Ockham Efficiency Theorem for Stochastic Empirical Methods

Kevin T. Kelly · Conor Mayo-Wilson

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Abstract  Ockham’s razor is the principle that, all other things being equal, scientists ought to prefer simpler theories. In recent years, philosophers have argued that simpler theories make better predictions, possess theoretical virtues like explanatory power, and have other pragmatic virtues like computational tractability. However, such arguments fail to explain how and why a preference for simplicity can help one find true theories in scientific inquiry, unless one already assumes that the truth is simple. One new solution to that problem is the Ockham efficiency theorem (Kelly 2002, Minds Mach 14:485–505, 2004, Philos Sci 74:561–573, 2007a, b, Theor Comp Sci 383:270–289, c, d; Kelly and Glymour 2004), which states that scientists who heed Ockham’s razor retract their opinions less often and sooner than do their non-Ockham competitors. The theorem neglects, however, to consider competitors following random (“mixed”) strategies and in many applications random strategies are known to achieve better worst-case loss than deterministic strategies. In this paper, we describe two ways to extend the result to a very general class of random, empirical strategies. The first extension concerns expected retractions, retraction times, and errors and the second extension concerns retractions in chance, times of retractions in chance, and chances of errors.

Keywords  Ockham’s razor · Simplicity · Problem of induction · Stochastic process · Mixed strategy.
1 Introduction

When confronted by a multitude of competing theories, all of which are compatible with existing evidence, scientists prefer theories that minimize free parameters, causal factors, independent hypotheses, or theoretical entities. Today, that bias toward simpler theories—known popularly as “Ockham’s razor”—is explicitly built into statistical software packages that have become everyday tools for working scientists. But how does Ockham’s razor help one find true theories any better than competing strategies could?1

Some philosophers have argued that simpler theories are more virtuous than complex theories. Simpler theories, they claim, are more explanatory, more easily falsified or tested, more unified, or more syntactically concise.2 However, the scientific theory that truly describes the world might, for all we know in advance, involve multiple, fundamental constants or independent postulates; it might be difficult to test and/or falsify, and it might be “dappled” or lacking in underlying unity [4]. Since the virtuousness of scientific truth is an empirical question, simplicity should be the conclusion of scientific inquiry, rather than its underlying premise [49].

Recently, several philosophers have harnessed mathematical theorems from frequentist statistics and machine learning to argue that simpler theories make more accurate predictions.3 There are three potential shortcomings with such arguments. First, simpler theories can improve predictive accuracy even when it is known that the truth is complex [48]. Thus, one is led to an anti-realist stance according to which the theories recommended by Ockham’s razor should be used as predictive instruments rather than believed as true explanations [14]. Second, the argument depends essentially on randomness in the underlying observations [8], whereas Ockham’s razor seems no less compelling in cases in which the data are discrete and deterministic. Third, the assumed notion of predictive accuracy does not extend to predictions of the effects of novel interventions on the system under study. For example, a regression equation may accurately predict cancer rates from the prevalence of ash-trays but might be extremely inaccurate at predicting the impact on cancer rates of a government ban on ash-trays.4 Scientific realists are unlikely to agree that

1For discussion of the following, critical points, see [25, 26] and [28].
2Nolan [36], and Baker [2, 3] claim that simpler theories are more explanatory. Popper [37] and Mayo and Spanos [34] both claim that simpler theories are more severely testable. Friedman [9] claims unified theories are simpler, and finally, Li and Vitanyi [33] and Simon [46] claim that simpler theories are syntactically more concise.
3See [7, 8, 14], which employ techniques developed in [1], and [11], which employs techniques developed in [48].
4More precisely, in regression and density estimation, the predictive accuracy of the model-selection techniques endorsed by Forster, Sober, Harman, and Kulkarni are evaluated only with respect to the distribution from which the data are sampled. Thus, for example, one can approximate, to arbitrary precision, the joint density of a set of random variables and yet make arbitrarily bad predictions concerning the joint density when one or more variables are manipulated. The objection can be overcome by estimating from experimental data, but such data are often too expensive or unethical to obtain when policy predictions are most vital.