutual dependence. For example, let's imagine an approach that begins by arguing for the "correctness" of one community as opposed to others.[6] Justifying and defending the centrality of the chosen community is difficult to do without reference to substantive causal claims about how credit gets allotted. For example, to justify using disciplines as the primary credit-assigning community, it would

[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 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).

make good sense to observe that scholarly prizes are distributed for excellence in particular disciplines (e.g., Nobel prize, Fields prize, academic society prizes) and that judgments about disciplinary excellence drive evaluations of quality and merit even in interdisciplinary contexts (Lamont 2009). However, it is not difficult to see how others could challenge the idea that disciplines should be the sole arbiter of credit: after all, Nobel-Prize winning work can originate and have higher impact in disciplines outside its awarded field (Szell, Ma, and Sinatra 2018); and, evaluations of disciplinary excellence can themselves be driven by evaluations of sub-disciplinary excellence (Lee 2012). However one feels about the claim that we should use disciplines as the ultimate arbiters of prestige, it is clear that its justification and defense should advert to normative and descriptive claims about how credit assignments work.

Likewise, we can see how the justification and defense for particular credit assignments should depend on normative and descriptive claims about community structure. For example, let's imagine a strategy for credit-assignment 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] Some scholars take this style of approach when trying to measure the relative

[7] Note that summing individual credit assessments into a collective one may not be tenable given the challenges of combining individual preferences into collective ones (Arrow 1950).

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). Justifying and defending this strategy requires invoking judgments about how best to demarcate the specific communities whose credit valuations are aggregated – in the case of Eigenfactor, communities are demarcated by individual journals. At a more basic level, note that even credit-assignments derived from a single community requires adverting to claims about how to demarcate that particular partition of the scholarly universe.

Finally, any theory of community and credit must countenance apparent heterogeneity in community and credit types. A number of recent policy papers call for moving towards broader conceptions of research excellence that recognize the diversity of research missions among individual scholars, programs, and academic institutions (Hicks and Wouters 2015, Wilsdon et al. 2015). Some call for valuing researchers whose work

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Note too that, on the face of it, summing values to calculate an overall score may seem like a case of commensuration (Espeland and Stevens 1998). However, 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 summing heterogeneous kinds of credit. For a more straightforward example of commensuration in scientific evaluation, see Lee (2015).

promotes rigorous science by using open practices (i.e., sharing code, materials, and data) and/or by replicating and synthesizing existing research (Moher et al 2019). Others call for recognizing the intellectual value of community-engaged scholarship which 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). Both of these movements cut across disciplinary and sub-disciplinary lines, suggesting heterogeneity in credit-assignments even within intellectual neighborhoods.

Note that any approach to addressing heterogeneity must decide how much it can be tolerated within gerrymandered communities before those communities must be fractured or otherwise redrawn. Too much tolerance and the model becomes descriptively and normatively ungrounded. Too little tolerance and the model's scope is radically decreased: for example, a model capturing an individual agent's personal community and credit functions – or the community and credit functions of an "intersectionally" categorized group of agents[8] – would generalize over a much smaller population than typical models which assume that credit is distributed in the same way, using the same credit function, across a more broadly drawn community of agents.

[8] "Intersectionally" is in scare quotes to mark my metaphorical departure from its standard use (Crenshaw 1989).

Note too that any approach to addressing apparent heterogeneity in community and credit types must be careful about ways that reference class problems can recur. For example, if we embrace pluralism in credit-types by adopting a multi-attribute utility model, where the types of credit are thought to be of qualitatively different types, then we would not know how much credit to assign – this time, to multiple credit types – in cases where different communities assign different amounts for each. If we instead embrace pluralism in credit-types by adopting a multi-attribute utility model, where types are indexed to different ways of gerrymandering communities, then we run into a challenge raised earlier: namely, how to weight the importance of different community-indexed credit types and how to justify the ways in which those community lines have been drawn. In these cases, increased technical sophistication is not sufficient to address the conceptual problem.

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.

Those who simply 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, solving the underlying *conceptual* problem requires developing rich, mutually-informed theories of community and credit that are based on fine-grained information about the structure and status systems of complex, heterogeneous scholarly networks. Richer theories of this sort would help us better understand the scope, descriptive power, and normativity of decision and game theoretic models of credit-seeking in science.

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