Preregistration and Incentives

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Abstract

Preregistering study designs is broadly supported as improving scientific credibility but criticized for limiting the scope of what can be learned. The paper investigates this tradeoff in a model where a researcher conducts a study and aims to convince an evaluator that the results are worth publishing. When both begin equally informed, the aim to publish is closely aligned with producing informative research, leaving preregistration redundant. When better informed, the researcher can credibly signal confidence by committing to a hypothesis. Thus, whether preregistration should be the norm in a field depends on how critically private information plays in designing studies.

Keywords: preregistration; information acquisition; verifiable disclosure
JEL codes: D82, D83, C90

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1 Introduction

Widespread failure to replicate published findings across the life and social sciences has sparked a movement toward increased openness and transparency in research practices.[1] A primary aim of the movement is to correct the prevailing incentive structure in science seen as rewarding strong, clean, and positive results, often at the expense of credibility.[2] Chief among the proposals is the call for researchers to preregister their study designs in public registries, thereby removing the temptation to depart from best practice after the empirical outcomes become known.[3] Preregistration has gained increasing acceptance (Swanson et al., 2020) and some journals now require it as a condition for publication.[4] Critics of the policy, however, argue that committing to a study design may come with a cost as researchers often gain useful insight as the analysis unfolds, revealing more informative directions to take the study than had previously been considered (Coffman and Niederle, 2015; Olken, 2015).

This paper examines the logic of preregistration in a setting where a researcher performs a study and reports the results to an evaluator who then decides if it has sufficient information content to publish. The researcher chooses how to collect data, which tests to run, and which results to include in the report, all with the goal of being published. Preregistration requires some or all of these choices to be made prior to starting the study.

What a game-theoretic treatment pulls out that has gone largely ignored is the crucial role played by the evaluator of the researcher's work. He is a referee, journal editor, or academic peer and his expectations discipline the researcher's behavior. As a result, preregistration is largely ineffective as a

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[1] For lack of replicability, see Prinz, Schlange and Asadullah (2011); Begley and Ellis (2012); Oswald et al. (2013); Open Science Collaboration (2015); Camerer et al. (2016); Fanelli, Costas and Ioannidis (2017); Leek et al. (2017); Bogdan et al. (2017); Camerer et al. (2018); Klein et al. (2018). Analyses of p-value distributions (Colquhoun, 2014; Krawczyk, 2015; Halsey et al., 2015; Altman and Krzywinski, 2016; Chavalarias et al., 2016; Vasishth et al., 2018; Ioannidis, 2019; Adda, Decker and Ottaviani, 2020; Brodeur, Cook and Heyes, 2020).

[2] See Ioannidis (2005); Simmons, Nelson and Simonsohn (2011); Stephan (2012); John, Loewenstein and Prelec (2012); Nosek, Spies and Motyl (2012); Gelman and Loken (2014); Hardwicke and Ioannidis (2018); Nosek et al. (2015, 2018); Grimes, Bauch and Ioannidis (2018); Heckman and Moktan (2020).

[3] See Ioannidis (2005); Nosek, Spies and Motyl (2012); Nosek et al. (2015, 2018)

[4] Member journals of the International Committee of Medical Journal Editors (ICMJE) have required preregistration of medical trials (aside from phase 1 trails) since 2005 (De Angelis et al., 2004) and the American Economic Review has required preregistration of randomized control trials since 2018.

tool for removing temptation and may indeed inhibit learning. However, if the researcher begins with private information relevant for interpreting the study's results, then preregistration can be used to credibly communicate this to the evaluator. This can work as cheap talk, for instance, indicating which statistically significant testing outcomes have good prior reasons to be taken seriously is more credible before the outcomes are observed. Preregistration can also serve as a costly signal—committing to a confirmatory study to test a single hypothesis can signal the researcher's confidence that it is true.

Section 2 sets up the benchmark model in which information is symmetric between parties; reflecting, for example, when an experimenter performs a clever twist on previous work but does not count herself as better able to predict how it will turn out than others in the field. The first question I ask is how closely aligned are the researcher's and evaluator's preferences over pre-analysis plans in equilibrium (Section 3). As it is the researcher's job to design the study and write the plan, strong misalignment at this stage has the potential to substantially limit the benefit from preregistration. What I find is that the interests of both parties are closely but not precisely aligned, with the researcher's aim to publish being ex ante equivalent to maximizing an increasing function of welfare. Under a broad range of conditions, the researcher is relatively more risk averse and so may preregister a safer study than is best for the evaluator, lending theoretical support to existing scholarship expressing this very concern (Stephan, 2012; Bhattacharya and Packalen, 2020).

An implication of the ex ante alignment is that the researcher cannot on average benefit from misinforming or withholding information from the evaluator. Therefore, as the main benchmark result, if the researcher is not too risk averse and can fully disclose her choices and results, preregistration does not improve welfare (Section 4). Essentially, when not too risk averse, the researcher prefers a (Blackwell) more informative study and so adopts a strategy of full disclosure with or without preregistration. But if all choices and results are to be disclosed, then the researcher would never prohibit a tempting action in the pre-analysis plan, rendering preregistration redundant. What is more, if the researcher is strongly risk averse, then commitment can be harmful if it is used to limit disclosure.

Even without the ability for full disclosure, knowing that the researcher selectively presents the strongest possible report can prove more informative than if her hands are tied by a pre-analysis plan. I illustrate this in a "monotone" environment where research informs a policy decision and research outcomes are ordered whereby higher outcomes provide stronger evidence for adopting the policy. The argument proceeds by demonstrating that if the researcher is tempted to depart from her plan in an equilibrium with preregistration, these departures can be used to construct a new welfare-improving equilibrium without preregistration. At this new equilibrium, the researcher presents the strongest possible report, shedding light on the broader body of evidence. This finding relates to recent work by Di Tillio, Ottaviani and Sørensen (2020) who demonstrate how selective reporting is indeed more informative than being non-selective for a number of common sampling distributions.

The benchmark model is then expanded in Section 5 to allow the researcher to start the game with superior information about the state and data generating process to that of the evaluator. For instance, years of learned experience in a particular country grant a development economist special knowledge about which subgroups are most likely to respond to a policy intervention. Preregistration can now improve welfare by allowing the researcher to convey details that could not be credibly revealed after the study has concluded. The constraints imposed by a restrictive plan, though costly to the researcher, can make it undesirable for other types to deviate and mimic her. For example, a researcher with a high prior on a particular hypothesis commits to only testing and reporting its outcome in a confirmatory study at the expense of conducting an exploratory analysis if the test fails, while a researcher with a low prior on all hypotheses engages in an exploratory study, untethered to a particular hypothesis.

A second departure from the benchmark model considers a less restrictive version of preregistration where pre-analysis plans are *flexible*; they allow the researcher to write down as much detail as desired about the intended study, but the plan has no commitment power. Flexible plans are equivalent to cheap talk messages, and so provide no benefit when both parties begin equally informed. They can offer a benefit when the researcher is better informed and some researcher information types mutually prefer to be distinguished ex ante, but at least one would prefer to mimic the other type for some results ex post. I illustrate when this does and does not help through examples.

Beyond the topic of academic research, the paper is relevant for the broader literature studying information acquisition and verifiable disclosure descending from Milgrom (1981) and Milgrom and Roberts (1986). I depart from previous work by focusing on preregistration and, to a lesser extent, in the way preferences are specified. The literature typically considers an agent who supplies information in hopes of influencing the action taken by a decisionmaker. Here she wants to publish, with no concern for how the information is otherwise acted on. These interests do not necessarily conflict, and the results directly apply to any setting where the decisionmaker takes an action more favorable to the agent whenever he believes the information she has supplied has led to a larger improvement in his own utility.

In the context of clinical trials within the pharmaceutical industry, Di Tillio, Ottaviani and Sørensen (2017) explore the role of a researcher's private information, demonstrating how it can be used to bias the design of a clinical trial, sometimes improving welfare, though generally the effect is ambiguous. Also related is the strand examining hidden testing and the disclosure of evidence, the chief finding being that allowing for the selective reporting of testing outcomes can lead the researcher to collect more evidence and improve the informativeness of the final report (Henry, 2009).[5] Given the focus, this paper abstracts from the costly effort of performing research.

The ability to commit to a study design connects to the literature on information design. The closest in this vein are Perez-Richet (2014) and Hedlund (2017) who look into the role of a privately informed sender. The key differences between this paper and the bulk of that literature are the publication preferences and the restricted set of information structures available in academic research. In fact, as long as the researcher is not too risk averse, if all information structures are available, there is an equilibrium in which the evaluator always learns the state (see Appendix B.2).

Frankel and Kasy (2020) take on the converse problem of what I study by characterizing the socially optimal publication rule. They find that society is best served by avoiding the publication of null results and instead publishing the most "extreme" results, also providing the precise form of the optimal publication

[5]Dynamic variations arrive at similar results (Felgenhauer and Schulte, 2014; Felgenhauer and Loerke, 2017) with Libgober (2020) extending the logic to show that the receiver can also benefit from a third party restricting the sender's transparency in revealing details of the experiment. In contrast to Henry (2009) where hidden testing helps the receiver and harms the sender, Herresthal (2020) finds that when the parties only disagree on the optimal action at intermediate beliefs, both can benefit from hidden testing.

rule for several canonical environments. Their framework serves as an important building block for my model, where the focus here is instead on the strategic behavior of researchers and the benefits to preregistration.

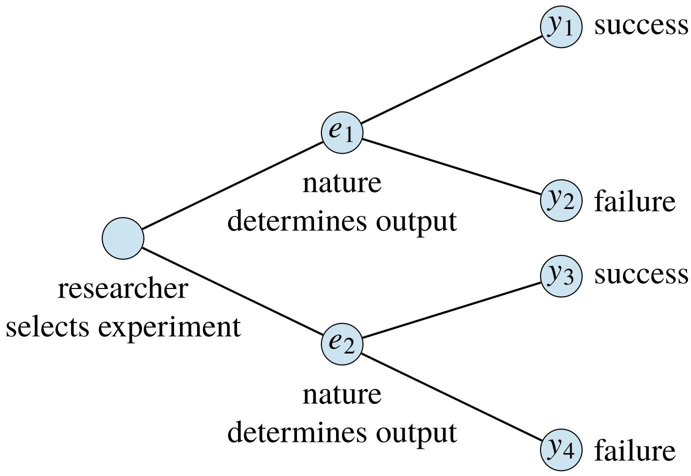
2 The Benchmark Model

This section introduces the model in which a researcher specifies a pre-analysis plan, conducts a study, and reports the results to an evaluator who decides whether or not to publish it for the benefit of a community. In the model, a study requires a number of decisions, reflecting choices like whether to randomly sort subjects into treatment and control groups or to select on characteristics (Di Tillio, Ottaviani and Sørensen, 2017; Banerjee et al., 2017), whether to collect more data after examining the initial observations (Henry and Ottaviani, 2019), which estimators to use (Spiess, 2018), and which results and methodological choices to share in the report. A pre-analysis plan grants commitment power by allowing the researcher to provide verifiable details for how she will proceed, incurring a penalty if the final report fails to verify that the plan was followed.

2.1 Research

The process of conducting a study is represented by a set of decision nodes N arranged in a finite directed rooted tree. At each node, either the researcher acts to collect data and perform tests or nature acts to determine which data realize. Let X denote the set of paths through N from the initial to a terminal node, with a typical element $x \in X$ called an **analysis**. An analysis captures all choices made by the researcher and data acquired over the course of the study. Upon concluding the analysis x, the researcher discloses details about how the study was run and what results were obtained in a **report** $r \subset X$ with $x \in r$. The set of reports R is assumed to be rich enough to describe any analysis $\cup_{r \in R} r = X$.

Prior to the analysis, the researcher provides details of the study in a **pre-analysis plan** $m \subset R$ such that submitting a report $r \in m$ verifies the plan was followed. A plan allows the researcher to commit to a study design or to share certain results, say, if all reports permitted by the plan describe the same experiment or disclose the outcome of a particular test. Naturally, plans may



Example of a study. *The researcher selects an experiment and nature determines the outcome, interpreted as either "success" or "failure." Reporting "success" translates to* $r = \{(e_1, y_1), (e_2, y_3)\}$. *Preregistering the first experiment translates to* $m = \{r_1, r_2\}$ *with* $r_i = \{e_1, y_i\}$ *for* $i = 1, 2$.

only restrict actions available to the researcher and not nature.[6] Denote the set of plans by M and assume it to be non-empty.

Research sheds light on the state of the world $\omega \in \Omega$ by way of the data produced by nature.[7] Let N_0 be the nodes at which nature is called to act and A_n the actions available at node n. Nature determines the state and realized data according to $p_0 \in \Delta(\Omega \times_{n \in N_0} A_n)$ where $\Delta(S)$ denotes the set of Borel probabilities over a set S. For the moment, I assume p_0 to be common knowledge. Later on, I relax this assumption and allow the researcher to start out better informed about the state and data generating process. Let $\mu_0 \in \Delta(\Omega)$ be the corresponding prior over the state.[8]

Example 1 (Hypothesis Testing)**.** *Over the course of this article, I use a simple example of hypothesis testing to illustrate ideas. The researcher collects data according to the unique available experimental design and can be used to examine* K *hypotheses* $\omega \in \{0, 1\}^K$. *Hypotheses can be tested with*

[6] Formally, for all $m \in M$, if $x \in r \in m$ calls nature to act at node n then for every successor node n' there exists another analysis $x' \in r' \in m$ that is equivalent to x up until node n and is followed by n'. Thus, as long as the researcher abides by the plan, the set of available reports at the end of the study is non-empty.

[7] To ensure all distributions are well-defined, assume Ω to be a complete separable metric space and endow $\Delta(\Omega)$ with the topology of weak convergence (see Section 2.2 in Ghosh and Ramamoorthi (2003)).

[8] For all measurable $B \subset \Omega$, $\mu_0(B) \equiv p_0(B \times_{n \in N_0} A_n)$.

possible outcomes $y_k \in \{k \text{ is significant}, k \text{ is not significant}\}$ *with error rates* $\alpha = \Pr(k \text{ is significant}|\omega_k = 0)$ *and* $\beta = \Pr(k \text{ is not significant}|\omega_k = 1)$ *and outcomes independent across hypotheses. The researcher can only effectively convey results for one of these tests. A pre-analysis plan can restrict the hypotheses for which the researcher is permitted to report the testing outcome.*

2.2 Payoffs

There is a community of individuals with an interest in the outcome of the study which may include policymakers whose choices are influenced by basic research, fellow scientists forming their research agendas, and private citizens interested in learning about the world. The community takes an action a from a compact set A with a continuous utility function $u(a, \omega)$. Let $U(a, \mu) \equiv E_\mu u(a, \omega)$ denote the expected utility and $a(\mu)$ a maximizer at belief μ with $a_0 \equiv a(\mu_0)$ the action taken at the prior. For simplicity, the community is assumed to naively fail to update beliefs in the absence of a publication, taking action a_0.[9]

Publishing a report incurs an opportunity cost c, drawn from a distribution G containing $c = 0$ in the support (possibly degenerate at zero), with its realization unknown to the researcher. Let the difference $\widehat{U}(\mu) \equiv U(a(\mu), \mu) - U(a_0, \mu)$ be the *perceived impact* of a report inducing belief μ. If the report verifies the plan was followed $r \in m$, then the evaluator, aiming to maximize community welfare, reads the report and only publishes it if doing so is worth the cost, namely, if its perceived impact exceeds c. If instead $r \notin m$, then the report is automatically rejected from publication.

The researcher's goal is to convince the evaluator that her report delivers a high impact. When sticking to the plan $r \in m$, the researcher's utility is strictly increasing in the perceived impact of the report

$$V = V(\widehat{U}(\mu)).$$

Otherwise, the researcher's utility is $\underline{v} < V(0)$ when departing from the plan $r \notin m$. Thus, departures from the plan are strictly dominated and never occur in

[9]Appendix B.1 explores the case when the community correctly revises beliefs when there is no publication. Equilibria where a_0 is taken in the absence of publication always exist when actions are binary-valued and constitute the sole class of equilibria when there is a large universe of potential topics to study.

equilibrium. Later on I consider *flexible plans* that relax the assumed penalty to departing from a plan.

This abstract formulation of the researcher's preferences allows us to capture a range of considerations. For instance, the researcher's sole aim may be to publish the report, receiving a unit payoff for a publication and no payoff otherwise; in which case, $V(\widehat{U}(\mu)) = G(\widehat{U}(\mu))$ in equilibrium. More broadly, a higher impact report might be published in a more prestigious journal or receive more citations.

2.3 Equilibrium

The solution concept is perfect Bayesian equilibria in mixed strategies. Denote the researcher's mixed strategy by $\sigma \in \Sigma$. Let $\lambda = (\lambda_{mr})_{(m,r)\in M\times R}$ with $\lambda_{mr} \in \Delta(r)$ be the evaluator's beliefs over the analysis conducted conditional on observing the pair (m, r) which, in equilibrium, are consistent with play on the equilibrium path. The evaluator's posterior over the state is assumed to update consistently with his beliefs about play λ, even off the equilibrium path. I often denote an equilibrium simply by the pair (σ, λ) where it is understood that the publication decision and community action are optimal with respect to beliefs.

Proposition 1. *There exists an equilibrium of the research game.*

All proofs withheld from the text can be found in the appendix. Throughout I compare equilibria of this game to those of the game without preregistration, where the researcher bypasses the stage of submitting a pre-analysis plan before running the study. Preregistration is said to improve welfare at an equilibrium (σ, λ) if it provides higher expected welfare than for any in the game without preregistration. Otherwise, preregistration is said to not improve welfare.

2.4 Remark

It is natural to wonder what happens if the evaluator is himself a sophisticated actor, aware of the researcher's strategic play, while the broader community reads reports naively. If the evaluator is a fellow academic serving as referee, then he would know firsthand the publication pressures facing the author of the manuscript, but the general public might not take this into account.

In fact, with a minor extension on the model, the conclusions do not rely on the community's sophistication. Suppose the researcher can give additional interpretation to the results in the form of a cheap talk message and, for simplicity, identify each message with a belief $\hat{\mu} \in \Delta(\Omega)$. Think of this message as the summary of results given in the abstract or conclusion. In an equilibrium where the community takes the message at face value, forming a belief identical to the message, the evaluator publishes the study if and only if the difference $U(a(\hat{\mu}), \mu)) - U(a_0, \mu)$ exceeds the cost. Clearly, the researcher does best to interpret the results consistently with what is disclosed to the evaluator $\hat{\mu} = \mu$.

3 Ex Ante Alignment

Let us first examine how closely related the researcher's and evaluator's preferences are at the moment the pre-analysis plan is written. Integrating over publication costs, the community's (expected) welfare when the report induces belief μ is given by[10]

$$\begin{aligned} W(\mu) &\equiv \int \left[\widehat{U}(\mu) - c\right]^+ \mathrm{d}G(c) + U(a_0, \mu) \\ &= \int_0^{\widehat{U}(\mu)} G(c)\mathrm{d}c + U(a_0, \mu). \end{aligned}$$

Notice, for any researcher strategy σ played against consistent beliefs, the expectation of the second term is independent of the strategy $E_\sigma U(a_0, \mu) = U(a_0, \mu_0)$ where E_σ corresponds to the distribution over the evaluator's posterior μ induced by σ. This means that the welfare index

$$w(\mu) \equiv \int_0^{\widehat{U}(\mu)} G(c)\mathrm{d}c$$

equivalently represents the evaluator's preferences over strategies: $E_{\sigma'} W(\mu) \geq E_\sigma W(\mu)$ if and only if $E_{\sigma'} w(\mu) \geq E_\sigma w(\mu)$. Since $V = V(\widehat{U}(\mu))$ is strictly increasing, the researcher's payoff is equivalently defined as a function of this welfare index $v(w)$, satisfying

$$w = \int_0^{V^{-1}(v)} G(c)\mathrm{d}c \tag{1}$$

[10] Here, $[b]^+ \equiv \max\{b, 0\}$ and the second expression is derived in Appendix A.

so that $v(w)$ is increasing with a curvature depending on the shape of the payoff function V and the cost distribution G. Let $\tilde{E}_\sigma$ correspond to the distribution over w induced by σ.

Proposition 2. *When played against consistent beliefs, (a) the evaluator prefers strategy σ' to σ if and only if $\tilde{E}_{\sigma'} w \geq \tilde{E}_\sigma w$, and (b) the researcher prefers σ' to σ if and only if $\tilde{E}_{\sigma'} v(w) \geq \tilde{E}_\sigma v(w)$.*

Thus, at the time of writing the pre-analysis plan, the researcher's desire for her report to be perceived as impactful is equivalent to wanting to maximize an increasing function of welfare. At the very least, if the distribution of welfare induced by a strategy σ' has first order stochastic dominance over that of another strategy σ, then both the researcher of evaluator agree that σ' is preferable to σ. Still, they may exhibit different risk preferences, with the researcher relatively more risk averse (risk seeking) than the evaluator with respect to w if $v(w)$ is concave (convex).[11]

For the most optimistic case, take $v(w)$ to be affine. For example, this occurs when there are two journals and the chance of publishing in the more prestigious of the two is proportional to the report's perceived impact, but publishing is costless and so guaranteed in at least one of the journals.[12] Here, interests are ex ante precisely aligned since $\tilde{E}_{\sigma'} w \geq \tilde{E}_\sigma w$ if and only if $\tilde{E}_{\sigma'} v(w) \geq \tilde{E}_\sigma v(w)$. When choosing a pre-analysis plan the researcher's decision rule is equivalent to examining the segment of the game stemming from each plan and then selecting one that achieves the highest expected welfare.

The answer changes when turning to the setting in which the researcher's exclusive aim is to publish, in which case $V = G$. Assuming G admits a differentiable density, differentiating (1) finds $v(w)$ to be concave if and only if G is log-concave. This means that under a large and common class of distributions for the cost, the researcher is relatively more risk averse than the evaluator. Drawing on the hypothesis testing example, consider a single binary hypothesis that can be rejected or accepted $a \in \{0, 1\}$ with utility $u(a, \omega) = a(2\omega - 1)$ and a prior $\mu_0(\{\omega = 1\}) = 1/4$ favoring rejection. Figure 1 plots the evaluator and

[11] This corresponds to the classic risk comparison due to Pratt (1964) and Arrow (1965). Of course, $v(w)$ might not be concave nor convex on the entire domain, avoiding a simple risk comparison.

[12] Letting b' and $b < b'$ be the researcher's payoff from a more and less prestigious publication respectively $v(w) = b'w + b(1 - w)$.

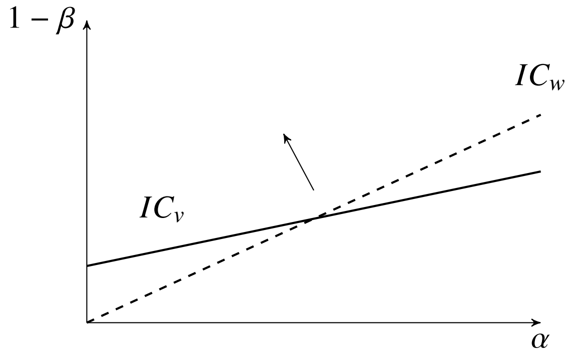


Figure 1: *Indifference curves for the evaluator IC_w and researcher IC_v when trading off power $1-\beta$ and false positive rate α.*

researcher indifference curves when trading off power $(1-\beta)$ and false positive rate α when the publication cost is uniformly distributed between zero and one. To remain indifferent an increase in the false positive rate must be met with an increase in power for both parties; though, the evaluator would require a larger increase in power than would the researcher. For instance, comparing two tests $(\alpha, 1-\beta) = (0.05, 0.8)$ and $(\alpha', 1-\beta') = (0.001, 0.6)$ the evaluator prefers the second test with a positive outcome delivering near certainty that acceptance is optimal. However, the researcher prefers the first test which can be seen as less risky—it is more likely to produce a positive outcome, though a positive outcome delivers a lower posterior.

4 Benchmark Results

This section weighs the benefit of removing temptation against the cost of inhibiting learning posed by preregistration. The main conclusion is that having an evaluator who shares the same information as the researcher at the start of the study generally leads preregistration to be either redundant or harmful. This lays the groundwork for the next section that shows how preregistration can serve a different role in improving welfare.

I begin by establishing two properties describing the function of preregistration in the present context. First of these, if preregistration is useful, then it must indeed serve as an instrument for removing temptation.

Lemma 1. *If preregistration improves welfare at an equilibrium (σ, λ), then the researcher must be tempted to depart from her plan. That is, in the game* *with flexible plans, all $\sigma' \in BR(\lambda)$ depart from the plan $r \notin m$ with positive probability.*

Second, if the researcher uses preregistration to voluntarily remove temptation, then the act must lead the evaluator to interpret reports differently.

Lemma 2. *Suppose σ' is tempting at an equilibrium (σ, λ) and σ'' differs from σ' only in the messages but involves no departures from the plan. Then reports cannot be interpreted identically between the two strategies: $\lambda_{mr} \neq \lambda_{m'r}$ for some $(m, r) \in supp(\sigma')$ and $(m', r) \in supp(\sigma'')$.*

Let us first suppose reports can be *exhaustive*, $\{x\} \in R$ for all $x \in X$, so that the researcher can disclose the choice made at each juncture and all relevant information gleaned over the course of the study. Reasoning through the familiar unraveling argument would suggest that if multiple analyses are described by the same vague report in equilibrium, then all must deliver the same perceived impact if fully disclosed; otherwise, the researcher would deviate and exhaustively report some analysis.[13] However, the pressure to disclose is even stronger in the context of research. Even if two analyses x and x' deliver the same impact when fully disclosed, presenting the vague report $r = \{x, x'\}$ garbles the information from each analysis and so may itself be perceived as less impactful than each individual exhaustive report.

In the absence of preregistration, the strong pressure to disclose provides that the evaluator always achieves the full disclosure payoff, however the study is carried out (see Appendix A.2). In fact, preregistration can be harmful if used to limit disclosure. For example, a plan may commit to only run a single test, removing the ability to perform additional tests for which the outcomes would otherwise be revealed in equilibrium.

Fortunately, this problem does not occur as long as the composition $v(w(\mu))$ is convex in μ so that the researcher *is not too risk averse*. Under this condition, the researcher prefers one strategy over another if it delivers Blackwell more informative reports; hence, she never writes a plan with the intent to limit disclosure. As the inner function $w(\mu)$ is necessarily convex, the outer function $v(w)$ may still be concave and the condition be satisfied. This is true of the

[13]See Milgrom and Roberts (1986) and Milgrom (2008) for the classic explication within the context of a seller disclosing details about product to a buyer.

hypothesis testing example given in the previous section.[14]

This brings us to the first benchmark result, revealing that the researcher does not use preregistration to limit temptation when not too risk averse and able to effectively disclose results. To isolate the effect of preregistration through allowing commitment, not by altering the set of potential study designs, the following allows any plan to be written.[15] The result would be unaffected by weakening this assumption. For example, a plan could be arbitrarily vague $R \in M$ or even precisely specify the exact action taken at each node.

Theorem 1. *If the researcher is not too risk averse, any plan can be written, and reports can be exhaustive, then preregistration does not improve welfare.*

When not too risk averse, the researcher prefers to write a plan that allows for a more informative study. Using this, for each equilibrium, there is another one in which the researcher performs the same study, submits an exhaustive report, the evaluator skeptically assumes the least impactful analysis of each report, and both parties are better off. From Lemma 1, if preregistration improves welfare at this new equilibrium, then the researcher must experience temptation. As any plan can be written, there is some plan that permits the temptation and is met with skepticism regardless. By Lemma 2, this leads to a contradiction since the researcher would just write the plan to permit the temptation.

In practice, a number of factors may limit how precise a report can be. Articles have finite length and people have limited time to devote to reading them. Simplifying the research environment, the conclusion extends when the information in reports can be combined, even if they cannot be be exhaustive.

Reports are *closed under non-empty intersections* if $r \cap r' \in R$ for any pair $r \in R$ and $r' \in R$ with $r \cap r' \neq \emptyset$. This is a common assumption in the disclosure literature (Ben-Porath, Dekel and Lipman, 2019) and says that if two reports can both verify an analysis, then so can there combination. Also, say that a plan m *does not preclude precision* if $r \subset r' \in m$ implies $r \in m$. Finally a study is *simple* if the researcher only acts at the initial node. A simple study still allows freedom over how to perform the experiment and which results to report, but it

[14] The composition evidently cannot be concave whenever some belief induces a change in action since $v(w(\mu_0)) < E_{\mu_0} v(w(\delta_\omega))$ where δ_ω applies point mass at $\omega \in \Omega$.

[15] That is, any $m \subset R$ satisfying the requirement given in Section 2 that plans can only restrict the researcher's actions.

precludes actions like strategic sampling that involve collecting additional data on the basis of the initial results.

Theorem 2. *If the study is simple, reports are closed under non-empty intersections, and any plan that does not preclude precision can be written, then preregistration does not improve welfare.*

In an equilibrium, the evaluator may be assumed to interpret message-reports pairs lying off the equilibrium path with skepticism. If the researcher writes report r but would be tempted by r' if not for her pre-analysis plan, then $r'' \equiv r \cap r'$ must be non-empty, preferable to r', and previously permitted by the plan. Thus, there can be no temptation at the end of the study when formulating the report. But if the researcher faces no temptation at the end of the study, her preferences at the initial node of the study remain the same.

Limits to disclosure may run deeper still when there is a constraint to how much information can be assimilated by the evaluator. The evaluator may only have the bandwidth to read a paper's main results, but not much more. Such cases would leave the researcher with a genuine choice about how to organize the results, without a uniquely most precise formulation. Constraints on disclosure of this sort provide an opportunity for preregistration to be useful, as the following example illustrates.

Example 2. *Suppose the community faces a problem to which it may respond by doing nothing, adopting a low-tech policy, or adopting a high-tech policy. Doing nothing yields zero payoff for sure and adopting a low-tech policy delivers a low payoff* $\ell < 0$ *with probability* $1 - q$*, a high payoff* $h > 0$ *with probability* q*, and with the low-tech policy preferable to doing nothing ex ante* $(1 - q)\ell + qh > 0$*. The high-tech policy requires expert knowledge as there are arbitrarily many ways to implement it, each with an equal prior chance of being the correct way. The payoff to implementing the high-tech policy incorrectly is arbitrarily low but the payoff to the correct implementation is high* $H > h$*. The researcher conducts a study in which she privately learns the state but only has the budget to effectively test and reveal either the payoff from the low-tech policy or the correct approach to implement the high-tech policy, but not both. Let publication itself be costless.*

Prior to the study, the best bet is to adopt the low-tech policy. Afterward, it is always best for the researcher to reveal how to implement the high-tech *policy and for the community to do so. However, if $H - (1-q)\ell - qh < -\ell$, the researcher would be tempted to reveal the payoff from the low-tech policy when it is harmful ℓ, inducing the community to take no action, but delivering a higher impact report.*[16] *In this case, researcher and evaluator alike would strictly benefit from a pre-analysis plan committing the researcher to reveal the proper way to implement the high-tech policy.*

The example is useful in demonstrating how limits to disclosure can make skepticism insufficient to prevent the researcher from departing from a strategy that is in her own best interest, so that she strictly benefits from having the option to commit herself to a rigid plan. One limitation of the example is that it relies on a tradeoff between supplying useful information and revealing when the default action would have been delivered a low payoff. In the context of research, particularly when testing discrete hypotheses, this tradeoff will be less relevant: The evidence that best supports accepting a hypothesis will typically also best demonstrate the imprudence of not accepting it.

Take the problem of accepting or rejecting a single binary hypothesis ($\omega \in \{0, 1\}$ and $a \in \{0, 1\}$ with $a_0 = 0$) and assume the net expected gain from accepting the hypothesis $U(1, \mu) - U(0, \mu)$ to be increasing in the chance that it is true $\mu(\{\omega = 1\})$. Suppose the plan requires reporting r after concluding an analysis x, but the researcher would otherwise be tempted to report r', even if met with skepticism. Let μ_r denote the equilibrium belief when r is reported. Notice, departing from the plan can only benefit the evaluator since

$$U(1, \mu_{\{x\}}) - U(0, \mu_{\{x\}}) \geq \min_{x' \in r'} U(1, \mu_{\{x'\}}) - U(0, \mu_{\{x'\}}) > U(1, \mu_r) - U(0, \mu_r)$$

That is, the researcher is only tempted when she privately knows that accepting the hypothesis is more strongly suggested by the evidence than would be indicated in her report if she stuck to the plan. More generally, if the environment is sufficiently monotone, desired departures from the plan can be used to construct equilibria that do strictly better than those with preregistration. The following describes a *monotone environment*.

Let $\Omega \subset \mathbb{R}^K$, actions be partially ordered, and utility satisfy increasing differences $u(a', \omega') - u(a, \omega') \geq u(a', \omega) - u(a, \omega)$ for $a' \geq a$ and $\omega' \geq$

[16] Suitable parameter values for this example are $\ell = -1$, $h = 3/2$, $H = 2$, and $q = 9/10$.

ω.[17] This reflects the idea that the community prefers higher actions in higher states. To ensure that the researcher prefers to induce higher actions, assume that $V(\widehat{U}(\mu')) \geq V(\widehat{U}(\mu))$ implies $a(\mu') \geq a(\mu)$ for all beliefs induced by research. This condition is immediately satisfied when the action is binary-valued: If a posterior μ leads to acceptance of the hypothesis then any posterior μ' preferred by the researcher must likewise lead to acceptance.[18] As another example, the community may face the option of adopting a new policy and also must decide to what degree $a \in \mathbb{R}_+$ it will be implemented with the benefit to adoption being $\omega \in \mathbb{R}$, utility taking the form $u(a, \omega) = a\omega - \frac{1}{2}a^2$, and the prior favoring non-adoption $E_{\mu_0}\omega \leq 0$.

There is only one way to conduct the study, but several methods to analyze and report the data. The researcher reports the outcome y^i for one of a finite number of specifications $i = 1, ..., I$ with $y = (y^i)_{i=1}^I$. A specification broadly refers to the modeling decisions that influence how the results are formulated, for instance, choosing the set of regressions to include and determining which estimates to feature most prominently in the write-up. The outcomes of specifications are well ordered and (ω, y) affiliated,[19] with all y realizing with positive probability. The outcome of at most one specification can be effectively reported and the researcher must commit to a specification in the pre-analysis plan.

Proposition 3. *In a monotone environment, for every equilibrium with preregistration there is an equilibrium without preregistration that provides higher welfare, strictly so if the researcher is tempted to depart from her plan and publications are costly.*

When specifications correspond to independent and identically distributed random variables, Di Tillio, Ottaviani and Sørensen (2020) characterize the distributions for which reporting the highest outcome is more informative than committing to a specification in advance. Under these conditions, the researcher is provided a simple strategy that is more information than committing to a

[17]Here, the partial order on the vectors is defined as $\omega' \geq \omega$ if and only if $\omega'_k \geq \omega_k$ for all $k = 1, ..., K$.

[18]It is without loss of generality to assume $a_0 = 0$ when actions are binary-valued. If instead $a_0 = 1$, then define a new partial order $\leq'$ for states and actions that provides the opposite comparisons as $\leq$.

[19]For example, $\omega = (\omega_1, ..., \omega_K)$ could be affiliated hypotheses with each specification providing the testing outcome for one hypothesis, with the outcome of the test satisfying the monotone likelihood ratio property.

specification in advance.

5 Better Informed Researcher

This section explores how a researcher who holds private information relevant to her study design may use preregistration to credibly signal this to the evaluator and improve welfare. The researcher may approach an experiment with a good reason for using one test over another. It is more credible if these reasons are shared at the start, particularly in the event that the test turns out striking results. The researcher might have previously run an informal pilot study, using the opportunity to refine the empirical question and work out kinks in the design. Preregistering the main study at this point can usefully communicate what was learned from the pilot.

At the start of the game, the researcher is now assigned one of a finite number of types $t \in T$ reflecting her private information over nature's strategy $p_t \in \Delta(\Sigma \times_{n \in N_0} A_n)$ with the corresponding prior over the state $\mu_t \in \Delta(\Omega)$.[20] Types are drawn from a known distribution π so that the evaluator's prior over nature's strategy and state are $p_0 = E_\pi p_t$ and $\mu_0 = E_\pi \mu_t$. After observing her type, the game proceeds as in the benchmark model. Also, suppose the researcher can provide additional discussion and interpretation to the results in the form of a cheap talk message z from a countably infinite set Z alongside her final report. Including this message makes clear that whatever benefit is provided by preregistration is due to the fact that communication occurs before the study has begun.

The following result establishes that if preregistration helps in previously considered settings, then it serves as an instrument for achieving separating equilibria. Extending Theorem 1 requires an additional condition be placed on the evaluator's beliefs, allowing the researcher to be more precise in her report without being met with additional skepticism. For all (m, r, z) on the equilibrium path and every $x \in r$, assume there is some message z' so that $\lambda_{mrz}(t, x) = \lambda_{m'\{x\}z'}(t, x)$ for all $t \in T$ where $m' = \{\{x\} : x \in X\}$. Refer to this condition combined with those in Theorem 1 as the conditions in Theorem 1*. For extending Proposition 3, a monotone environment is as described in Section

[20] For all measurable $B \subset \Omega$, $\mu_t(B) \equiv p_t(B \times A_0)$.

4 where all types agree that (ω, y) are affiliated, though they hold distinct beliefs.

Theorem 3. *If the researcher begins better informed than the evaluator with the setting as in (a) Theorem 1*, (b) Theorem 2, or (c) Proposition 3, then a welfare improving equilibrium is not a pooling equilibrium*

This result tells us that if preregistration improves welfare, then it must provide separating equilibria that would otherwise not exist. It can do this in two distinct ways. First, a pre-analysis plan can serve as a cheap talk message. Even if the researcher is never tempted to depart from the plan, in a separating equilibrium, the plan can be used to relay useful information to the evaluator, allowing him to draw more accurate inferences from the results of the study. Second, preregistration can serve as a costly signal of the researcher's beliefs when the researcher would be tempted to depart from her plan. That is, removing flexibility in the study design can make it undesirable for other types who hold different beliefs to mimic her strategy. I now explore both roles in turn.

5.1 Cheap Talk

To isolate the effect of preregistration as cheap talk, suppose pre-analysis plans are flexible, they allow the researcher to provide as much detail as desired about the aims of the study—the central hypothesis, how outcomes will be interpreted—though ultimately, the researcher is free to conduct the study however she wishes with no cost to submitting a report precluded by the plan $r \notin m$.

First, observe that a flexible plan cannot improve welfare when the evaluator is just as informed at the start of the study as the segment of the game following each message is precisely the game with no preregistration. The situation changes when the researcher is initially better informed than the evaluator as a flexible plan may now meaningfully convey details that incorporate the researcher's expertise. Let us now identify the conditions under which flexible plans can improve welfare. For simplicity, the following discussion focuses on pure strategy equilibria.

For any strategy with preregistration, there is a strategy without preregistration that delivers identical information to the evaluator. Intuitively, while the researcher submits her plan before beginning the study, the evaluator would end up with the same information if she were to instead append the plan to her final report. Take (σ, λ) to be an equilibrium with flexible plans and construct an equivalent profile (σ', λ') in the game without preregistration as follows. Let ρ be a bijective mapping $\rho : M \times Z \to Z$ and define σ' to be identical to σ except that $z' = \rho(m, z)$ is submitted whenever (m, z) would have been. Let beliefs λ' satisfy $\lambda'_{r\rho(m,z)} = \lambda_{mrz}$ for all triples (m, r, z) on the equilibrium path and be skeptical otherwise.

Proposition 4. *Suppose there is a pure strategy equilibrium (σ, λ) with flexible plans that delivers higher welfare than any equilibrium without preregistration. Then in such an equilibrium, there must be two types t and t' who submit different plans ($m_t \neq m_{t'}$), but at an equivalent profile without preregistration (σ', λ') one would deviate to mimic the other type (t would submit $z_{t'} \in supp(\sigma_{t'})$) for some but not all results.*

This proposition states that if flexible plans improve welfare, then there must be a pair of types who write distinct pre-analysis plans, but if asked to append the plan to the final report, one would rewrite her plan to match that of the other type after obtaining some but not all results. For flexible plans to help, there must be a temptation for types to mimic each other in their reports, but not so strong a temptation that they mimic each other in their plans. The following example illustrates this. Assume ex ante alignment ($v(w)$ to be affine) in this and subsequent examples.

Example 3 (Hypothesis Testing Continued)**.** *Continuing with the running example, suppose there are K independent binary hypothesis to be accepted or rejected, with it preferable to accept a hypothesis if it is more likely than not to be true: $\omega_k \in \{0, 1\}$ and $a_k \in \{0, 1\}$ for $k = 1, 2, ..., K$ with $u(a, \omega) = \sum_{k=1}^{K} a_k(2\omega_k - 1)$. The researcher approaches the study with a particular hypothesis in mind, to which she assigns high prior, assigning a low prior to all others. The evaluator views each hypothesis as equally likely, holding a uniform prior over K researcher types with beliefs $\mu_H \equiv \Pr(\omega_k = 1|t_k)$ and $\mu_L \equiv \Pr(\omega_k = 1|t_{k'})$ for all $k = 1, ..., K$ and $k' \neq k$. Suppose the evaluator only wishes to accept a hypothesis $a_k = 1$ if it was assigned a high prior and the outcome of the test is significant, that is, $\mu_L < \frac{\alpha}{1-\beta+\alpha} < \mu_H < \frac{1-\alpha}{\beta+1-\alpha}$.*

Assuming $|M| \geq K$, allowing researchers to submit flexible plans achieves the first best outcome. Each type records the most likely hypothesis and then sticks to reporting its outcome. This serves as an equilibrium, if the evaluator *believes that the researcher follows this strategy, it is in the researcher's best interest to honestly indicate the most likely hypothesis in her pre-analysis plan since it is the one with the highest chance of achieving a significant outcome* $\mu_H(1-\beta) + (1-\mu_H)\alpha > \mu_L(1-\beta) + (1-\mu_L)\alpha$. *Without a pre-analysis plan, there is the temptation to report the outcome of the less likely hypothesis when only it turns out significant. Depending on the parameters, this has the effect of either breaking down information transmission altogether or inducing the evaluator to accept hypotheses when it is suboptimal.*

The example highlights the two crucial ingredients for flexible plans to improve welfare. First, at an optimal equilibrium it must be that some types mutually prefer to distinguish themselves ex ante, but at least one would prefer to mimic another after obtaining some results. If instead Example 3 only involved testing a single binary hypothesis for which types either have a high or low prior, low types would not distinguish themselves from high types in their pre-analysis plans. Second, given that the evaluator believes that some types distinguish themselves in their plans, it must be a best response for each of these types to in fact distinguish themselves. In the preceding example, this is achieved by the fact that a more likely hypothesis is also more likely to turn out a significant result.

5.2 Costly Signal

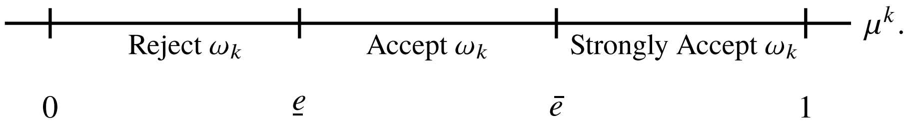
This section presents an illustrative example for how rigid pre-analysis plans can facilitate a welfare-improving separating equilibria.[21] Building on Example 3, suppose now that a researcher may approach the study with a hypothesis in mind as before, but may now also be engaging in pure exploration. In particular, I introduce an additional researcher type into the mix who assigns a low prior to all hypotheses.[22] The evaluator's prior is $\frac{1}{K}\pi$ for each of the first K "high" types and $1-\pi$ for the final "low" type.

The community rejects a hypothesis $a_k = 0$, accepts it as supported by "suggestive" evidence $a_k = 1$, or accepts it as supported by "strong" evidence $a_k = 2$. Payoffs are additively separable $u(a, \omega) \equiv \sum_{k=1}^{K} \tilde{u}(a_k, \omega_k)$ with $\tilde{u}$

[21] The setting is not precisely the monotone environment, but it is straightforward to extend Theorem 3 (c) to include this case.

[22] Formally, there are $K+1$ types with beliefs $\mu_H \equiv \Pr(\omega_k = 1|t_k)$ and $\mu_L \equiv \Pr(\omega_k = 1|t_{k'})$ for all $k = 1, ..., K$ and $k' \neq k$.

satisfying increasing differences, each action optimal on an open set of beliefs. Hence, letting μ^k denote posterior belief that $\omega_k = 1$, there are cutoffs $\underline{e}$ and $\bar{e}$ such that the optimal action is described by the following

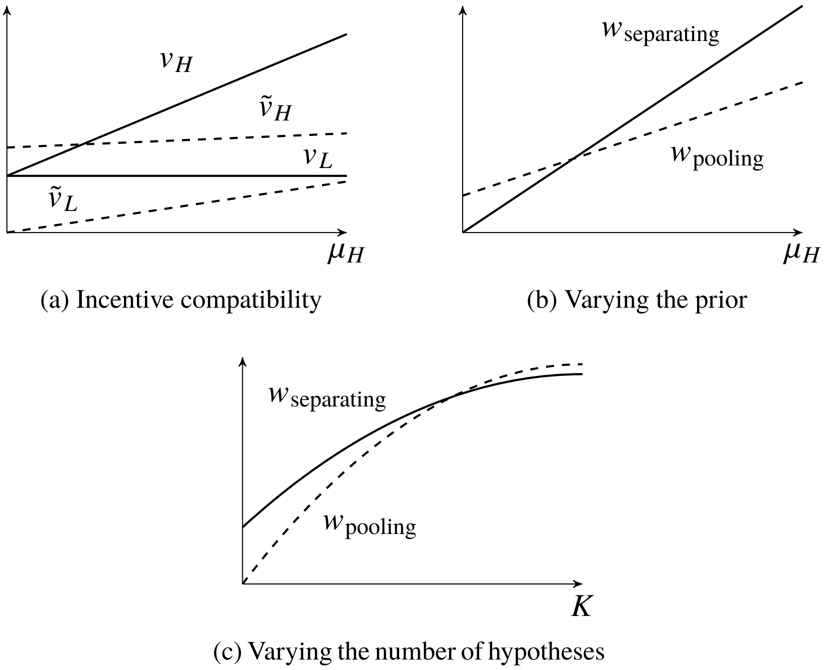


We are interested in the case where if types were known, a high type k achieving success for hypothesis k is followed by $a_k = 2$, otherwise success is followed by $a_k = 1$ and failure followed by $a_k = 0$.[23] For preregistration to be of use, suppose there are sufficiently few high types so that a success is followed by $a_k = 1$ when the type is not known. Clearly, there can be no equilibrium with flexible plans that ever leads to strong acceptance $a_k = 2$. The best that can be done with flexible plans or in the absence of preregistration is for high types to report the significant outcome for the more likely hypothesis when it realizes and to otherwise report some other significant outcome. Refer to this as the *pooling equilibrium* since it captures the highest achievable welfare when high and low types are pooled together from the perspective of the evaluator.

Suppose preregistration allows the researcher either to commit to reporting the outcome of a particular test or to proceed without any constraints. Consider the strategy in which high types commit to the hypothesis they deem more likely and the low type conducts an unfettered exploratory analysis. Relative to the game without preregistration, the high types incur the cost of not being permitted to conduct an exploratory analysis. They also benefit since a success is followed by strong acceptance.

Figure 2 displays the incentive compatibility constraints and welfare for the proposed separating equilibrium and pooling equilibrium when setting error rates at $(\alpha, \beta) = (0.05, 0.2)$, the low prior $\mu_L = 1/8$, payoffs $u(1, \omega) = 2\omega - 1$ and $u(2, \omega) = 9\omega - 7$, with an equal mix of high and low types $\pi = 1/2$. Subfigures (a) and (b) set $K = 6$ and subfigure (c) sets $\mu_H = 0.4$. Increasing the high prior μ_H as depicted in Subfigure (b) leads to a larger welfare gain to adopting the separating equilibrium. Increasing the number of hypotheses (Subfigure (c)) leads to a larger social cost imposed by the constraints of the

[23] This requires $\frac{\mu_H}{1-\mu_H}\frac{1-\beta}{\alpha} > \frac{\bar{e}}{1-\bar{e}} > \frac{\mu_L}{1-\mu_L}\frac{1-\beta}{\alpha} > \frac{\underline{e}}{1-\underline{e}} > \frac{\mu_H}{1-\mu_H}\frac{\beta}{1-\alpha}$.



(a) Incentive compatibility

(b) Varying the prior

(c) Varying the number of hypotheses

Figure 2: *These figures plot the incentive compatibility constraints to achieve a separating equilibrium and compare the welfare between separating and pooling equilibria. v_i and $\tilde{v}_i$ are the low ($i = L$) and high ($i = H$) type's expected payoffs to playing their strategy in the separating equilibrium and to deviating to the other's strategy respectively. $w_{separating}$ and $w_{pooling}$ are expected welfare in the equilibrium separating high and low types and pooling both types respectively.*

rigid pre-analysis plans. One should note that there are parameters for which the benefit from preregistration outweighs the cost and incentive compatibility holds for arbitrarily large values of K.[24]

5.3 Registered Reports

It is useful to consider how the signaling view of preregistration interacts with another proposed publishing model called registered reports (Nosek et al., 2018) which is available to authors at the *Journal of Development Economics*. With registered reports, researchers submit their study designs for review before observing the research outcomes. If the evaluator agrees that the design is high enough in quality, the report is given in-principle acceptance, published as long

[24]For instance, this is satisfied by setting the high prior to $\mu_H = 1/2$ and lowering the fraction of high types to $\pi = 1/4$.

as the study abides by the plan. By placing rewards on design rather than results, registered reports mitigates the signaling benefit of preregistration. The logic for using preregistration as a signal is that the researcher has better information about how the results of the study will turn out. With registered reports, relaying private information becomes less important, what matters to the researcher is writing a plan that is impressive to the evaluator.

For illustration, suppose the researcher's preferences are lexicographic with the first priority being to publish and only after that for the report to be read as impactful. Regardless of the researcher's private beliefs, when writing the pre-analysis plan her sole concern is for the evaluator to gauge her study design as holding promise. As a result, a strict equilibrium involves all researcher types pooling on the same pre-analysis plan, removing any ability to use preregistration to signal private information. Of course, there are independent arguments supporting registered reports. For example, if the model is extended to allow the researcher to intrinsically desire higher welfare in addition to wanting to publish, clearly registered reports can help align incentives. The point here is simply that the logic for these two publishing models is both separate and incompatible.[25]

6 Discussion and Conclusion

This paper investigates whether preregistration leads to more informative research in a setting where a researcher performs a study and aims for her work to be published. I show how preregistration can improve welfare when used by the researcher to signal private information to the evaluator of her work (e.g. referee, journal editor), but it is generally not useful as a tool for commitment per se. Essentially, the expectations of an evaluator who begins endowed with the same information as the researcher serve well to discipline her behavior, making commitment unnecessary and potentially costly when it limits learning. But when the researcher begins with a better understanding of the research environment, committing to design choices in a pre-analysis plan lends credibility to the design having independent support and not being tailored to the data ex post.

[25] In the context of contracting information acquisition, Yoder (2018) finds that it is broadly sufficient to offer rewards on the basis of a study's outcomes without the need to place explicit incentives on researcher effort or chosen methods.

The type of information preregistration helps convey can result from personal experience, as it would when an economist relies on her familiarity with the inner workings of a government or the particulars of a cultural group when deciding how to measure the effect of a policy intervention. Information asymmetry can also emerge endogenously in the research process, say, by first running an informal pilot study and then using what is learned from this to preregister a more robust design for the main study. There are also sample-splitting techniques in which a portion of the data is freely examined in order to formulate and preregister informed hypotheses, which are then tested on the remainder of the data (Anderson and Magruder, 2017; Fafchamps and Labonne, 2017). In these cases, there is an incentive to relay information by committing to a design when it is more likely to produce desirable results than its alternatives.

These observations are also important when considering alternative publication models. One of these is “registered reports" which bases the publication decision on the study’s design rather than its empirical findings. With registered reports, there is an incentive is to select the design deemed best by the evaluator, regardless of what the researcher personally believes is best, counteracting the benefits from signaling through preregistration. Another approach is for journals to encourage replication studies, though the effect of this will depend on how it links with researcher incentives. In light of my results, requiring independent replications to publish has the potential to further exacerbate researcher risk aversion, and lead to the adoption of safer and less informative designs.

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A Appendix: Proofs for Main Text

Expected welfare is defined to be

$$\begin{aligned} W(\mu) &= \int \left[\widehat{U}(\mu) - c\right]^{+} \mathrm{d}G(c) + U(a_0, \mu) \\ &= \int_0^{\widehat{U}(\mu)} \left(\widehat{U}(\mu) - c\right) \mathrm{d}G(c) + U(a_0, \mu) \end{aligned}$$

Noting that $\widehat{U}(\mu) - c = \int_0^{\widehat{U}(\mu)} \mathbf{1}(z \geq c)\mathrm{d}z$ is non-negative we can apply Tonelli's Theorem to find

$$\begin{aligned} \int_0^{\widehat{U}(\mu)} (\widehat{U}(\mu) - c)\mathrm{d}G(c) &= \int_0^{\widehat{U}(\mu)} \int_0^{\widehat{U}(\mu)} \mathbf{1}(z \geq c)\mathrm{d}z\mathrm{d}G(c) \\ &= \int_0^{\widehat{U}(\mu)} \int_0^{\widehat{U}(\mu)} \mathbf{1}(z \geq c)\mathrm{d}G(c)\mathrm{d}z \\ &= \int_0^{\widehat{U}(\mu)} G(z)\mathrm{d}z \end{aligned}$$

and thus expected welfare is equivalently written as

$$W(\mu) = \int_0^{\widehat{U}(\mu)} G(c)\mathrm{d}c + U(a_0, \mu).$$

A.1 Proposition 1 (Equilibrium Existence)

The following proves equilibrium existence for the more general version of the model given in Section 5, when the researcher begins with privileged information. The timing for the extensive form is

1. Nature selects the state $\omega \in \Omega$ and researcher type $t \in T$.

2. Researcher observes her type t and submits a pre-analysis plan $m \in M$.

3. At each decision node of the study $n \in N$, either the researcher or nature are called to act, and select an action in A_n.

4. At a terminal node of the study, the researcher submits a report $r \in R$ and message $z \in Z$.

5. The evaluator observes (m, r, z). If the plan is followed $r \in m$, the evaluator decides whether or not to publish the report. If the plan is not followed $r \notin m$, the report is automatically rejected.

6. The community either observes (m, r, z) if it is published or learns that no publication was made, and then selects an action $a \in A$.

As mentioned in the text, I assume that after reading the plan m, report r, and message z, the evaluator's beliefs about the state update consistently with his beliefs about the researcher's strategy, even off the equilibrium path. To derive the posterior, suppose the researcher's type is t, the analysis is x, with $y \subset x$ the actions taken by nature over the course of the analysis. Notice that the researcher's actions are themselves not informative about the state when her type and the outcomes she has observed are known to the evaluator.[26] Let $\tilde{N}_0 \subset N_0$ be nature's decision nodes reached during the analysis so that we can express $y = (y_n)_{n \in \tilde{N}_0}$. The posterior given (t, x) is thus

$$\mu(B|t,x) = \frac{p_t(B \times_{n \in \tilde{N}_0} \{y_n\} \times_{n \in N_0 \setminus \tilde{N}_0} A_n)}{p_t(\Omega \times_{n \in \tilde{N}_0} \{y_n\} \times_{n \in N_0 \setminus \tilde{N}_0} A_n)}, \quad \text{for all measurable } \; B \subset \Omega.$$

When the evaluator's beliefs about play are λ, then after observing (m, r, z) his posterior over the state becomes

$$\mu_\lambda(B|m,r,z) = \sum_{t \in T, x \in r} \mu(B|t,x) \lambda_{mrz}(t,x).$$

An equilibrium is described as follows. The researcher's strategy σ maximizes her expected payoff at every information set she is called to act. For every triple (m, r, z) on the equilibrium path, the evaluator's beliefs about play $\lambda_{mrz} \in \Delta(T \times r)$ are consistent $\lambda_{mrz}(t,x) = P(t, r|m, r, z, \sigma)$. The evaluator's strategy is to publish whenever the perceived impact of the report exceeds the cost $\widehat{U}(\mu) \geq c$ and the community's strategy maximizes $U(a, \mu)$ where $\mu(\cdot) = \mu_\lambda(\cdot|m, r, z)$.

To prove equilibrium existence, it is without loss in generality to assume the set of cheap talk messages Z to be finite since any equilibrium with finitely many messages remains an equilibrium with infinitely many messages by specifying

[26] Letting $e \subset x$ be the actions taken by the researcher $\mu(B|e,t,y) = \frac{P(e|t,y,B)P(t,y|B)}{P(e|t,y)P(t,y)} = \mu(B|t,y)$ where the last equality follows simply because the researcher's actions are themselves independent of the state given (t, y), and so $P(e|t, y, B) = P(e|t, y)$.

that the evaluator interprets each message not in the original finite set as if it were one in the original set. If the support of the prior μ_0 and the cost distribution G are both finite, then standard results provide the existence of an equilibrium (Kreps and Wilson, 1982). Fortunately, the model is simple enough for a direct proof of equilibrium existence that accommodates larger state and cost spaces.

Proof of Proposition 1. Let $I \in \mathcal{I}$ be the information sets at which the researcher is called to act and $\sigma = (\sigma_I)_{I \in \mathcal{I}}$ the researcher's mixed strategies. Consider a transformation of the game wherein player $I \in \mathcal{I}$ chooses σ_I at information set I and the evaluator chooses $\lambda = (\lambda_{mrz})_{(m,r,z) \in M \times R \times Z}$ with payoffs

$$\hat{u}(\lambda, \sigma) = -\sum_{m,r,z} \|\lambda_{mrz} - P^{\dagger}(\cdot|m, r, z, \sigma)\| P(m, r, z|\sigma) \tag{2}$$

$$\hat{v}_I(\sigma, \lambda) = \sum_{m,r,z} V[\max_{a \in A} U(a, \mu_{\lambda_{mrz}}) - U(a_0, \mu_{\lambda_{mrz}})] P(m, r, z|\sigma, I) \quad \text{for all} \quad I \in \mathcal{I} \tag{3}$$

with $\|\cdot\|$ denoting Euclidean distance and with $P^{\dagger}(t, x|m, r, z, \sigma) \equiv P(t, x|m, r, z, \sigma)$ whenever $P(m, r, z|\sigma) > 0$ and $P^{\dagger}(t, x|m, r, z, \sigma) \equiv 0$ otherwise. Notice, while $P^{\dagger}(t, x|m, r, z, \sigma)$ is not continuous in σ, because $\|\lambda_{mrz} - P^{\dagger}(\cdot|m, r, z, \sigma)\|$ is bounded, (2) is indeed continuous in σ. Further, $\mu_\lambda(B|m, r, z)$ is continuous in λ for any measurable $B \subset \Omega$ so that, by the theorem of the maximum, $\max_{a \in A} U(a, \mu_{\lambda_{mrz}})$ is continuous in λ. Thus, the preceding describes a game with $|I| + 1$ players, each with continuous payoffs and actions in a compact convex subset of a Euclidean space; hence, there exists an equilibrium (σ^*, λ^*) (Glicksberg, 1952).

It also follows that there exists an equilibrium of the research game in which the researcher plays σ^*, the evaluator's beliefs about play are λ^*, the evaluator's posterior over the state updates consistently with beliefs about play μ_{λ^*}, and with publication decisions and community actions optimal with respect to beliefs. □

A.2 Unraveling

In the absence of preregistration, the strong pressure to disclose provides that the evaluator always achieves the full disclosure payoff, however the study is carried out. To the contrary, suppose the evaluator strictly benefits from a vague report r being made more precise in equilibrium. Denoting $w_r \equiv w(\mu_r)$ and $E_{x|r}$ the equilibrium expectation over analyses when the report is r, this implies

$$w_r < E_{x|r} w_{\{x\}} \iff \int_0^{v(w_r)} G(c)\mathrm{d}c < E_{x|r} \int_0^{v(w_{\{x\}})} G(c)\mathrm{d}c \tag{4}$$

so that $v(w_r) < v(w_{\{x\}})$ for some analysis x, and thus play is not in equilibrium, a contradiction.

Proposition A.1. *If reports can be exhaustive, equilibrium welfare without preregistration is equivalent to the researcher playing the same strategy but submitting exhaustive reports.*

Conversely, the researcher never benefits from withholding information in equilibrium. Otherwise, if a report is strictly preferred to full disclosure $v(w_r) > v(w_{\{x\}})$ for some $x \in r$ on the equilibrium path, since all others making the report prefer it to full disclosure, this reverses the strict inequalities in (4) violating the fact that welfare can only improve with the release of more information $w_r \leq E_{x|r} w_{\{x\}}$.

Corollary A.1. *If there is only one way to conduct the study and reports can be exhaustive, then preregistration does not improve welfare.*

This follows by noting that with only one way to conduct the study, the full disclosure welfare is unique and achieved without preregistration.

A.3 Theorem 1

Let $E_{\sigma\lambda}$ correspond to the distribution over the evaluator's posterior μ when the researcher plays σ against the belief λ.

Definition A.1. *The evaluator is* ***skeptical*** *when his belief about play λ' minimizes the perceived impact for any message and report*

$$\lambda'_{mr} \in \arg\min_{\tilde{\lambda}_{mr} \in \Delta(r)} \widehat{U}(\mu_{\tilde{\lambda}_{mr}}) \quad \text{for all} \quad m \in M \quad \text{and} \quad r \in R$$

Playing any strategy σ against skepticism λ' delivers a lower payoff to the researcher than playing it against any other belief λ: $E_{\sigma\lambda'} v(w(\mu)) \leq E_{\sigma\lambda} v(w(\mu))$.

Proof of Lemma 1. By Lemma A.5, if the researcher does not face temptation at an equilibrium with preregistration, then there is an equilibrium with flexible plans delivering the same welfare. By Lemma A.6, since information begins symmetric between the researcher and evaluator (essentially $|T| = 1$) for any equilibrium with flexible plans, there is an equilibrium without preregistration delivering just as much welfare. □

Proof of Lemma 2. σ' being tempting in an equilibrium (σ, λ) is to say that in the game with flexible plans

$$E_{\sigma'\lambda} v(w(\mu)) > E_{\sigma\lambda} v(w(\mu)) \quad \text{and} \quad \Pr(\{r \notin m\}|\sigma') > 0.$$

If σ'' only differs from σ' in the plans, but their reports are interpreted identically despite the change in plans, then σ'' induces precisely the same distribution of posteriors as does σ', implying $E_{\sigma''\lambda} v(w(\mu)) = E_{\sigma'\lambda} v(w(\mu))$. If σ'' does not involve departures from the plan, the unilateral deviation from σ to σ'' makes the researcher strictly better off, contradicting the assumption that (σ, λ) is an equilibrium. □

Proof of Theorem 1. We first show that if (σ, λ) is an equilibrium then the profile (σ', λ') is also an equilibrium where σ' is the strategy that conducts analyses identically to σ, submits a plan that permits them to be reported exhaustively, always reports exhaustively, and λ' is skeptical. The existence of such a strategy σ' follows from the assumption that any plan can be written.[27] If (σ', λ') were not an equilibrium, then for any deviation $\sigma'' \in BR(\lambda')$

$$E_{\sigma''\lambda} v(w(\mu)) \geq E_{\sigma''\lambda'} v(w(\mu)) > E_{\sigma'\lambda'} v(w(\mu)) \geq E_{\sigma\lambda} v(w(\mu)) \qquad (5)$$

implying (σ, λ) is also not an equilibrium. The first inequality in (5) is due to λ' being skeptical, the second inequality captures the desire to deviate, and the third inequality holds because σ' delivers Blackwell more informative reports to σ and $v(w(\mu))$ is convex.

If (σ, λ) improves welfare, then so must (σ', λ') by the aforementioned Blackwell comparisons of their reports. By Lemma 1, the researcher must face temptation at (σ', λ') by some other strategy σ''. However, as any plan can be submitted, there exists another strategy that only differs from σ'' in plans, involves no departures from the plans, and reports are interpreted the same as

[27] In particular, submitting $m = R$ or $m = \{\{x\} : \{x\} \in \text{supp}(\sigma)\}$ are satisfactory.

in σ'' since both strategies are played against skepticism. By Lemma 2, the researcher would not voluntarily remove temptation, implying the contradiction that (σ', λ') is not an equilibrium. Hence, (σ, λ) does not improve welfare. □

A.4 Theorem 2

The following theorem considers "simple" studies in which the researcher only acts at the initial decision node n_0 of the study. Denote a generic action available at this node by $e \in A_{n_0}$ and to simplify discussion, refer to this action as the "experiment." Similarly, denote a generic action vector taken by nature as $y \in \times_{n \in N_0} A_n$ and call this the "outcome."

Proof of Theorem 2. Let (σ, λ) be an equilibrium with rigid plans and without loss in generality suppose λ is skeptical off-path. For a given pair (m, e), say that the experiment *follows the plan* if there is an analysis of the form $x = (e, \cdot)$ described by some permitted report $x \in r' \in m$ and otherwise the experiment *departs from the plan*. Notice that if the experiment departs from the plan, then any subsequent report is not permitted $r \notin m$ and incurs the penalty $\underline{v}$. As this is necessarily off the equilibrium path and the researcher is indifferent across all of these reports, it is also without loss to assume that reports are as precise as possible: If r reports x then for any $x \in r'$, $r \subset r'$.

I will argue that, in the game with flexible plans, $(\sigma(r|y, e, m))_{r \in R}$ remains the optimal reporting strategy for all (m, e, y) and $(\sigma(e, m))_{e \in A_{n_0}, m \in M}$ remains the optimal choice of plans and experiments.

Move to the game with flexible plans and fix the evaluators beliefs at λ. By assumption $\sigma(r|y, e, m)$ remains optimal when experiments depart from the plan. Let us now show that the researcher has no incentive to deviate when writing the report as long as the experiment follows the plan. If following σ calls the researcher to submit r but she strictly prefers to deviate to some r', then (1) the two must overlap $r'' \equiv r \cap r' \neq \emptyset$ and (2) r' must have been previously excluded $r' \notin m$. Because plans do not preclude precision, r'' was previously permitted by the plan but r was chosen. Moreover, reporting r'' is preferable to r' due to the evaluator's skepticism. Combining these two observations finds that reporting r is preferred to r', yielding the desired conclusion.

It cannot be strictly optimal to select a pair (m, e) in which the experiment departs from the plan since any subsequent reports are met with skepticism:

By the assumption that any plan not precluding precision can be preregistered, the researcher could do just as well by submitting the vague plan $m' = R$. But among strategies in which the experiment follows the plan, σ is optimal; hence, (σ, λ) remains an equilibrium. By Lemma 1, preregistration does not improve welfare. □

A.5 Proposition 3

The following lemma is used in the construction for the proof of Proposition 3.

Lemma A.1. *If* (ω, y) *are affiliated, then* $\mu(B|y^1 = \bar{y}^1, \underline{y}^k \leq y^k \leq \bar{y}^k, \forall k \neq 1) \geq \mu(B|y^1 \leq \bar{y}^1, \underline{y}^k \leq y^k \leq \bar{y}^k, \forall k \neq 1)$ *for all increasing sets* $B \subset \Omega$.

Proof. The conclusion follows from Milgrom and Weber (1982) Theorem 23, since

$$E[\mathbf{1}_B(\omega)|S \cap C] \geq E[\mathbf{1}_B(\omega)|S] \tag{6}$$

where S is the sublattice $S = \{\omega \in \Omega, y^1 \leq \bar{y}^1, \underline{y}^k \leq y^k \leq \bar{y}^k, \forall k \neq 1\}$, C is the increasing set $C = \{\omega \in \Omega, y^1 \geq \bar{y}^1, y^k \in Y^k, \forall k \neq 1\}$, and $\mathbf{1}_B(\omega)$ is evidently non-decreasing in (ω, y). □

Lemma A.2. *Assume* $V(\mu') \geq V(\mu)$ *implies* $a(\mu') \geq a(\mu)$. *For any equilibrium there is an equivalent equilibrium in which reports can be arranged in a sequence* $(r_j)_{j=1}^n$ *where the lowest indexed report available is always reported.*

Proof. In any equilibrium we can arrange reports in a sequence $(r_j)_{j=1}^n$ such that a lower index corresponds to a report that yields a weakly higher payoff for the researcher. If the researcher is indifferent between any reports they must recommend the same action. Hence, payoffs remain unchanged if we assume that the researcher reports the lowest indexed r_j. □

A direct corollary of this is that the cheap talk messages in reports can provide no additional information (this is relevant for Theorem 3 (c)).

Lemma A.3 (Adjacent Swap)**.** *Assume* $V(\mu') \geq V(\mu)$ *implies* $a(\mu') \geq a(\mu)$. *Let* $(r_j)_{j=1}^n$ *correspond to a reporting strategy in which the lowest indexed element available is always reported. Moreover, suppose that if* r_j *and* $r_{j'}$ *report the respective outcomes* y_i *and* $y_i' > y_i$ *from the same specification, then* $j' < j$.

If, when the evaluator believes that the researcher follows this strategy, there are two adjacent elements r_k and r_{k+1} in which the researcher strictly prefers to report r_{k+1} over r_k, then swapping them $(r_1, ..., r_{k+1}, r_k, ..., r_n)$ weakly improves the expected welfare.

Proof. Let σ correspond to $(r_j)_{j=1}^n$ and σ' the proposed deviation. Let $W(\sigma)$ and $W(\sigma')$ denote the expected welfare when the community best responds to the respective strategies and γ the expected welfare from the researcher deviating σ' but the community's actions proceeding as if the researcher continued to play σ. As a best response, necessarily $W(\sigma') \geq \gamma$. The desired conclusion will follow by showing that $\gamma \geq W(\sigma)$.

To simplify notation, let a_r denote the optimal action and μ_r the belief when r is reported and the researcher is believed to play σ. Additionally, let $\mu_{r_k,r_{k+1}}$ be the belief when r_k is reported and it is additionally known that the outcome in r_{k+1} has been realized, again when it is believed that the researcher is playing σ.

The only event in which the researcher's strategy differs between σ and σ' is when both r_k and r_{k+1} realize, so that the inequality $\gamma \geq W(\sigma)$ holds if and only if

$$\int \left[U(a_{r_{k+1}}, \mu_{r_k,r_{k+1}}) - U(a_0, \mu_{r_k,r_{k+1}}) - c\right] \cdot \mathbf{1}\left(\widehat{U}(\mu_{r_{k+1}}) \geq c\right) \mathrm{d}G(c) \quad (7)$$

$$\geq \int \left[U(a_{r_k}, \mu_{r_k,r_{k+1}}) - U(a_0, \mu_{r_k,r_{k+1}}) - c\right] \cdot \mathbf{1}\left(\widehat{U}(\mu_{r_k}) \geq c\right) \mathrm{d}G(c) \quad (8)$$

Because $\mu_{r_k,r_{k+1}} \succeq_{FOSD} \mu_{r_{k+1}}$ (by Lemma A.1) the integrand in (7) is non-negative. Since the researcher strictly prefers to deviate, $\widehat{U}(\mu_{r_{k+1}}) > \widehat{U}(\mu_{r_k})$, and thus (7) exceeds

$$\int \left[U(a_{r_{k+1}}, \mu_{r_k,r_{k+1}}) - U(a_0, \mu_{r_k,r_{k+1}}) - c\right] \cdot \mathbf{1}\left(\widehat{U}(\mu_{r_k}) \geq c\right) \mathrm{d}G(c). \quad (9)$$

This expression exceeds (8) if and only if

$$(U(a_{r_{k+1}}, \mu_{r_k,r_{k+1}}) - U(a_{r_k}, \mu_{r_k,r_{k+1}})) \cdot (1 - G(\widehat{U}(\mu_{r_k}))) \geq 0. \quad (10)$$

Because the researcher prefers to deviate, it must be that $a_{r_{k+1}} \geq a_{r_k}$. Additionally, $\mu_{r_k,r_{k+1}} \succeq_{FOSD} \mu_{r_{k+1}}$ and $a_{r_{k+1}}$ is optimal at $\mu_{r_{k+1}}$ so that we achieve the following inequalities respectively

$$U(a_{r_{k+1}}, \mu_{r_k,r_{k+1}}) - U(a_{r_k}, \mu_{r_k,r_{k+1}}) = \int \left[u(a_{r_{k+1}}, \omega) - u(a_{r_k}, \omega)\right] \mathrm{d}\mu_{r_k,r_{k+1}}(\omega) \tag{11}$$

$$\geq \int \left[u(a_{r_{k+1}}, \omega) - u(a_{r_k}, \omega)\right] \mathrm{d}\mu_{r_{k+1}}(\omega) \geq 0. \tag{12}$$

One should note that if the deviation strictly increases the chance of a publication, we obtain a strict inequality between (7) and (9) which further provides that the deviation strictly increases welfare. □

Proof of Proposition 3. Let (σ, λ) be an equilibrium in which the researcher adopts a rigid plan and without loss in generality, suppose the strategy involves preregistering only one plan with probability one. Label the reports $(r_j)_{j=1}^n$ so that the researcher submits the lowest indexed report available. Consider a deviation to a new strategy σ' with reports $(r_j)_{n'}$ which is the same as the original strategy for the first $n-1$ terms, adds all but the lowest outcomes from the excluded specifications, and places r_n at the end. In particular, let these new terms be placed in reverse order so that if r_k and $r_{k'}$ report outcomes from the same and previously excluded specification, then $k > k'$ implies that the outcome of the former is less than the outcome of the latter. For example, suppose there are three specifications with outcomes $(y_j^i)_{j=1}^n$ for $i = 1, 2, 3$ and σ involves preregistering and reporting the outcomes for the first one $i = 1$. Then the following lists the outcomes for both strategies where the leftmost outcome that occurs is always reported.

$$\begin{aligned}
&\sigma : y_n^1, y_{n-1}^1, \ldots, y_1^1 \\
&\sigma' : y_n^1, y_{n-1}^1, \ldots, \underbrace{y_n^2, y_{n-1}^2, \ldots, y_2^2, y_n^3, y_{n-1}^3, \ldots, y_2^3}_{\text{excluded in } \sigma}, y_1^1
\end{aligned}$$

Specify the evaluator's beliefs to be consistent with the new reporting strategy (and skeptical off-path). Notice that this strategy marks a Blackwell improvement for the evaluator. Hence, if this new reporting strategy paired with consistent beliefs by the evaluator constitutes an equilibrium, the proof is complete.

If this new strategy is not an equilibrium, then there must be some r_k that the researcher strictly prefers to report over r_{k-1}. By Lemma A.3 we can swap them to obtain a new strategy $(r_1, ..., r_k, r_{k-1}, ..., r_{n'})$ and improve welfare. If this new strategy constitutes an equilibrium, then we can conclude. Otherwise, another swap can improve welfare.

The final step of the proof shows that because the process of adjacent swaps is transient, and thus because there are only finitely many reporting strategies the process must eventually arrive at a strategy at which the researcher does not wish to deviate.

Let $r^0 = (r_j)_{n'}$ be the order of reports according to σ' and $(r^\ell)_\ell$ the sequence of strategies obtained through the process of adjacent swaps. Define another sequence $(\chi^\ell)_\ell$ such that each element χ^ℓ is equal to the lowest index for an element that has been involved in an adjacent swap up to step ℓ. For example, if $r^0 = (r^0_1, ..., r^0_k, r^0_{k+1}, ..., r^0_n)$ and we swap terms to $r^1 = (r^0_1, ..., r^0_{k+1}, r^0_k, ..., r^0_n)$ which are then relabeled as $r^1 = (r^1_1, ..., r^1_k, r^1_{k+1}, ..., r^1_n)$ then $\chi^1 = k$. Since the researcher strictly prefers swaps, χ^ℓ provides the index for a report at which the researcher obtains a strictly higher payoff using strategy r^ℓ than using strategy r^0; hence, no r^ℓ can ever equal r^0. By the same argument, each element of $(r^\ell)_\ell$ is unique and thus the process eventually concludes. □

The following lemma is used in the proof for Theorem 3 (c).

Lemma A.4. *If (ω, y) are affiliated in p_t for all t, then they are affiliated in $p_0 = E_\pi p_t$.*

Proof. By Milgrom and Weber (1982) Theorem 23, (ω, y) being affiliated in p_t is equivalent to

$$E_{p_t}[f(\omega, y)|SB] \geq E_{p_t}[f(\omega, y)] \geq E_{p_t}[f(\omega, y)|SB^C] \tag{13}$$

for any sublattice $S \subset \Omega \times Y$, increasing set $B \subset \Omega \times Y$, and non-decreasing function f. Taking the expectation of the above with respect to π delivers the desired conclusion. □

A.6 Theorem 3

Lemma A.5. *If preregistration delivers higher welfare at an equilibrium (σ, λ) than any equilibrium with flexible plans, then the researcher must be tempted to* *depart from her plan. That is, in the game with flexible plans, all $\sigma' \in BR(\lambda)$ depart from the plan $r \notin m$ with positive probability.*

Proof. In the game with flexible plans, it cannot be that $\sigma \in BR(\lambda)$ or else (σ, λ) is a flexible equilibrium achieving the same welfare. Any other strategy that also sticks to the plan was previously available and receives the same payoff as before, hence σ is weakly preferred to all of these. □

Lemma A.6. *In an equilibrium with flexible plans, if all types pool on the same plans ($P(m|\sigma_t) = P(m|\sigma_{t'})$ for all t and t' in T and all $m \in M$) then there is an equilibrium without preregistration delivering weakly higher welfare.*

Proof. For an equilibrium with flexible plans (σ, λ) let $\sigma_t^m \in \Delta(\times_{n\in N\setminus N_0} A_n \times R \times Z)$ denote the researcher's equilibrium strategy conditional on submitting plan m and being type t . Equilibrium welfare is given by

$$\sum_{t\in T} \sum_{m\in M} E_{\sigma_t^m \lambda} w(\mu) \Pr(m|\sigma_t)\pi(t).$$

Notice that it remains an equilibrium if all types deviate and only submit a plan m^* in the support of σ maximizing $\sum_{t\in T} E_{\sigma_t^m \lambda} w(\mu)\pi(t)$. All types are indifferent between this deviation and their original equilibrium strategy. Moreover, the evaluator's beliefs about play remain consistent on path with this deviation as

$$\lambda_{m^*rz}(t,x) = \frac{P(m^*, r, z, t, x|\sigma)}{P(m^*, r, z|\sigma)} = \frac{P(x, r, z|m^*, t, \sigma)P(m^*, t|\sigma)}{P(r, z|m^*, \sigma)P(m^*|\sigma)} = \frac{P(x, r, z|m^*, t, \sigma)\pi(t)}{P(r, z|m^*, \sigma)}.$$

Moving to the game without preregistration, notice that the profile (σ', λ') with $\sigma' = \sigma^{m^*}$ and $\lambda'_{rz} = \lambda_{m^*rz}$ for all $r \in R$ and $z \in Z$ must also be an equilibrium. But this equilibrium without preregistration delivers no less welfare than (σ, λ). □

Proof of Theorem 3. (a) Suppose (σ, λ) is a pooling equilibrium that improves welfare. Let σ' be the strategy in which every type performs the same study, but preregisters $m' = \{\{x\} : x \in X\}$, reports exhaustively, and submit the ex post cheap talk message so that the evaluator's beliefs update to $\mu(\cdot|m', \{x\}, z') = \mu(\cdot|m, r, z, x)$ where the researcher would have originally submitted (m, r, z). I claim that (σ', λ') where λ' is consistent with σ' but skeptical otherwise is an equilibrium.

First, notice that the convexity of $v(w(\mu))$ and the Blackwell ranking of strategies implies that researcher types are, on average, better off in the newly proposed equilibrium $E_{\sigma'\lambda'}v(w(\mu)) \geq E_{\sigma\lambda}v(w(\mu))$. This also means that no type is made strictly worse off as this would imply that some type is made strictly better off, and she could have played the new strategy before against the same beliefs; hence, $E_{\sigma_t'\lambda'}v(w(\mu)) \geq E_{\sigma_t\lambda}v(w(\mu))$.

Observe that λ' is either identical to λ or strictly more skeptical, implying $E_{\tilde{\sigma}_t\lambda}v(w(\mu)) \geq E_{\tilde{\sigma}_t\lambda'}v(w(\mu))$ for any strategy $\tilde{\sigma}_t$. Combining these observations with the fact that (σ, λ) is an equilibrium implies

$$E_{\sigma_t'\lambda'}v(w(\mu)) \geq E_{\sigma_t\lambda}v(w(\mu)) \geq E_{\tilde{\sigma}_t\lambda}v(w(\mu)) \geq E_{\tilde{\sigma}_t\lambda'}v(w(\mu)) \tag{14}$$

for all $\tilde{\sigma}_t$; thus, (σ', λ') is an equilibrium.

If (σ, λ) improves welfare, then so must (σ', λ'). Since types are pooling on m', by Lemmas A.5 and A.6 some type must face temptation in equilibrium. Since any triple $(m', \{x\}, z)$ is received with either the same beliefs or met with less skepticism than any other (m, r, z') with $m \neq m'$ or $\{x\} \neq r$, we may suppose that any temptation involves preregistering m' and submitting an exhaustive report. But all such deviations involve following the plan; hence, are not temptations. Thus, $(\sigma,', \lambda')$ and so (σ, λ) cannot improve welfare.

(b) The same argument in the proof for Theorem 2 shows that any pooling equilibrium remains an equilibrium when plans are flexible. But if all types pool on the same plan, then it does not improve welfare by Lemma A.6.

(c) Let (σ, λ) be an equilibrium in which all types play the same strategy. As all types must be indifferent over all plans in the support, we may without loss of generality suppose that they pool on a pure strategy, submitting the same rigid plan. In particular, let them pool on the rigid plan which, conditional on being submitted, leads to the highest expected welfare among plans in the support of σ. Applying the argument given in Lemma A.2, every equilibrium cheap talk message sent alongside a report must lead to the same action; hence, we can assume that all reports are accompanied by the same message. Since types agree that (ω, y) are affiliated, then they remain affiliated with respect to the prior (Lemma A.4). Following the same construction as in Proposition 3, we can construct a flexible equilibrium that achieves no less welfare than the rigid equilibrium. □

A.7 Proof of Proposition 4 (Flexible Plans)

Let (σ, λ) be an equilibrium with flexible plans that improves welfare and (σ', λ') an equivalent profile in the game without preregistration as defined in the text. By Lemma A.6 at least two types must submit different plans. Similarly, σ' cannot be a best response for all types or else (σ', λ') is an equilibrium in the game without preregistration achieving the same welfare as (σ, λ). Suppose t strictly prefers to deviate to $\sigma''_t \in BR(\lambda')$. It cannot be that each report made in σ''_t maps back to a message-report pair that was either previously submitted by t or off the equilibrium path, this option was previously available at the same or a higher payoff and t weakly preferred σ_t; hence, σ'_t would be preferable to σ''_t. Furthermore, it cannot be that each report made in σ''_t lies in the support of $\sigma'_{t'}$ for a particular $t' \neq t$. Otherwise, in the game with flexible plans, t would have strictly preferred to deviate and submit the same plan as t' and then follow the equivalent of this new strategy. Thus, $\emptyset \neq \text{supp}(\sigma''_t) \cap \text{supp}(\sigma'_{t'}) \neq \text{supp}(\sigma''_t)$ for some t' as desired.

B Appendix: Additional Results

B.1 Fully Bayesian Community

This section considers a community that updates beliefs in the absence of a publication. There is a single journal and the researcher's only goal is to have her report published. A publication yields a unit payoff to the researcher, failing to publish yields a payoff of zero, and the support of costs is taken to be $\mathbb{R}_+$ so that $V(\widehat{U}(\mu)) = G(\widehat{U}(\mu))$ is strictly increasing.

Frankel and Kasy (2020) wrestle with the question of how to determine the action taken in the absence of publication. I have focused on equilibria in which the non-publication action coincides with the ex ante optimal action a_0. First, observe that such an equilibrium always exists when actions are binary valued

Proposition B.1. *If the action is binary $a \in \{0, 1\}$, there always exists an equilibrium in which the ex ante optimal action a_0 is taken when the report is not published.*

Proof. Without loss, suppose $a_0 = 0$. Let $d(\omega) \equiv u(1, \omega) - u(0, \omega)$ so that it must be that $E_{\mu_0} d(\omega) < 0$. Supposing the evaluator expects a_0 to be taken in the event of no publication, he only publishes the report when $E_\mu d(\omega) > c$. In the event of a rejection, for a given researcher strategy the community's expectations become

$$E[E_\mu d(\omega)|\text{reject}] = \frac{1}{\Pr(\text{reject})} E_{\mu_0} d(\omega) - \frac{\Pr(\text{publish})}{\Pr(\text{reject})} E[E_\mu d(\omega)|\text{publish}] < 0$$

so that $a_0 = 0$ remains optimal. □

In reality, the sheer mass of publications has grown at an exponential rate over time (Bornmann and Mutz, 2015; Fortunato et al., 2018) so it is unlikely that a negative publication decision would be noticed by the community. As observed in Frankel and Kasy (2020), this can be represented by supposing there are a large number of topics that can be studied so that a negative publication decision does not indicate to the community which topic was rejected. To capture this, suppose the state can be partitioned into L independent topics $\Omega = \times_{\ell=1}^{L} \Omega_\ell$ and utility takes the form $u(a, \omega) = \sum_{\ell=1}^{L} u(a^\ell, \omega^\ell)$. Nature first selects a topic $\ell \in \{1, 2, ..., L\}$, each with equal probability, and then the researcher conducts a study that only sheds light on this topic ℓ. The community only learns the topic in the event that the report is published.

Proposition B.2. *Suppose there are L independent and symmetric topics with a unique ex ante optimal action $a_0 = a(\mu_0)$. For L sufficiently large, in all equilibria the non-publication action is a_0.*

Proof. Since the support of costs is large, every topic has a positive chance of rejection, regardless of the results. In particular the rejection probability is bounded below by some $\epsilon > 0$ for all topics regardless of the strategy. For a given set of beliefs about play, the marginal posterior probability measure over ω^ℓ after learning that the submitted report was rejected is

$$\begin{aligned}\mu^\ell(\cdot|\text{reject}) &= \mu^\ell(\cdot|\ell \text{ reject}) \Pr(\ell \text{ reject}|\text{reject}) + \sum_{\ell' \neq \ell} \mu^\ell(\cdot|\ell' \text{ reject}) \Pr(\ell' \text{ reject}|\text{reject}) \\ &= \mu^\ell(\cdot|\ell \text{ reject}) \Pr(\ell \text{ reject}|\text{reject}) + \mu^\ell(\cdot) \left(1 - \Pr(\ell \text{ reject}|\text{reject})\right).\end{aligned}$$

as the dimensions are independent so $\mu^\ell(\cdot|\ell' \text{ reject}) = \mu^\ell(\cdot)$. For a given topic, the set of interim types is finite and so the set of possible beliefs over the interim types is compact; hence, we can find a belief maximizing the difference between the posterior and prior in the event the ℓ is known to have failed publication $\|\mu^\ell(\cdot|\ell \text{ reject}) - \mu^\ell(\cdot)\|$, where $\|\cdot\|$ corresponds to the Prokhorov metric. Denote this maximal difference as b. Thus for any beliefs about play

$$\begin{aligned}\|\mu^\ell(\cdot|\text{reject}) - \mu^\ell(\cdot)\| &= \|\mu^\ell(\cdot|\ell \text{ reject}) - \mu^\ell(\cdot)\| \Pr(\ell \text{ reject}|\text{reject}) \\ &\leq b\frac{1}{1+\epsilon L}.\end{aligned}$$

Thus, taking L to be sufficiently large, the posterior resides in a small enough neighborhood of the prior so that a_0 remains uniquely optimal in the event of non-publication. □

B.2 Fully Revealing Analysis

This section makes the point that if there is an analysis that always reveals the state, then as long as the researcher is not overly risk averse the ex ante alignment will lead her conduct the fully revealing strategy. Importantly, this remains true even if the researcher starts out better informed than the evaluator. To this end, restrict risk aversion by assuming $v(w(\mu))$ to be convex just as in Section 4. To reduce notation, let us write this function simply as $v(\mu)$.

Suppose there is an analysis that always reveals the state. Since revealing the state leaves no room for strategic uncertainty, the payoff to conducting this analysis is independent of the evaluator's beliefs about play. I want to show that there exists an equilibrium in which the state is always revealed. Toward a contradiction, suppose there is an equilibrium in which some type strictly prefers her strategy to revealing the state

$$E_{\sigma_t} v(\mu) \geq E_{\mu_t} v(\delta_\omega) \text{ for all } t \in T \text{ and strictly for some } t' \in T.$$

Taking the expectation over types, this implies

$$E_\pi E_{\sigma_t} v(\mu) > E_\pi E_{\mu_t} v(\delta_\omega) \iff E_\sigma v(\mu) > E_{\mu_0} v(\delta_\omega).$$

However, convexity of $v(\mu)$ means that $v(\mu) \leq E_\mu v(\delta_\omega)$. Taking the expectation of this inequality with respect to σ and combining it with the rightmost inequality from above finds

$$E_{\mu_0} v(\delta_\omega) \geq E_\sigma v(\mu) > E_{\mu_0} v(\delta_\omega)$$

implying a contradiction. In fact, this proves the even stronger claim that in every equilibrium, each type is indifferent between her equilibrium strategy and fully revealing the state.