Resolving governance disputes in communities: A study of software license decisions

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Abstract: Resolving governance disputes is of vital importance for communities. Gathering data from GitHub communities, we employ hybrid inductive methods to study discussions around initiation and change of software licenses—a fundamental and potentially contentious governance issue. First, we apply machine learning algorithms to identify robust patterns in data: resolution is more likely in larger discussion groups and in projects without a license compared to those with a license. Second, we analyze textual data to explain the causal mechanisms underpinning these patterns. The resulting theory highlights the group process (reflective agency switches disputes from bargaining to problem solving) and group property (preference alignment over attributes) that are both necessary for the resolution of governance disputes, contributing to the literature on community governance.
INTRODUCTION

Communities are an increasingly important form of organizing (Adler, 2001; Adler and Heckscher, 2017; Lee and Edmondson, 2017). Prominent examples come from domains as diverse as open source software (OSS) (Dahlander and Frederiksen, 2012; Foss, Frederiksen, and Rullani, 2016; Hippel and Krogh, 2003; O’Mahony and Ferraro, 2007), common pool resources (CPRs) (Dietz, Ostrom, and Stern, 2003; Ostrom, 1990), scientific consortia (e.g., Human Genome Project, Collins, Morgan, and Patrinos, 2003), and communities of practice within and across firms (e.g., 3D printing design, Stanko, 2016).

Like any organization that draws on diverse resources and efforts to pursue a set of goals, communities encounter disputes among their constituent individuals and coalitions (Deutsch and Krauss, 1962; Jehn and Bendersky, 2003; March, 1962; see also Amit and Schoemaker, 1993; Danneels, 2008). Dispute resolution is therefore a hallmark of effective and efficient community governance (e.g., Ostrom, 1990). An organization’s core governance principles—about the direction, control, and coordination of its members—are meant (at least in part) to prevent the emergence of destructive disputes, and when disputes do occur, to aid in their resolution (Gulati, Lawrence, and Puranam, 2005; Gulati and Singh, 1998; March and Simon, 1958; Williamson, 1975).

However, disputes can also erupt around the very governance principles themselves. If not resolved, disputes over fundamental principles such as the distribution of resources, rights, and responsibilities, can derail the functioning or even jeopardize the existence of a community. Disputes pertaining to core governance principles that affect the entire community (governance disputes hereafter) differ substantially from disputes concerning operational matters (e.g., the division and allocation of tasks, or management of resources) that typically affect only a subset of community members at a time (henceforth operational disputes). Whereas theory and research on mechanisms for resolving operational disputes are rapidly growing, studies on governance disputes remain rare (Saeed, McDermott, and Boyd, 2017). The nascent state of knowledge on

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1 A type of good consisting of natural or human-made resource systems (e.g., irrigation systems, forests, or fisheries) that is characterized by non-excludability (difficult to exclude actors from gaining utility from the resource) and subtractability (use by one actor precludes use by another).
how communities resolve governance disputes (Dietz et al., 2003) warrants empirically-driven, inductive investigation.

One plausible reason why research is still scant on governance disputes in communities is that records of such disputes are often inaccessible. Those momentous occasions, when most if not all members were involved in resolving disputes over governance principles remain largely buried in the communities’ history, not documented or available for research. It is also possible that unresolved governance disputes removed those proto-communities from possible scholarly scrutiny today. As a result, analysis of governance disputes may be difficult for researchers working with data limited to functioning communities (e.g., Ostrom, 1990), since by virtue of their existence, these communities have escaped or resolved significant governance disputes and their counterparts that did not may no longer exist.

We leverage an unusual research opportunity found in the public discussions on GitHub, an online platform hosting numerous open source software development (OSS) communities, to explore the question of how communities resolve governance disputes. We aim to understand the conditions that increase or decrease the likelihood of resolution, and the processes that underpin differences in outcomes. Two factors motivate our choice of empirical context: (a) OSS communities are an important contemporary type of community for organizing economic activity (e.g., Dahlander and Frederiksen, 2012; O’Mahony and Ferraro, 2007), and (b) they provide a unique window into the phenomenon of governance dispute resolution with a non-decaying electronic record.

Our exploration focuses on a particular type of governance dispute: disputes vis-à-vis the software license that governs a given community’s core software development project (Markus, 2007; O’Mahony and Siobhan, 2003). License disputes are of strategic importance for an OSS community, because they determine how the software is used, modified, and combined with other software(s) (Lerner and Tirole, 2005), thereby affecting all downstream users’ innovation capabilities (Murray and O’Mahony, 2007). Furthermore, they have significant impact on the community’s ability to attract not only developers (Lerner and Tirole, 2005; Subramaniam, Sen, and Nelson, 2009) but also corporate partners, who then combine OSS products or services with proprietary ones (Deodhar et al., 2012; Economides and Katsamakas, 2006).
We sample disputes surrounding the initiation or revision of a software license decision, collecting quantitative and qualitative data on these disputes. The dispute instances we discovered involve a large volume of data, making it difficult to rely solely on traditional inductive methods that involve manually analyzing each case separately. Therefore, we combine machine learning analysis with in-depth content analysis to develop a novel theory (Puranam et al., 2020; Tidhar and Eisenhardt, 2020). In effect, we pioneer a two-pronged approach to inductive research: First, using machine-learning algorithms we document robust patterns across the entire sample (183 cases). These patterns are unlikely to be the result of sampling error or functional form idiosyncrasies, because the algorithms we apply vary in the functional forms and we repeatedly split the data to build and test models using out-of-sample prediction accuracy as a criterion. Second, we focus on analyzing in depth a randomly selected sub-sample (61 cases) to enhance the theoretical understanding of mechanisms underlying the patterns we detected.

Our key finding is that governance disputes in OSS communities can take the form of either bargaining or problem solving processes. The latter group process is more likely when “reflective agency” is manifested. This involves individual interventions that can help steer the discussion towards the attributes of the software licenses (e.g., openness and permissiveness) rather than the alternatives themselves (e.g., GPL and MIT). To the extent that the group has the property that there is pre-alignment of preferences on attributes among members, attribute-based discussions (i.e., discussions focusing predominantly on license attributes) can aid resolution. If either condition (i.e., reflective agency and pre-alignment of attribute preference) is absent, then the dispute remains a hard to resolve bargaining problem.

This study is the first to document the resolution mechanisms in governance disputes on license decisions, and thus provides a complement to the growing literature on operational disputes in online communities (e.g., Forte, Larco, and Bruckman, 2009; Klapper and Reitzig, 2018). Its insights help to understand resolution of not only disputes of strategic and economic importance (i.e., how to manage intellectual property and appropriate value) to online communities in particular (Lerner and Schankerman, 2010) but also disputes of existential significance (i.e., how to establish fundamental governance principles) to communities in general (Dietz et al., 2003; Ostrom, 1990).
LITERATURE REVIEW

Governance Disputes in Communities

The central problem in community governance concerns the alignment of members’ interests and actions to collectively create and capture value (Gulati, Puranam, and Tushman, 2012; Von Krogh et al., 2012; O’Mahony and Bechky, 2008; Olson, 1965). As members seek to realize both collective and individual interests through community involvement, they inevitably experience disagreements or encounter disputes at some point. As a result, mechanisms for effective dispute resolution are a necessary condition to sustain collective action over time (Hardin, 2005; Morrill and Rudes, 2010).

Studying communities such as those that organize around common pool resources (CPR), scholars reasoned that explicit collective goals to sustain and build resources would be sufficient to align members’ interests and agreement on rules for use of those resources (e.g., Adler and Heckscher, 2017; Heckscher and Adler, 2006; Sherif, 1958). However, Ostrom and colleagues (e.g., Dietz et al., 2003; Ostrom, 1990) found that disputes do arise across communities with such goals, and concluded that community viability depended on one or more (explicit) dispute resolution mechanisms (e.g., Dietz et al., 2003; Wilson, Ostrom, and Cox, 2013).

Ostrom (1990) laid out a set of eight governance principles that she argued would allow communities to effectively manage their resources (see Cox, Arnold, and Tomás, 2010 for a recent discussion): (1) clear definition of community boundaries (who is in and out), (2) fair system of rewards, (3) collective choice rules that have community approval, (4) monitoring mechanisms, (5) applying gradated sanctions on free riders, (6) conflict resolution mechanisms, (7) autonomy for community self-governance, and (8) coordination with other relevant communities and organizations. Yet, how these governance principles are agreed upon within communities and what happens when disputes about them arise are unknown. Put differently, it is clear that governance principles are necessary to resolve operational disputes, but how disputes about governance principles themselves are resolved remains unspecified (Dietz et al., 2003:
1911; Saeed et al., 2017: 590). We turn next to relevant work on dispute resolution in organizations with a bearing on this issue.

**Dispute Resolution in Organizations**

Early studies in a structural-rationalist tradition treated disputes as a threat to efficient governance in organizations (Kolb and Putnam, 1992; Weber, 1946), and placed considerable emphasis on the institution of formal authority as a primary means of dispute resolution (March and Simon, 1958; Simons, 1947). Later, the structural-rationalist tradition was complemented by a cultural tradition rooted in Selznick (1948) portrayal of organizations as simultaneously bureaucratic and relational. Culture, values, norms, and ultimately preferences, were recognized to play an essential role in how disputes are understood among members (Menkel-Meadow, 2001), and dispute resolution therefore “include(s) subtle actions couched in everyday activities (e.g., remedial exchanges, avoidance), as well as formalized negotiation and law, quasi-legal structures (e.g., arbitration, mediation, and employee grievance mechanisms), and collective action” (Morrill and Rudes, 2010: 633). An important contribution of the cultural tradition (which guides our approach) has been the recognition that theorizing about dispute resolution demands careful empirical examination of the contexts in which disputes unfold (Barley and Tolbert, 1991; Budd and Colvin, 2014; Roche, Teague, and Colvin, 2014).

The cultural tradition gave rise to two streams of studies on work-related disputes in organizations, focusing on *roles* and *systems*, respectively (Currie et al., 2017). The first stream reveals the role of managers for exercising their formal organizational authority, expertise, and interpersonal skills to enforce a solution (Karambayya and Brett, 1989), when disputes cannot be resolved laterally. The second centers around alternative dispute resolution (ADR) *systems*, which cover various methods (negotiation, mediation, and arbitration) for settling disputes outside of court, and show that these systems offer flexibility in the choice of mechanisms and their combination to fit the specific context of a dispute (Löhr et al., 2017; Ross and Conlon, 2000).

Both structural and cultural approaches have proceeded on the assumption that dispute-
related roles and systems exist in organizations. For example, managers are responsible for resolu-
ing disputes, and an optimal mix of ADR systems, judicial process, or other resolution me-
chanisms are readily deployable (Edelman et al., 2011; Roche and Teague, 2012; Ross and Conlon, 2000). Yet, communities operating in non-hierarchical settings often lack dispute-related roles and pre-designed systems (Currie et al., 2017). In fact, roles and systems are themselves governance principles (Ostrom, 1990), leaving open the question of how disputes are resolved when they arise around the governance principles themselves (see Helms, Oliver, and Web, 2012).

**Dispute resolution in online communities**

Digital technology enables individuals, firms, and other organizations separated by time and space to convene, interact, share, and create resources in online communities, largely on a voluntary basis (Boudreau and Jeppesen, 2015; Foss et al., 2016; Gulati et al., 2012; Lee and Cole, 2003; Miller, Fabian, and Lin, 2009; Moon and Sproull, 2002; Preece, 2000; Sproull and Arriaga, 2007). While members of online communities tend to voluntarily assemble and contribute to a common goal (e.g., developing software), such communities—like their offline counterparts—are by no means exempt from disputes (Arazy et al., 2015; Kane, Johnson, and Majchrzak, 2014; Kittur and Kraut, 2010; Lee and Cole, 2003; Raymond, 1999; Wang et al., 2015; Weber, 2004).

Yet, the absence of traditional organizational features such as hierarchy and formal authority distinguishes disputes in online communities from other organizational disputes (Faraj et al., 2016; Faraj, Jarvenpaa, and Majchrzak, 2011; Gulati et al., 2012; Lakhani, Lifshitz-Assaf, and Tushman, 2013). Moreover, interactions among community members are (a) anonymous by choice (i.e., individuals may choose not to reveal their identities); (b) simultaneous (i.e., many participants can interact at the same time creating a “cacophony” of opinions) or asynchronous (there are long time gaps between contributions to a discussion); (c) unrestricted (e.g., participants are free to enter or exit and their participation is not easily controlled); (d) recorded (i.e., past discussion and actions are kept for all to inspect); and (e) low in media richness (i.e.,
without facial expression or body language). It is reasonable to expect these attributes to give dispute resolution in online communities a distinctive flavor.

An emerging stream of literature has taken on this challenge and has examined operational disputes on (editing) tasks in the Wikipedia online community (Forte et al., 2009; Kittur et al., 2007; Klapper and Reitzig, 2018; Piskorski and Gorbatâi, 2017). Collectively, these studies point to two surprising aspects. First, the mechanisms (roles and systems) set up with a global mandate (i.e., to resolve issues wherever they occur in the community) rarely seem necessary to resolve local disputes (i.e., those involving a few participants or a particular task). For instance, since its formation in 2003, the Wiki community’s arbitration committee had ruled on less than 500 disputes by 2014 (Piskorski and Gorbatâi, 2017; see parallels to Kellogg, 2009; or Jensen and Scacchi, 2005 study on NetBeans). Conversely, in a similar period Wikipedians had resolved around 640,000 cases of editing conflicts on the “talk” page—an informal discussion forum—with voluntary intervention by a fellow contributor occupying an “administrator” role (Klapper and Reitzig, 2018). It thus appears that Wikipedia contributors are able to resolve operational disputes without invoking the globally accessible resolution mechanism (Forte et al., 2009; see parallels to Löhr et al., 2017). Instead, forms of distributed and informal authority seem more prominent in reaching resolution (Dahlander and O’Mahony, 2011; Klapper and Reitzig, 2018). Second, governance disputes involving basic principles that involve the entire community have either been rare or largely escaped scholarly scrutiny. Thus, questions remain about why governance disputes are rare in online communities and how they are resolved when they do occur.

**RESEARCH DESIGN**

**Context**

We chose GitHub as the context to examine governance dispute resolution. GitHub is currently the world’s largest OSS development platform (Gousios et al., 2014), hosting 35 million projects.
and 14 million users. Many GitHub projects comprise communities of individuals (i.e., owners, collaborators, and other contributors) who jointly develop a software product. Each project has at least one owner who initiates the project and holds the copyright of the project’s software repository as long as an open source license is not in place. Collaborators are those who have contributed a significant amount of code to the project. The owner has the power to change the visibility of the repository from private to public or vice versa, and to delete parts or the entire repository when she holds the sole copyright. However, once a license is adopted, ownership is distributed according to license terms. The adoption or change of a license is thus a significant event in the community, as it establishes a basic governance principle.

In the absence of an employment contract, the owner has no formal authority over collaborators or other contributors. Further, the owner has limited power to restrict access to the software code. Other participants (neither owners nor collaborators) hold various rights ranging from pushing, merging, and closing pull requests for code to creating and editing releases of the software. Participants may exit the project or even “fork” it (i.e., take a copy of source code and start a new project to produce a separate software package), thereby posing a restraint to autocratic behavior by project owners (Kane et al., 2014; Raymond, 1999).

The GitHub online platform has a discussion page where community members can express their opinions or dissatisfaction (e.g., with software performance or project direction) and seek solutions (Bissyande et al., 2013). These discussions provide an opportunity to examine various topics important to the functioning of online communities, ranging from operational tasks such as bug fixes to major governance decisions such as license choices.

Among various discussions, license decisions tend to generate broad participation, conflicting views, and heated debates (Alspaugh, Seacchi, and Asuncion, 2010; DiBona, Ockman, and Stone, 1999). Because it is almost impossible for a single developer to be familiar

\[\text{\footnotesize 2 Each project has a repository—the most basic element in GitHub—which contains all project files and stores each file’s revision history. Repositories can have multiple collaborators and can be public or private.}\]
with the plethora of licenses available, license decisions are among the most difficult governance decisions to make (Almeida et al., 2017). Even when developers know the technical aspects of a license, they may not fully comprehend its intellectual property implications. Alspaugh et al. (2010) report that developers often unintentionally write software components under different licenses that legally conflict with each other, or are technically incompatible with the overall software architecture. With such incompatibility, components cannot be merged into a software product unless there is a fundamental change in the license regime.

Given the importance of license decisions (e.g., Singh and Phelps, 2013) and the high potential for discussion around them to produce disputes in online communities, we use license discussions in OSS projects as a useful window into dispute resolution on core governance principles in communities.

Sample and data

GitHub has a built-in issue tracking system. An issue opens with a comment, proceeds with a discussion, and ends with an explicit or implicit closure. Issue tracking offers an unprecedented opportunity to map a dispute resolution process from start to finish. We used the GitHub issue search function within the Application Programming Interface (API) to identify all projects that contain issues with “license” in its title.

More than two thirds (71.6%) of GitHub’s 35 million projects have only a single participant (its owner) (Kalliamvakou et al., 2016) and thus are unable to generate any discussion. Most of the remaining projects either do not have a complete discussion history available or do not require a license discussion. We therefore focus on multi-member projects that are recent (i.e., less than 5 years old) and independent (i.e., without a parent project), for two reasons. First, more recent projects are more likely to have a complete archival record of license discussions (see St. Laurent, 2004), which enables us to observe dispute (non-)resolution. Second, independent projects do not inherit license decisions from a parent project or those established by a legacy owner, potentially requiring a license discussion. The search for issues with the term
“license” in its title provided us with about 80,000 issues, but less than 1,000 satisfied the selection criteria (multi-member, recent, independent). Among the remaining issues, a manual check for dispute episodes resulted in the identification of 183 issues from 183 projects, totaling 1998 discussion participants.

Projects in our sample were intended for a variety of applications, and as a result, the projects’ code bases vary in complexity and volume, ranging from only 4 software commits to 28,887 commits (average = 2,577.09; s.d. = 4,863.49). At the time when we collected our data, projects had been in existence for an average of 1,162.05 (s.d. = 590.56) days, with the youngest project being 32 days old, and the oldest 3,806 days old. Including projects of different types, commit levels, and ages improved the robustness of our inductive theorizing.

The 183 discussions in our sample comprised a total of 983 web-format pages with a mean of 5.4 pages per discussion. An average discussion contained 26.54 comments (s.d. = 28.40), with 1,566.28 total words (s.d. = 2,379.77), from 11 participants (s.d. = 12.19).

**Analytical strategy**

We build theory using algorithm-supported induction, where machine learning (ML) algorithms in conjunction with human interpretations yield robust and interpretable conclusions about patterns in data (Puranam et al., 2020). Specifically, we follow a multi-step analytical strategy as presented in Figure 1. In Step 1, we develop a basic understanding of the phenomenon from manually analyzing eight cases, specifying variables that are potentially relevant to governance dispute resolution in online communities. In Step 2, we establish robust associations among variables, or the “stylized facts” pertaining to the entire sample, using ML algorithms. In Step 3, to explain the patterns detected in Step 2, we conduct detailed textual analysis of disputes in a random sub-sample (one third) of our data.

‘Insert Figure 1 here’

**Step 1: Understanding the phenomenon**
We first carefully examine an initial (randomly selected) set of eight discussions. Each of the four authors independently read two discussions in detail. Next, we swapped the discussions and repeated the first step until each author had read all eight discussions. We then shared our interpretations and reviewed the commonalities and differences among discussions. In addition, we consulted documents on OSS development and software licenses to understand the technological dimensions involved in the license decisions.

This process of reading, discussion, and consultation uncovered 11 variables (i.e., issue type, project age, project size, admin group size, discussion group size, initiator status, initiator contribution, polarization of opinions, imbalance in participation, information intervention, and procedural intervention), capturing important structural and processual features of disputes over license decisions. Some of these variables (e.g., project age and size) were measured by information directly available on GitHub, whereas others (e.g., participants’ interventions) were coded in the spirit of grounded theory (Strauss and Corbin, 1990). The definitions and descriptive statistics of these variables are presented in Appendices I and II. While coding these variables was a laborious yet feasible manual task, detecting patterns across 183 cases is infeasible to do manually. This is perhaps one reason why inductive researchers have typically focused on only a few cases. Our approach allows us to escape this constraint, by using ML algorithms instead of manual analyses to induce patterns of inter-relationships in a much larger sample.

**Dispute resolution**

In our context, disputes are conflict or controversy situations where participants advocate different opinions or make distinctive claims about a software license and/or its attributes. The resolution of a dispute over a license requires an explicit decision (typically recorded by the owner) to (a) adopt or not adopt a license or (b) change or not change the license. The variable Resolution is coded as “1” when an explicit decision is taken, either to retain the current IP status (current license or owner’s copyright status) or change the current IP status (switch to or adopt a new license). In all such cases in our sample, we found no explicit dissent on the recorded
decision among the majority of participants in the discussion. *No resolution* therefore implies that no decision is taken due to failure to agree on a decision either to adopt a software license or to change the existing license.

**Context of the dispute**

**Issue type.** We found that disputes targeted two types of license issues: the adoption of a first license, which we term a “greenfield issue,” and the revision of an existing license, which we term a “brownfield issue.” The variable *issue type* captures this distinction and was coded based on reading all 183 cases manually. In our analysis, we examine whether dispute resolution processes are qualitatively different across these types of issues.

**Participation.** We identified three ways to conceptualize the scale of participation: *project group size*—the number of contributors in the project; *admin group size*—the number of participants who hold some decision rights (i.e., owners, collaborators, and administrators); and *discussion group size*—the number of commenting participants involved in the dispute discussion. Larger groups involved in a dispute may indicate the more contentious nature of the problem, and also make it harder to reach an agreement that is acceptable to all (March and Olsen, 1976; Olson, 1965; Ostrom, 1990).

**Characteristics of the dispute**

**Initiator characteristics.** Whether the initiator of the discussion was a project owner or not, and the amount of source code contributed by the initiator (contribution), could shape the amount of attention and support she receives from other participants. From prior research on operational disputes in online communities, we believe these variables may signify the competence-based status of the initiator (Dahlander and O’Mahony, 2011; Klapper and Reitzig, 2018). We obtained relevant information on the initiator’s characteristics from the GitHub interface.

**Initial polarization of opinions.** Discussion groups could vary in terms of how different their participants’ opinions are on licenses initially (support for alternatives). The *initial
polarization of opinions could, for example, make convergence more difficult (Maciejovsky and Budescu, 2013). We measured this by reading all 183 cases and coding the diversity of opinions in the initial stages of the discussion.

**Project age.** We measured project age by the days elapsed since initiation of the project and the time the license discussion arose. Project age is a common correlate to many aspects of online communities (e.g., Grewal, Lilien, and Mallapragada, 2006). In particular, project age may be related to the extent participants in the community feel a need to settle on a license in order to safeguard project success (Subramaniam et al., 2009).

**Resolution process**

**Interventions.** Participants could intervene in the dispute resolution process either by providing relevant information (e.g., answering a specific question about licensing) or by influencing the procedures of the resolution process (e.g., initiating a vote, adding a member). These interventions were hand-coded by reading all 183 cases.

**Imbalance in participation.** While certain participants are very active and could sometimes dominate a discussion, others are relatively silent and only comment occasionally during the entire course of the discussion. Imbalance in participation has been shown to be an important parameter in the life of online communities (e.g., Arazy et al., 2011; Shah, 2006). We computed this using the Gini coefficient of participation across all discussion participants.

**Step 2: Establishing robust patterns**

We utilize a core function of machine learning (ML)—the selection of important predictor variables (also known as feature selection) for removing variables that are redundant (i.e., adding little unique information) or overfitting (i.e., failing to predict across subsets of the data). Because different algorithms implicitly feature different families of functional forms, they may not generate the same predictive model (Abu-Mostafa, Magdon-Ismail, and Lin, 2012). We therefore searched for variables that are consistently identified across different algorithms and subsamples, and appear in models that make good out-of-sample predictions. Specifically, we
chose LASSO (least absolute shrinkage and selection operator), its variants with bootstrap aggregation, LASSO in combination with artificial neural networks (similar to the approach of Zhou and Jiang, 2003), and ridge regression (Tibshirani, 1996). These algorithms are very useful for selecting the most important variables that have robust associations with the outcome of interest. More details on these algorithms are available in Appendix III.

Our approach holds three key advantages over using standard statistical tools such as regressions to identify associations that seem statistically significant (e.g., drawing on linear regression or comparison of means and cross-tabs; see Glaser, 2008). First, when searching for robust patterns rather than testing hypotheses, tests of significance can be misleading (e.g., significant relationships need not be important predictors). Second, the associations established through regression models that fit the data may be sample specific (i.e., relationships need not be robust beyond the sample, the primary challenge created by “p-hacking”). Techniques for assessing the robustness of findings to sampling error are necessary for an exercise such as ours. Third, regression models or correlations assume particular functional forms (outcomes or likelihoods of outcomes are modelled via linear functions of covariates), which may become too restrictive if the study aims to inductively build theory.

**Step 3: Interpreting and explaining the patterns**

While ML algorithms generate a predictive model based on the robust associations detected in the data, such a model by itself is not an explanation (Mullainathan and Spiess, 2017). In the final analytical step, we explore more detailed qualitative data and reason abductively (Bamberger, 2018; Peirce, 1878) to provide internally consistent explanations for the patterns detected in Step 2. To this end, we created a random sub-sample of 61 cases for textual analysis and explanation, aimed at developing an in-depth understanding of the processes. Taking a grounded theory approach (Strauss and Corbin, 1990), two researchers independently coded these cases using Nvivo. This round of qualitative analysis generated 27 open codes (Strauss, 1987) of which 7 codes (Table 1) capture the dispute resolution process, 10 codes (Table 2)
capture the interventions exercised by participants, and 10 codes (Appendix IV) capture license attributes.

‘Insert Tables 1 & 2 here’

Next, we conducted axial coding (Strauss and Corbin, 1990) and grouped open codes into broader themes. These themes reflect the temporal order in which a dispute unfolds (i.e., genesis, dispute process, and resolution outcome). Further, we analyze the theoretical relationships among these broader themes and position them in the causal link accordingly. Our interpretations, generated abductively through iterations with data and literature where necessary, gave rise to a process model of governance dispute resolution in online communities.

**FINDINGS**

In what follows, we describe what we found at each stage and the questions our findings further engendered in the sequence they occurred. Our objective is to enable readers to understand (and replicate) the process of our investigation.

**Identifying robust patterns in the data**

Using a combination of ML algorithms (detailed results are presented in Appendix V), we were able to identify models that (i.e., with ANN plus LASSO) had between 72.24% (F1 score = 0.072 and MCC = 0.43) and 75.40% (F1 score = 0.74 and MCC = 0.52) accuracy.

The pattern of robust association we found is striking, both in what it includes and excludes. Consistently across all algorithms, four variables—discussion group size, informational intervention, procedural intervention, and issue type (i.e., greenfield vs. brownfield)—emerged as robust predictors of resolution. Project age, project group size, admin group size, initiator status, initiator contribution, initial polarization of opinions, and imbalance in participation turned out not to be important in predicting resolution or non-resolution. Recall that our initial reading of eight cases led us to identify a list of 11 variables. If we had stopped at Step 1, we might have...
concluded that all those variables were relevant for explaining dispute resolution in online communities. However, in the full sample not all variables identified in Step 1 turned out to be robust predictors of resolution. Put differently, Step 2 helped us remove the redundant variables, avoid overfitting our explanations to the selected sample of eight cases, and allow the subsequent analysis to focus on the robust and important set of variables in our context.

Further, among the variables identified as having a robust association with resolution, not all results are intuitive. In particular, discussion group size has a positive relationship with dispute resolution (i.e., discussions with more participants are systematically more likely to reach resolution). In most bargaining and conflictual situations, large size makes it harder for a group to reach a resolution (e.g., Olson, 1965; Ostrom, 1995; Roth, Murnighan, and Schoumaker, 1988). A possible explanation for our counterintuitive finding about group size is that a large number of discussants reflects the importance of a project, thereby creating a stronger intent among participants to resolve intellectual property disputes or willingness to defer to others’ opinions. However, if this reasoning were accurate, the variables project group size or administrator group size should have appeared as robust predictors. Because project and administrator group sizes were not robust predictors, we ruled out this alternative explanation.

Understanding the antecedents of resolution

To explain the causal structure in the pattern of relationships among the variables we uncovered through machine learning, we next conducted in-depth qualitative analysis of the governance disputes.³ We took a random sample comprising one third of the total cases (N = 61) for detailed examination, using open and axial coding. In terms of pattern detection, this sub-sample is representative of the full sample, since it is a random sub-sample. We also verified that the ML analysis revealed the same key predictors of resolution in this sub-sample.

Attribute-based discussions are resolved more often than alternative-based discussions

³ We also conducted fuzzy set QCA with the key predictors (reported in Appendix VI). The results are consistent with the insights from the content analysis reported here.
After coding the textual data of the sub-sample 61 cases, we found that a governance dispute could be initiated around one of the two themes—license alternatives or attributes of these alternatives. Commonly discussed license alternatives included MIT, BSD, LGPL, and GPL. Commonly discussed license attributes included permissiveness, protectiveness, compatibility, and ease of contribution by developers. Various license alternatives differed from each other on at least one of these attributes. Appendix IV presents the license attributes and alternatives discussed in our sample.

In the following excerpt from project *Elegant-mind*, one owner of the project started a discussion and suggested changing the current license from GPL to LGPL. Another owner joined and suggested that MIT might be a better alternative and the debate went on. This case is an example of an alternative-based discussion and it did not reach a resolution.

*Sjostoeiling*: I would like to start a license discussion. Evolution itself is licensed with GPL2, which is OK so far. But I think we do better, if we take LGPL for the core, because the core is a library and is used as a library (framework). Is it OK for you that we publish our enhancements under LGPL instead of GPL?

*Yama*: I think MIT is best, but is it difficult? If it is so, I think that LGPL is better.

Conversely, project Vis.js illustrates an attribute-based discussion, in which the dispute was resolved by adopting a dual license of Apache and MIT. One owner of this project states:

*Josedejong*: Currently vis.js is licensed under the Apache 2.0 License. This license is incompatible with, for example, the GPLv2 licenses. I’m not sure how big this issue really is. But in order to better serve our users, we are considering whether it is useful to change the license. A few things are important for us: 1. as much as possible freedom for the user; 2. protection for the user (like against patent threats or changing the license conditions later on); 3. keep attribution (honor the people and our company investing so much in this library). While MIT is a nice fit for (1), Apache 2.0 better serves (2) and (3). We could choose one of the two, or even choose a dual license allowing both. Do you have any opinion on the licensing of vis.js?

This distinction between attribute- and alternative-focused discussions did not arise from the application of machine learning; rather it resulted from qualitative coding the textual data. The distinction turned out to be critical, because disputes that did not reach resolution (14 of 61 cases) consistently focused on license alternatives. Among these 14 unresolved governance
disputes, 12 started with discussing alternatives. Although these discussions touched on attributes at some point, they failed to completely turn the focus to attributes. In contrast, in the majority of disputes that reached a resolution (34 out of 47), participants either began with discussing attributes (16) and focused on them throughout or switched the focus of discussion from alternatives to attributes (18). When alternative-based discussions did achieve resolution (in 13 cases), it was through procedural interventions, either by a unilateral decision made by the owner (10) or by a voting procedure suggested by the participants (3). Our first interpretive insight is that disputes are more likely to be resolved when discussions focus on the license attributes, instead of on license alternatives.

To triangulate this insight against the patterns we had discovered through ML, we also assessed whether the predictors of resolution were positively associated with an attribute-based discussion. Since we had data on attribute- versus alternative-based discussions only in 61 cases, we created 1,000 bootstrap samples of these cases and ran the same logistic regression model in each sample, with discussion group size, issue type, procedural intervention, and information intervention as predictors of an attribute-focused discussion. This procedure is known as bootstrap aggregation or bagging (Abu-Mostafa et al., 2012).

The results show that in 815 of the 1,000 samples, discussion group size had a positive effect on a discussion being attribute focused (with an average coefficient of 0.043). Similarly, in 1,000 out of the 1,000 samples, brownfield issue type had a negative effect on a discussion being attribute focused (with an average coefficient of −1.175). These results strongly suggest that attribute-focused discussion is the mechanism that connects the two predictors of resolution we found through ML (i.e., discussion group size and issue type) and resolution outcome. Additionally, informational intervention had a consistently negative (822 of 1,000 samples) but small effect on attribute-focused discussions (−0.02), indicating that more such interventions inevitably arise as the discussion progresses without resolution. Procedural intervention had a consistently positive (716 of 1,000 samples) effect on attribute-focused discussions (0.08). It is
also likely that informational interventions complicate the discussion and create further divergence whereas procedural interventions simplify the discussion and facilitate convergence.

Next, we qualitatively analyzed the discussion data with the aim to understand why larger discussion groups or greenfield projects might systematically be more likely to feature attribute-based discussions around licenses.

_Switching from alternative-based to attribute-based discussions: The role of reflective agency_

We found it noteworthy that even those governance disputes that start with discussing alternatives, at some point may undergo an important change toward attributes. We define this critical point where the focus of a dispute pivots from license alternatives to attributes as a “switch.” The following snippet illustrates such a switch:

_Trustmaster:_ “I agree with Alfredo and would recommend following the best practices of the open source world by choosing either MIT or Apache. The more limitations are imposed on a project, the less likely it is that people (and companies, which is important) keep contributing to it over time.” (Project Jsfbp)

In the above example, the discussion pivoted toward reflecting on what attribute is really important for their communities (e.g., permissiveness or little constraint). Once the desired attribute became clearer to the participants, the process looked less like bargaining in a search space defined by alternatives, and more like collective problem solving in a search space defined by attributes. The dispute in project Jsfbp was eventually resolved by adopting the MIT license.

A focus on the attributes allows the participants to learn about their individual preferences regarding attributes, discover the convergence (or the lack of it) of preferences, and search for one or more alternatives that satisfy those preferences. Therefore, we conceptualize this mode of dispute resolution as “problem solving.” In contrast, when focusing on alternatives, disputants engage in bargaining over the merits or drawbacks of different alternatives.

Accordingly, this mode of governance dispute resolution can be conceptualized as “bargaining.” In the following paragraphs, we show in detail how these two modes of dispute resolution distinctly unfold.
We found that participants in some disputes anchored their advocacy of a preferred alternative on the group’s preferred attribute in order to gain support. For instance, a contributor kripken in project Servo advocated the MIT license as a feasible alternative because of its permissiveness—an attribute that later turned out to be preferred by most participants in the group. After an extensive discussion a resolution was reached—the main repository of Servo was licensed under MPL2, and the rest under a dual license of Apache and MIT.

Kripken: There could be a big benefit to using the MIT license as this would be the only browser available under a permissive license (WebKit is LGPL, Gecko is MPL, others proprietary). Even without debating the benefits of permissive licensing, there is a benefit to having different licensing than existing browsers to fill a different need and attract new users.

Further, we found that focusing on attributes enabled resolution by making participants more open to being persuaded. For example, in project Telegram-bot, the discussion started as a debate over alternatives between the owner Yagop and a contributor Asdofindia.

Asdofindia: AGPL fixes a loophole in GPL license that renders GPL useless when it comes to telegram-bot... That’s why Diaspora, Wordpress, etc. use AGPL. I think AGPL is the best for our telegram-bot too. Since Lua isn’t compiled to binary, GPL offers no protection at all, at the moment.

Yagop: I want to keep GPL, at least at the moment.

Asdofindia: I’m just telling you that you may as well release this in public domain because it gives the same protection that GPL does to your hard work—no protection....

Fortunately, a collaborator Rockneurotiko pointed out that “I think that you guys misunderstood AGPL. AGPL protects the source code server over the network, like webpages, but telegram-bot doesn’t serve the source code over the network, it is just running as if it were a binary, so GPL protects it exactly the same way as AGPL.” and established code protectiveness as a preferred attribute among disputants. From that point on, the discussion turned into a collective problem-solving process and participants converged toward AGPL license.

The qualitative analysis of the textual data revealed a second insight: the switch from alternative-based discussion to attribute-based discussion results from a set of actions that we conceptualize as “reflective agency.” Specifically, we define reflective agency

Electronic copy available at: https://ssrn.com/abstract=3567391
as social actions that are rooted in critical interpretation and mindful reflection and that can be exercised by one or more individuals. In our sample, we found two different yet interrelated forms of reflection: challenging or re-examination of an underlying attribute of a particular license and analyzing and comparing underlying attributes across different license alternatives.

The following snippet illustrates how a participant challenged the current understanding of GPL:

Hopeseeks: Man. Whomever thinks the GPL is “open source” needs to get their heads checked. It’s like saying Communism’s forced appropriation of everyone’s creations is the ultimate form of “Charity” :D (Project Utilphp, resolved, decided against GPL)

On the other hand, the quote below shows how a participant compared the underlying attributes across different license alternatives and how such a comparison revealed commonality and differences across licenses:

Josdejong: [I]n order to better serve our users, we are considering whether it is useful to change the license. A few things are important for us: 1. as much as possible freedom for the user, 2. protection for the user (like against patent threats or changing the license conditions later on), 3. keep attribution (honor the people and our company investing so much in this library). While MIT is a nice fit for (1), Apache 2.0 better serves (2) and (3). (Project Vis, resolved, adopted a dual license of Apache and MIT)

These reflections help to reframe the issue at hand by finding the underlying attributes that are at the heart of the community’s governance principles. For example, in project Agar.io-clone, after the owner Haytd expressed his confusion, developer Ariamiro summarized compatibility and simplicity as the attributes that differentiated the large subset of alternatives discussed, substantially reducing the complexity of comparing and contrasting license alternatives. This dispute was soon resolved by adopting MIT as the final license.

Haytd: Actually, for me, this product is 100% free and open for everyone, you can use it in any purpose. I don’t know if there is any license to match this. And how about what other contributors think?

Ariamiro: If you want people using the game for any purpose choose Public Domain; if you want a good and simple license choose MIT. I don’t recommend that you continue without a license.

We did not find any evidence that status (e.g., project owner or contributor) mattered for the expression of reflective agency. Instead, we observed that any participant engaged in such
reflections could transform the discussion from bargaining to problem solving, by challenging and analyzing the current state of discussion. Our concept of reflective agency is consistent with Dewey’s work that emphasizes the role of individual actions in transforming public communication (Dewey, 1922).

Online communities attract people with a vast array of expertise and backgrounds (Wang et al., 2015). This diversity creates two collaboration challenges in license decisions: First, members may not agree on which license alternative is more desirable. Second, members have different understandings of license alternatives, and thus may find it difficult to find the alternative that scores the best on the commonly desired attributes. When disputes arise, reflective agency solves the first problem by reframing the discussion from bargaining over which alternative is better into comparing the alternatives in terms of various attributes. It then tackles the second challenge by reflecting on the discussions and generating a shared understanding of the different alternatives. When this understanding is collectively accepted by group members, it creates a common ground for agreement (Bechky, 2003; Leonardi, 2015). Coupled with alignment of preferences over attributes, the result is a successful resolution.

Note that although switches make the functioning of reflective agency more visible, it is quite likely the discussions that already began with a focus on attributes are just as much an instantiation of reflective agency. Some participants may be able to conceive of a discussion as being more likely to be productive if it can be initially focused on attributes.

**Reflective agency in different issue configurations**

The value of procedural interventions is intuitive, because these interventions resemble mediation in an ADR system, although interventions in our context do not need to be carried out by individuals who hold specific roles. The negative association between informational interventions and resolution is understandable once we realize that the longer the discussion remains unresolved, the more information is likely be introduced by participants. While procedural interventions simplify the discussion and facilitate convergence, informational
Interventions may also complicate the discussion and create further divergence. However, why resolution should be easier in greenfield issues and larger discussion groups is less clear, particularly since reflective agency is not specific to project owners (i.e., contributors and regular participants also exercise this function). To answer this question, we conducted further qualitative analyses (Appendix VII), comparing greenfield versus brownfield issues and large (N > 11, which is the mean size) versus small discussion groups (N < 11).

This comparison leads to a third insight: brownfield and greenfield issues differ substantially in their possible paths to resolution. We found that for a project to preserve the integrity of software written under an existing license, changes in license (i.e., brownfield issues) can only be made to a new license that is backward compatible. The requirement of license compatibility restricts the space of available alternatives from which the next license can be selected. In brownfield issues, the existence of a license may itself center the discussion on alternatives to that license, preventing the discussion from switching toward attributes, and eventually from reaching resolution. This is evident in project Toxcore, in which participants repeatedly went back to the original license LGPLv3, and were not willing to deviate from it.

In contrast, in greenfield issues the search for a license can proceed more freely along both license attributes and alternatives. For example, in project Oh-my-fish, although there were only four participants, they were able to cover a broad range of possible licenses. Were the dispute resolution process a pure bargaining one, the existence of a status quo and the subsequent fixation on it would act as a focal point that promotes convergence to a negotiated outcome (e.g., Schelling, 1960). As bargaining is a mixed-motives game involving both elements of conflict and coordination (Schelling, 1960), anchoring by all participants on a common reference point can promote rapid agreement, though not necessarily an integrative one. The absence of such an effect reiterates that a pure bargaining perspective does not offer a good explanation for our data.
The qualitative comparison also allows a more comprehensive explanation of why a larger discussion group size is advantageous for dispute resolution. When we examine and compare the dispute processes in depth, it became clear to us that the likelihood that someone displays reflective agency by reframing the discussion around attributes is higher in larger discussion groups. Larger groups such as *WordPress* and *Toxcore* typically featured reflective agency, whereas smaller discussion groups such as *Elegant-mind* and *Drawile* did not.

An explanation for this size effect can be given as follows: consider \( x \) as the probability of any individual in a discussion group being able to convincingly frame the discussion in terms of attributes (i.e., a particular individual would exercise reflective agency). Even if \( x \) is low, the probability (denoted as \( p \)) that at least one individual will do so successfully (i.e., the emergence of reflective agency in the group), which is \( 1-(1-x)^n \), grows rapidly with group size \( n \). For instance, \( p \) is close to 80% even if \( x \) is only 30% for \( n = 5 \). This is a corollary of the Condorcet jury theorem well established in experimental and field research on group problem solving and decision making (e.g., Laughlin, 2011; Lorge and Solomon, 1955; Nemeth, 1986; Wittenbaum and Stasser, 1996). Therefore, a problem-solving perspective (e.g., Laughlin, 2011) provides a fitting explanation for what we have observed.

In sum, reflective agency makes a discussion more likely to be attribute-based (rather than alternative-based). It more often emerges in greenfield discussions because of unconstrained search space and in large groups because of a higher probability that at least one individual will display reflective agency.

**Alignment of preferences on attributes as a necessary condition**

An important necessary condition also emerged from our analysis: the high rates of resolution in governance disputes that are attribute focused are possible only when there is alignment in the community on what the important attributes are. In theory, participants could disagree just as violently over attributes as they would over alternatives. However, our analysis revealed a strong alignment in participants’ attribute preferences in most of the projects in our
sample. Our open coding of the textual data revealed that even though the disputes touched upon numerous attributes, only three—permissiveness, protectiveness, and compatibility—remained prominent throughout the sample. Further, among the discussions in which permissiveness was raised, 31 discussion groups subsequently adopted a permissive license (e.g., MIT and Apache).

For those familiar with OSS development, this strong alignment of preferences over attributes is hardly surprising. Participants join OSS communities in part because they value sharing and collaboration (Belenzon and Schankerman, 2015; Ren, Chen, and Riedl, 2016; Shah, 2006). Individuals embracing an open source ideology self-select into such online communities (Stewart and Gosain, 2006). Therefore, not only do participants in this context have alignment of preferences on attributes, but they are also likely to be aware of the social norms in the communities that conduct such projects (Stewart and Gosain, 2006). Self-selection by participants thus ensures that within a specific project, they are likely to find at least some common ground around certain attributes. The following snippets provide evidence that within project Btcfoundation, participants converge on a fundamental value—openness. The participants eventually opted for the MIT license and resolved the dispute.

_Pmlaw:_ It’s not about being religious, just read the licenses: MIT is more open than GNU/GPL. GNU/GPL imposes your view of the world on every downstream user. Of course, the committee is free to make whatever decision it likes, I was asked for my opinion and I offered it.

_Johnness:_ I’m not interested in a license that forces a similar openness on future users, or demands attribution. I think the most open license possible would be best. From what has been presented so far, it sounds like the MIT license is our best bet. I recommend we go with that.

With strong preference alignment, attribute-based discussions could then proceed to resolve the governance disputes. However, when such alignment is absent, attribute-based discussions did not lead to resolution. For example, in project Toxcore, although the license dispute started off with a focus on the attributes (i.e., compatibility and freedom), the participants were rapidly divided into two camps, with one strongly favoring compatibility for
maximizing market share, and the other favoring permissiveness (freedom) over commercial success. As a result, no resolution could be reached:

*The Austin Howell:* Free software is free software; I don’t care what Stallman says. Ensuring the privacy of possibly hundreds of millions of people is more important than the license. To do this we should have a license that ensures maximum market share.

*TrevorDark:* All I can see LGPL doing for this software is creating non-free user interfaces for it, which just doesn’t make sense. And frankly I think non-free interfaces to Tox is kind of a frightening idea, just a bad idea in general.

However, the alignment of preference on attributes is not a sufficient condition for resolution. Unless an attribute focused discussion is triggered through reflective agency, the alignment may not even be discovered, let alone useful. In the next section, we condense the causal logic underpinning our findings into an inductively derived theoretical model of the dispute resolution process in online communities.

**EMERGING THEORY**

Given our findings, we develop a theoretical model integrating group process and group property to explain the resolution of disputes pertaining to core governance principles in online communities. Our central argument is that disputes that take the form of collective problem solving in attribute space enjoy a higher likelihood of resolution than those that resemble bargaining in the alternative space. This is conditional on the alignment of participants’ preferences over attributes—an alignment grounded on participants’ self-selection into the OSS community.

**Group process: The importance of reflective agency**

Our emerging theory stipulates that governance disputes in communities are resolved through two distinct group processes: problem solving and bargaining (see Figure 2). When a dispute discussion focuses on the attributes from the onset or manages to switch the focus to attributes at some point of the process, it resembles problem solving and is more likely to attain resolution. This is facilitated by “reflective agency,” whereby one or more participant(s) reflects on the problem underlying the (potential) dispute and recognizes a productive path forward.
Reflective agency steers participants in disputes away from advocating one over another alternative, to searching for an alternative that satisfies commonly preferred attributes.

‘Insert Figure 2 here’

**Group property: The importance of preference alignment**

Reflective agency by itself does not ensure resolution. A second necessary condition for resolution is that preferences over governance principle attributes are largely shared among discussion participants. In OSS communities, the salient role of self-selection (i.e., voluntary joining) makes this condition possible. In firms, the alignment of preferences on key attributes may also emerge through sorting—either in attention to such preferences for hiring new employees or allowing employees to self-select into projects.

**DISCUSSION**

Governance disputes and their resolution are critical in the lives of communities, yet they have been under-studied and under-theorized. Exploiting the availability of complete archival records for discussions in GitHub communities, we studied how disputes vis-à-vis the software license—a core governance principle of these communities—are resolved. We found that when governance disputes in communities bear the signature of group problem-solving processes rather than a multi-party bargaining process, they are more likely to be resolved. However, such a resolution is far from inevitable, and our theory reveals two necessary conditions: the emergence of reflective agency and the alignment of preferences over attributes. Reflective agency is manifested when at least one individual in the group is able to reflect on the problem and transform or initiate the discussion along the lines that are attribute focused (rather than alternative focused). This conceptual “transposition” of the discussion into the problem-solving domain facilitates resolution under conditions where there is a pre-alignment of preferences among participants around key attributes of the governance principles. Although the
counterfactual is unobservable, it is logical to expect that in the absence of reflective agency, even if participants have aligned preferences over attributes, they may not discover this important fact and therefore miss the opportunity for resolution.

Our theory has important boundary conditions regarding types of disputes and communities. First, this theory is derived from studying disputes arising from license decisions in governing intellectual property. While such decisions are core to any organization, they represent only one type of governance principle, albeit a central one. It is possible there are other governance principles at stake in online or offline communities, such as the development of procedures on how to resolve operational disputes, for which community members may share little alignment on preferences. Thus, we call for research that explores the process of dispute resolution over other types of governance disputes.

Second, our theory was inductively built from a context (OSS development) in which members, to a large degree, share common preferences because of self-selection (Butler et al., 2014; Von Krogh et al., 2012; Spaeth, von Krogh, and He, 2015) and contribute to the production of a public good (Lerner and Tirole, 2002). Shared preferences such as a commitment to voluntarism, learning, openness, and sharing of code are known to draw volunteers into such online communities (Dahlander and O’Mahony, 2011; Stewart and Gosain, 2006). The high degree of alignment in preferences over attributes is a result of effective sorting (self-selection) mechanisms in online communities. There are at least two reasons why sorting could be more effective in online communities.

First, online communities are not necessarily restricted by a common geography (Mahony and Lakhani, 2011) and thus may enjoy a broader base for sorting than other communities where those restrictions apply. Second, the transparency resulting from permanent, electronic records (Marlow, Dabbish, and Herbsleb, 2013) creates clear guidelines for individuals to self-select in or out of an online community. In contrast, offline communities rarely have such transparent documentation of community members’ preferences. New members often need to
learn the encrypted value, norm, and culture through an extended process of socialization. Despite porous borders and freedom to exit, considerable time may elapse between joining and a member’s decision to exit (due to incompatible preference) in offline communities. Thus, if one would take a cross-sectional look into an offline and online community at any point in time, the latter will possibly have a higher level of preference alignment.

However, we are cautiously optimistic about the relevance of our results beyond online communities. Preference alignment on attributes may be a broad-based feature of communities, more so than scholars have hitherto imagined. For example, in many of the communities surrounding the common pool resources (CPR) that Ostrom and colleagues (Ostrom, 1990; Wilson et al., 2013) studied, membership at birth together with the process of growing up within these communities must undoubtedly facilitate the internalization of group norms, thereby affecting and to some extent aligning individual preferences. This alignment may both prevent and help resolve governance disputes.

Furthermore, today even traditional (offline) communities—be they communities of practice within a firm, research collaboration, or social movements—rely extensively on digital tools. Many companies have already been using online discussions and virtual collaboration tools (e.g., Slack, Zoom, Monday.com) among employees and with partners or customers. The global pandemic created by COVID-19 has expedited this trend by propelling organizations around the world to adjust rapidly to remote collaboration. The insights generated by our study have implications for the leadership and coordination of all these forms of virtual collaboration.

Despite its limitations, our study contributes to the literature on community governance in general and dispute resolution in online communities in particular. It extends the understanding of dispute resolution in online communities from an operational one (e.g., Forte et al., 2009; Klapper and Reitzig, 2018) to a more strategic one. Our theory explains otherwise puzzling observations about OSS communities, such as the rare occurrence of governance disputes and the positive association between discussion group size and resolution. First, we
contend that because participants’ self-selection into these communities generates a degree of pre-alignment on preferences over attributes, governance disputes are rare in these communities. Second, our theory predicts that when disputes do break out, larger groups may be more likely to see resolution because of a higher probability for reflective agency to emerge. Our theory thus constitutes a starting point for future empirical work on communities operating in online and offline settings, possibly covering a broader range of governance principles that define, bestow, and distribute rights and rewards on community members (Lerner and Tirole, 2002; Ostrom, 1990) beyond intellectual property.

Beyond its theoretical implications, our two-pronged approach advances inductive methods by separating pattern detection and pattern explanation that are traditionally entangled. When detection and interpretation occur simultaneously, two risks arise. First, cognitive constraints limit the number of cases researchers may be able to analyze, thereby raising the risk of overfitting (i.e., the explanation may be valid in the small sample studied but does not extend to other samples). Second, researchers’ confirmatory biases and motivated information processing may lead to false positives or false negatives (e.g., seeing patterns that are explainable in an intuitive or interesting manner versus not seeing others that are less intuitive). Our approach takes some steps towards mitigating both risks. Compared to traditional inductive research methods, our approach can handle a larger number of cases—an improvement that allowed us to be confident that our detected pattern is not a result of overfitting. As a consequence, the resulting insights from our approach should have an advantage in making out-of-sample predictions—the ultimate objective of all (inductive) theorizing.

Further, our approach integrates insights from both quantitative and qualitative analyses, where neither alone could have fully explained the phenomenon of interest. The use of ML algorithms enabled us to effectively detect robust patterns in data. These robust patterns, which formed the basis for our abductive reasoning, were detected algorithmically, and are replicable by others who use the same data and procedures. Subsequently, we interpreted the textual data,
narrowing down the cases to examine in depth based on results of the algorithmic analysis. We related our interpretations to existing literature—elements of inductive research that are not replaceable by algorithms—to offer our explanation to this pattern. Our work is among the first empirical studies in the field of strategy to combine ML with more traditional sense-making approaches for theory induction.

Finally, our emerging theory informs the practice of community governance in both online and offline settings. Given the importance of reflective agency we found in our study, an implication is that those who help govern communities, when they cannot rely on traditional hierarchical structures or ADRs to aid dispute resolution, may yet rely on a combination of reflective agency aided by alignment on preferences created through sorting. Rather than count on the chance that reflective agency will emerge, they might recruit individuals with the capacity for reflective agency, identify them (e.g., based on text analysis of prior online interactions), or even train moderators of communities in using such skills.

Similarly, insofar as the presence of a permanent, transparent record of the community’s preferences and the absence of geographic constraints facilitate more effective sorting, offline communities or even traditional organizations could benefit from comparable practices. First, these communities and organizations could increase the transparency of the values and preferences shared in an organization or a community. An initial step involves simply better documentation of values and the next step requires more effective communication, which could be achieved by improving internal communications, especially during the on-boarding phase and transmitting clear, authentic signals when communicating externally. Second, these communities and organizations could also resort to online processes for dispute resolution. The full visibility and archiving available in online processes might help to resolve disputes in a manner superior to offline interactions (Marlow et al., 2013).
CONCLUSION

This study explores the question of how communities resolve governance disputes. Gathering data from discussions surrounding software license decisions, we employed a combination of machine learning and qualitative methods to detect and explain patterns in the data. Our findings on how OSS communities settle principles for governing intellectual property led to an emerging theory, stipulating that governance disputes in these communities are resolved through two distinct process—problem solving and bargaining. When a dispute discussion focuses on the license attributes, it resembles problem solving and is more likely to attain resolution. The switch from an alternative-based to attribute-based discussion rests on reflective agency that reframes the discussion by decomposing conflicting opinions into shared preferences. Larger groups and discussions that are not constrained by a status quo, are more likely to reach resolution because of a higher probability for reflective agency to emerge. Our work contributes to the rapidly growing literature on the effective functioning of online communities, and to the broader literature on community governance and dispute resolution.
Table 1. Dispute resolution process

| Aggregate themes          | Open codes with examples of representative quotes                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------|
| **Dispute genesis**       |                                                                                                                     |
| - Disputes on alternatives|                                                                                                                     |
|   Expressing clear preferences over alternatives | “I’ve always been a fan of MIT. I don’t know what we should be thinking about legally here, but it’s my go-to license and I love seeing GitHub open source software licensed under it.” (A participant in project *Atom*) |
|   Expressing indifference between alternatives | “I’m fine with all 4 of those licenses (LGPL, Apache2, BSD, MIT) if they’re necessary to get wire onto workshop.” (A participant in project *Wire*) |
| - Disputes on attributes  |                                                                                                                     |
|   Disputing attributes via dialogue | “The Ms-Pl is incompatible with many free software licenses, as it imposes a unique restriction: (D). If you distribute any portion of the software in source code form, you may do so only under this license by including a complete copy of this license with your distribution...” “There are many GPL-, LGPL-, and AGPL-licensed libraries, yet we cannot legally combine these with DotNetZip due to the terms of the Ms-Pl.” “Dual-licensing under Apache 2 or MIT would resolve the problem. As GitHub notifies people who are mentioned, re-licensing would involve pasting the list of contributors into this thread and asking for a release of their copyright. Getting approval can take anywhere from a few days to several months, depending upon contributor awareness. We would also need to get approval from @DinoChiesa for the original code on SVN.” (Three participants in project *DotNetZip.Semverd*) |
| **Resolution process**     |                                                                                                                     |
| - Bargaining in alternative space | Remaining in alternative space by not defending options | “CC-BY SGTM.” “I’m happy with CC-BY.” (Two participants in project *Presentations*) |
| - Problem solving in attribute space | Remaining in alternative space through failure to switch to attributes | “@Riamse, care to expand on your ‘no,’ please?” “No. Just close the issue, you’re never going to change my mind.” (Two participants in project *Afch*) |
|                           | Collectively solving issues of license fit for project | “I think that you guys had misunderstood AGPL. AGPL protect[s] the source code server over the network, like webpages (that’s why diaspora, wordpress, is AGPL), but telegram-bot doesn’t serve the source code over the network, [it] is just running like if it were a binary, |
so GPL protect[s] it exactly the same ... [as] AGPL. Even more, you can’t communicate telegram-bot over the network. It’s tg who communicates with telegram-bot, and the telegram servers with tg. Check this and this.” (A participant in project Telegram-bot)

Building a common understanding of license specifications

“@Scotchester, that’s a great question. Luckily, I don’t think we have to worry about it. All external dependencies are pulled in after checkout: JavaScript and CSS via Bower, and Java and Clojure via Leiningen. The repo should have no external code in it currently. Given @NoahKunin’s comments and @tauberer’s document, I’m convinced. Let’s take @marcesher’s advice and wait until @virtix can comment, but this pull request has my +1.” (A participant in project Qur)

- Switch

The point where the focus of a discussion shifts from alternatives to attributes

“Yes, a dual license does not need to be compatible, but I was pointing out that if the default license was CC0, CC-BY, or CC-BY-SA, then it would not matter that a user added the CC-BY-ND as alternate license. The default, freer license would already grant more rights and there would be no way for users to force the non-default license. I’m against CC-BY-ND as the default because most people won’t change it and my opinion is that we should promote free culture here. [Segue to next debate point]...”

“In summary, Freeeeeeeedeooooooommmmmmm.” (A participant in project terms of serive_206)

“Yes, but basically you don’t expect any reward from dishonest people and honest people won’t hesitate rewarding you if they succeed. This is proven to work by many open source projects, like Node.js itself for instance. I agree with Alfredo and would recommend following the best practices of the open source world by choosing either MIT or Apache. The more limitations are imposed on a project, the less likely it is that people (and companies, which is important) keep contributing to it over time.” (A participant in project jsfbp_3)

Resolution outcome

- No resolution

Failing to reach a resolution in brownfield

“If we can’t get a sign-off, I don’t think relicensing is possible.” (A participant in project DotNetZip.Semverd)

Failing to reach a resolution in greenfield

“As I read it currently, even using the modern.IE images as they are clearly intended by MS is not compatible with their own licensing. Until all of that gets sorted out, I can’t license ievms in a traditional sense. I hope you understand.” (A participant in project Ievms)

- Resolution

Reaching a resolution in brownfield

“I have made a pass at replacing the LGPL license with BSD throughout the codebase, and I’m going to mark this fixed. If there’s any additional changes needed to migrate, file new issues for those please.” (A participant in project Ffi)

Reaching a resolution in greenfield

“Thanks for bringing this to my attention. I wasn’t aware that certain countries had such restrictive default licenses. I’ve added a license file (WTFPL) so people know where they stand.” (A participant in project Awesome-php)
### Table 2. Interventions during a dispute process

| Actions                          | Specific activities                      | Illustrative quotes                                                                                                                                 |
|---------------------------------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| **Procedural interventions**    |                                         |                                                                                                                                                      |
| **Close a discussion**          | Include a participant                    | “@wikipedia-mahdul—Still awaiting your vote.” *(Nathan2055 in project Ajof)*                                                                      |
|                                 | Exclude a participant                    | “@albanpeignier’s 1 contribution was merged post-LGPL, but technically written against the BSD license. Can probably scratch that off the list.” *(shoutset in project Ff)* |
|                                 | Conduct a vote                          | “Unless someone disagrees, I’ll create an issue in the next hours pinging everyone that has contributed to this project to ask for their permission to add an MIT license to this project.” *(Bpinto in project Oh-my-fish)* |
|                                 | Make a unilateral decision              | “The poll for the license of our materials is now closed. See the votes here. All of those who voted chose the MIT license for the materials. I modified the MIT license based on the license used in the Foundation’s bylaws and posted it here.” *(Nikosbentenitis in project Bitfoundation)* |
|                                 | Close a discussion                      | “Update: Let’s hold off for a little while. I have a call in to somebody more knowledgeable.” *(Kleinmatic in project Tabula)*                      |
|                                 | Re-open a discussion                    | “Just close the issue, you’re never going to change my mind.” *(Riense in project Ajof)*                                                             |
|                                 | **Informational interventions**          |                                                                                                                                                      |
| **Reveal personal preference of** | **Volunteer information about an attribute or an alternative** | “Nothing about a project being GPL has any bearing on what license I as a contributor use for my contributions. The GPL 2 states: You may not copy, modify, sublicense, or distribute the Program except as expressly provided under the License.” *(Mahkob in project Neovim)* |
| **Make a**                      | **Provide answers about an attribute or an alternative** | “Here’s a great example of how project-open-data handled their license migration: project-opendata/project-open-data.github.io#135.” *(Willnorris in project Hugo)* |
| **Conduct a vote**              | **Exclude a participant**               | “Just for tracking purpose: question for Timotheus’ code relicensing at https://en.wikipedia.org/wiki/User_talk:Timotheus_Canens#AFCH_relicensing” *(Wikipedia-mahdul in project Ajof)* |
|                                 | **Include a participant**               | “Is that compatible with the license for our resources?” *(LB in project ChessPlusPro)*                                                              |
|                                 | **Advocate the merit of an attribute or an alternative** | “Nothing about a project being GPL has any bearing on what license I as a contributor use for my contributions. The GPL 2 states: You may not copy, modify, sublicense, or distribute the Program except as expressly provided under the License.” *(Mahkob in project Neovim)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Here’s a great example of how project-open-data handled their license migration: project-opendata/project-open-data.github.io#135.” *(Willnorris in project Hugo)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Just for tracking purpose: question for Timotheus’ code relicensing at https://en.wikipedia.org/wiki/User_talk:Timotheus_Canens#AFCH_relicensing” *(Wikipedia-mahdul in project Ajof)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Is that compatible with the license for our resources?” *(LB in project ChessPlusPro)*                                                              |
|                                 | **Advocate the merit of an attribute or an alternative** | “Nothing about a project being GPL has any bearing on what license I as a contributor use for my contributions. The GPL 2 states: You may not copy, modify, sublicense, or distribute the Program except as expressly provided under the License.” *(Mahkob in project Neovim)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Here’s a great example of how project-open-data handled their license migration: project-opendata/project-open-data.github.io#135.” *(Willnorris in project Hugo)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Just for tracking purpose: question for Timotheus’ code relicensing at https://en.wikipedia.org/wiki/User_talk:Timotheus_Canens#AFCH_relicensing” *(Wikipedia-mahdul in project Ajof)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Is that compatible with the license for our resources?” *(LB in project ChessPlusPro)*                                                              |
| **Advocate the merit of an attribute or an alternative** | **Advocate the merit of an attribute or an alternative** | “Nothing about a project being GPL has any bearing on what license I as a contributor use for my contributions. The GPL 2 states: You may not copy, modify, sublicense, or distribute the Program except as expressly provided under the License.” *(Mahkob in project Neovim)* |
|                                 | **Advocate the merit of an attribute or an alternative** | “Here’s a great example of how project-open-data handled their license migration: project-opendata/project-open-data.github.io#135.” *(Willnorris in project Hugo)* |
| **Advocate the merit of an attribute or an alternative** | **Advocate the merit of an attribute or an alternative** | “Just for tracking purpose: question for Timotheus’ code relicensing at https://en.wikipedia.org/wiki/User_talk:Timotheus_Canens#AFCH_relicensing” *(Wikipedia-mahdul in project Ajof)* |
| **Advocate the merit of an attribute or an alternative** | **Advocate the merit of an attribute or an alternative** | “Is that compatible with the license for our resources?” *(LB in project ChessPlusPro)*                                                              |

"[O]ne reason it’s important for code like this to be truly open source: someone—the good guys—could use it to simulate various voter registration fraud scenarios in a controlled environment, in order to come up with ways to detect and defeat such fraud. One never knows the unexpected but legitimate uses to which code might be put; therefore one never knows in advance the full effect of seemingly innocuous restrictions." *(Kjøgel in project Voter-registration)*

"Apache license includes permission to use patented material freely, and really spells out the BSD license. That’s why I like it. Plus, we can change the license as we want without the silliness with the GPL." *(A participant in project Wire)*

"I’m in favour of free (as in speech), so the most permissive possible :)" *(Patow in project World Citizenship)*

"My requirements for a license are just two things: 1. I want as many people to use my code as possible. I want as few barriers as possible, both legal and mental. 2. I want it to be as clear as possible to developers who are not lawyers that the above is true." *(Natefinch in project Hugo)*

"Nothing about a project being GPL has any bearing on what license I as a contributor use for my contributions. The GPL 2 states: You may not copy, modify, sublicense, or distribute the Program except as expressly provided under the License." *(Mahkob in project Neovim)*

"Here’s a great example of how project-open-data handled their license migration: project-opendata/project-open-data.github.io#135." *(Willnorris in project Hugo)*

"Just for tracking purpose: question for Timotheus’ code relicensing at https://en.wikipedia.org/wiki/User_talk:Timotheus_Canens#AFCH_relicensing” *(Wikipedia-mahdul in project Ajof)*

"Is that compatible with the license for our resources?" *(LB in project ChessPlusPro)*

"@mlubin: Yes, we should add a clause to the site license saying that all content is MIT unless otherwise indicated. (StefanKarpinski in project Julidang)"
Figure 1. Research questions and analytical steps

RQ: How are governance disputes resolved in communities?

**STEP 1**

Understanding the phenomenon of dispute resolution in online communities

- Reading of 8 cases in depth by each author
- Comparing, contrasting, and sharing our interpretation
- Consulting related literature

Defined resolution and developed a list of 11 variables to capture the structural and processual features of a dispute

Coded these predictors in the entire sample

**STEP 2**

Applying machine-learning algorithms for detecting robust associations (N= 183)

- Algorithm 1: Lasso only
- Algorithm 2: Lasso + Bagging
- Algorithm 3: Lasso + ANNs
- Algorithm 4: RIDGE only

Found discussion group size, informational intervention, procedural intervention, and issue type consistently predicted resolution

Why is resolution more likely in larger discussion groups and greenfield issues?

Interpreting the robust patterns by analyzing a random sub-sample (N= 61)

Conducting open coding and axial coding to develop theoretical constructs

**STEP 3**

- Insight 1: disputes are more likely resolved in attribute-based discussions
- Insight 2: reflective agency facilitates the switch from alternative- to attribute-based discussion
- Insight 3: brownfield and greenfield issues differ substantially in paths to resolution

Developed a process model through inductive theorizing

Electronic copy available at: https://ssrn.com/abstract=3567391
Figure 2. A model of group process underpinning dispute resolution in OSS communities

Stage 1. Dispute Genesis

Stage 2. Resolution Process

Stage 3. Resolution Outcome
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### Appendix I. Initial list of relevant constructs

| Predictors                  | Measurement                                                                 |
|------------------------------|-----------------------------------------------------------------------------|
| Issue type                   | Issue-concerned initiation (i.e., greenfield) or change (i.e., brownfield) of a license |
| Project size                 | Count of all project contributors                                           |
| Admin group size             | Count of owners, collaborators, and admin                                   |
| Discussion group size        | The number of commenting participants involved in the dispute discussion     |
| Initiator status             | Initiator of issue is project owner or not                                  |
| Initiator contribution       | Percentage of source code contributed by owners and collaborators            |
| Project age                  | Age of project when issue was initiated                                     |
| Polarization of opinions     | Construct of polarization (denoted by $P$) combines two structural factors of discussions: number of alternatives and distribution of preferences over them. To assess polarization of opinions within discussions, we first counted all license alternatives available in a discussion. We adopted the following measure proposed by Reynal-Querol (2002) to measure political polarization: $P = \sum_{i=1}^{m} \sum_{j=1}^{m} n_i^2 n_j \delta_{ij}$ |

Suppose participants are distributed over $m$ license alternatives, with $n_i$ being the share of participants supporting license choice $i$. Denote by $\delta_{ij}$ the distance between license alternatives $i$ and $j$. For the sake of simplicity, we take $\delta_{ij} = 1$ for $i \neq j$ and $\delta_{ij} = 0$ for $i = j$. This is equivalent to an assumption that all alternatives are equidistant from each other in concept space, which we feel compelled to make, lacking further data to make ordinal distinctions between different license alternatives. Suppose a discussion involves single or multiple participants; when all participants support one alternative, $P$ would take on its lowest value of 0, and when support of all participants is equally distributed among various alternatives, $P$ would take on its highest value of 0.25. In this instance, $P$ is calculated as follows:

Electronic copy available at: https://ssrn.com/abstract=3567391
\[ P = \sum_{i=1}^{m} n_i^2 (1 - n_i) \]

**Informational intervention**

We operationalize the volume of activity dealing with seeking and sharing information between the seeker and the sender into the construct “information sharing.” This includes the total number of activities that belong to a set of events such as asking and answering questions. For a complete list of such activities and examples, see Table 2.

**Procedural intervention**

We also operationalize rigorous procedural steps often undertaken throughout the issue to facilitate the direction of the discussion into procedural influence. This set of activities included undertakings such as opening and closing of an issue, including more participants, and calling for a vote, among others. For a complete list of such activities and examples, see Table 2.

**Imbalance in participation**

To assess the imbalance of contributions from participants, we computed the Gini frequency in terms of total number of comments. The Gini coefficient (also known as Gini index) captures statistical dispersion, and was originally intended to represent income distribution within a population. It is the most commonly used measure of inequality (Atkinson, 1970). The Gini coefficient is typically calculated from unordered size data as the “relative mean difference,” that is, the mean of the difference between every possible pair of individuals (total number of comments in our context), divided by the mean size \( \mu \):

\[
G = \frac{\sum_{i=1}^{m} \sum_{j=1}^{m} |x_i - x_j|}{2n^2 \mu}
\]
### Appendix II. Descriptive statistics and correlations of initial predictors

| Statistic                        | Mean   | St. Dev. | Min | Max   | 1   | 2   | 3   |
|----------------------------------|--------|----------|-----|-------|-----|-----|-----|
| 1. Resolution outcome           | 0.54   | 0.50     | 0   | 1     |     |     |     |
| 2. Issue type                    | 0.70   | 0.46     | 0   | 1     | -0.27** | 1  |
| 3. Project group size            | 71.62  | 119.73   | 1.00| 606.00| -0.14* | 0.19* | 1  |
| 4. Admin group size              | 2.95   | 3.35     | 0.00| 27.00 | 0.10 | -0.12 | 0.14* |
| 5. Discussion group size         | 11.04  | 12.20    | 2   | 75    | 0.07 | 0.06  | 0.16* |
| 6. Initiator status              | 0.18   | 0.38     | 0   | 1     | -0.04 | 0.02  | 0.00 |
| 7. Initiator contribution        | 0.54   | 0.35     | 0.00| 1.00  | 0.07 | 0.00  | 0.00 |
| 8. Project age                   | 1.162.05| 590.56   | 32.00| 3.806.00| -0.02 | 0.15* | 0.32** |
| 9. Polarization of opinions      | 0.12   | 0.10     | 0.00| 0.25  | -0.06 | -0.19* | -0.01 |
| 10. Informational intervention   | 31.70  | 33.99    | 0   | 27    | -0.15* | 0.11  | 0.22** |
| 11. Procedural intervention      | 5.53   | 4.73     | 0   | 39    | -0.01 | -0.01 | 0.20** |
| 12. Imbalance in participation    | 0.30   | 0.14     | 0.00| 0.87  | -0.07 | 0.03  | 0.02 |

| Statistic                        | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------------------------------|---|---|---|---|---|---|----|----|
| 4. Admin group size              | 1 |   |   |   |   |   |    |    |
| 5. Discussion group size         | 0.54** | 1 |   |   |   |   |    |    |
| 6. Initiator status              | -0.05 | -0.02** | 1 |   |   |   |    |    |
| 7. Initiator contribution        | 0.01 | 0.14 | -0.09 | 1 |   |   |    |    |
| 8. Project age                   | 0.15* | 0.12* | -0.04 | 0.06 | 0.06 | -0.12 | 1 |   |
| 9. Polarization of opinions      | -0.05 | -0.08 | 0.06 | 0.08 | -0.12 | 1 |   |   |
| 10. Informational intervention   | 0.19* | 0.76** | -0.18* | 0.15 | 0.04 | 0.03 | 1 |   |
| 11. Procedural intervention      | 0.03 | 0.05** | -0.10 | 0.18* | -0.01 | 0.24** | 0.75** | 1 |
| 12. Imbalance in participation    | -0.04 | 0.15* | -0.24** | -0.05 | 0.06 | 0.10 | 0.38** | 0.32** |

* p < 0.1, ** p < 0.01, ***p < 0.001 for Pearson correlation.
Appendix III. Machine learning analyses

Machine-learning algorithms embody fewer restrictions as compared to tools based solely on limited functional forms (e.g., linear regression or logistic/Poisson regression) to fit associations in data. At the same time, such algorithms are advantageous in avoiding overfitting by penalizing model complexity (e.g., regularization) and checking out of sample prediction (e.g., k-fold cross-validation). The latter involves segmenting the dataset into “training” samples (to fit models) and “test” samples (to check predictive accuracy of models fit on training data). By iterative partitioning of the data into training and test sets and subsequent model fitting and testing, robust associations can be discovered that are less likely to be specific to a particular sample and the sampling error it contains.

Feature selection (Guyon and Elisseeff, 2003) is the process of reducing the number of explanatory variables to describe a response variable. Feature or variable selection makes the model easier to interpret (removing variables that are redundant or add little information), and prevents overfitting to the data (Abu-Mostafa, Magdon-Ismail, and Lin, 2012). An extensive set of variable selection methods is available with machine learning literature, including principal component regression, LASSO, partial least squares, and so on. See Castle, Qin, and Reed, (2009) and Abadie and Kasy (2017) for a comparative study on various feature selection method. Among these, we used the least absolute shrinkage and selection operator (LASSO) and its variants for our analysis, as this is a relatively straightforward way to carry out variable selection and also seems to provide good predictions in practice (Varian, 2014).

In the first analysis, we used LASSO in order to perform both regularization and feature selection (Tibshirani, 1996). The LASSO method puts a constraint on the sum of the model parameters’ absolute values. The loss function consists of summed errors squared, and a regularizer, which is the sum of coefficient absolute values.

In the second analysis, we used bootstrap aggregation, or bagging, in order to reduce the variance and prediction error of the LASSO method (Buja and Stuetzle, 2006). The bagging method combines bootstrapping with aggregation. More specifically, multiple runs of LASSO using different training data for each run through bootstrapping (random sampling with replacement from the given dataset) are aggregated through a majority voting system in order to generate a new model based on these aggregated parameters (Bach, 2008; Breiman, 1996). Bagging is one of the popular so-called “ensemble” methods designed to improve the stability and accuracy of machine learning algorithms.

In the third and final analysis, we combined an artificial neural network (ANN) ensemble with LASSO by using the former as a preprocess of the latter (similar to Zhou and Jiang, 2003),

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4 Ensemble methods are a set of approaches that combine several machine learning algorithms together to make more accurate predictions than any individual model. The method typically first constructs a set of classifiers, which then classifies new data points by taking a (weighted) vote on the predictions of each individual classifier.
who used a combination of artificial neural network ensemble and C4.5 decision tree–based rule induction. First, an ensemble of artificial neural networks is trained. Artificial neural networks are known to be good at modeling complex interactions in the data, albeit at the expense of interpretability. The resulting model is then used to produce a second training set of a larger size by feeding the vectors of predictor variables to the trained ensemble and replacing the original outcome with the one predicted by the ANN ensemble. Additional training data can also be created by randomly generating vectors of predictor variables and combining them with their corresponding outcome predicted by the ANN ensemble.

This procedure essentially creates a much larger dataset out of a smaller one, which will feature the same (possibly uninterpretable) relationships in the predictions as in the original small training dataset. These predictions can then be used to train a second model such as LASSO that is much better at enabling interpretation because it drops less important features. This approach functions as a “cascade of comprehension,” beginning with hard-to-interpret models like the ANN ensemble to scale up the data, and easy-to-interpret models like LASSO to simplify and extract insight from it. Further details of these three analyses are provided below.

In the final analysis, we used RIDGE in order to perform both regularization and feature selection (Tibshirani, 1996). The RIDGE method puts a constraint on the sum of squares of the model parameters’ absolute values. The loss function consists of summed errors squared, and a regularizer, which is the sum of absolute values of coefficients.

All of our machine learning analyses were implemented in Python, using the package scikit-learn (Pedregosa et al., 2011). Scikit-learn provides simple and efficient tools for machine learning and is available with an open source license (BSD license). For all of our analysis, we used the feature_importances in scikit-learn to measure feature importance. We published the codes of their machine learning analyses as a GitHub project, with an MIT license; it is available upon request.

**Analysis 1. LASSO only**

In this analysis, we implemented LASSO, a regression method that involves penalizing the absolute size of the regression coefficients (Tibshirani, 1996). By penalizing (or adding a constraint on the sum of the estimate absolute values), some of the parameters’ estimates shrink towards zero (Yuan and Lin, 2006; Zhao and Yu, 2006). This provides us with a convenient way of automating variable selection.

To avoid overfitting, it is common practice to adopt cross-validation when performing supervised machine learning. We performed k-fold cross-validation, where the original sample is

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3 Artificial neural networks (ANNs) function on the mathematical representations inspired by the functioning of the human brain. Neural networks are considered to be universal approximators of functions (Funahashi, 1989; Hornik, Stinchcombe, and White, 1989), especially nonlinear relationships (Lek et al., 1996). (White, 1992: 79) claimed that “neural networks are capable in principle of providing good approximations to just about anything one would like.” An extensive set of neural networks has been suggested in the literature for both supervised and unsupervised learning (Bishop, 1995).
randomly partitioned into $k$ equal-sized subsamples (in our analyses $k = 8$). Of these subsamples, a single subsample is retained as the validation data for testing the model, and the remaining $k-1$ subsamples as training data. The $k$ results from the folds are then averaged to produce a single estimation of model performance.

We used SMOTE sampling technique to maintain balance between positive and negative labels while training our model. This is recommended for smaller datasets with skewed distribution of the dependent variable. We used the SGDClassifier (stochastic gradient descent) function in scikit-learn package to implement the LASSO classifier with logistic loss function and L1 penalty.

**Analysis 2. LASSO combined with bagging**

In this analysis, we implemented a technique commonly known as the ensemble method that constructs multiple models and then combines them to produce improved results. Ensemble methods are considered to produce more accurate solutions than a single model. Bagging is such an ensemble method, where the variance of the prediction is reduced by averaging the models trained from multiple datasets generated from the original dataset using bootstrapping (sampling with replacement) (Breiman, 1996). The generated datasets are of the same size as our original dataset. In our analyses, we generated 15 bootstrapped datasets with stratified sampling (i.e., maintain the proportion of labels in the outcome variable).

In all-bootstrapped dataset, LASSO was implemented and the standardized coefficients thus obtained were averaged in order to obtain the powerful predictors. Eight-fold stratified cross-validation was performed, and for each fold the analysis was run 10 times in order to average out the effect of randomness. In the same fashion as Analysis 1, we used the SGDClassifier (stochastic gradient descent) function in scikit-learn to implement the LASSO classifier with logistic loss function and L1 penalty.

**Analysis 3. LASSO combined with ANNs**

This analysis took an approach similar to Zhou and Jiang, (2003). First, an ANN ensemble was trained with the original data. Our ANN ensemble contains 25 neural networks that are trained on different bootstrapped datasets. Each neural network consisted of one hidden layer with eight neurons and rectified linear unit (ReLU) as the activation function. This was implemented using the MLPClassifier function in the scikit-learn package using the stochastic gradient descent for optimization. We fed the feature vectors of the original data to the trained ensemble and replaced the expected outcome labels of the original training instances with the labels output from the ensemble model. With this method, we generated a new dataset. Additional training data were appended by randomly generating feature vectors and combining them with their corresponding class labels output from the ensemble.

Finally, LASSO was used to select the best features. Eight-fold stratified cross-validation was performed and for each fold, the analysis was run 10 times and the results were averaged.
Again for LASSO, we used the SGDClassifier (stochastic gradient descent) function in scikit-learn to implement the LASSO classifier with logistic loss function and L1 penalty. The BaggingClassifier function in scikit-learn was used to implement the ensemble.

**Analysis 4. RIDGE only**

In this analysis, we implemented RIDGE, a regression method that involves penalizing the square of absolute size of the regression coefficients (Abu-Mostafa et al., 2012). By penalizing (or adding a constraint on the sum of the estimate absolute values), some of the parameters’ estimates shrink towards zero (Yuan and Lin, 2006; Zhao and Yu, 2006). This provides us with a convenient way of automating variable selection.

Similar to the case of LASSO, we performed k-fold cross-validation, where the original sample is randomly partitioned into k equal-sized subsamples (in our analyses we used k = 8). Of the k subsamples, a single subsample is retained as the validation data, and the remaining k−1 subsamples as training data. The k results from the folds are then averaged to produce a single estimation of model performance. Additionally, we used the SGDClassifier (stochastic gradient descent) function in scikit-learn package to implement the LASSO classifier with logistic loss function and L2 penalty.
## Appendix IV. License attributes and alternatives

| License attributes       | Definition                                                                 | Examples of issue excerpts                                                                                                                                                                                                 | License |
|--------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| **Ease of corporate use**| The extent to which the license facilitates or hinders adoption for corporate use | “For personal use the license is fine, but it would be nicer if the software had a properly open license (apache, bsd or MIT, for example) for ‘corporate use.’ It’s not about not contributing back, but just the added legal hassle using contagious licenses in anything.” (abb in project Hugo) | MIT     |
| **Ease of contribution** | The extent to which the license facilitates or hinders contributions          | “Instead, Apache places more restrictions on those who want to actually contribute to ensure everyone’s playing fair.” (tswicegood in project Tabula)                                                                 | GPL     |
| **Degree of standardization** | The extent to which the license is altered to suit specific needs               | “The current wording ‘make me unhappy’ isn’t a clear legal statement. It’s really hard to make clear statements about non-commercial and pseudo–non-commercial licenses.” (sethwoodworth in project Open-Dyslexic) | BSD     |
| **Simplicity of language** | The extent to which the clauses are interpretable                             | “I usually prefer MIT because it’s simpler and shorter, it can be read and understood in 1 min without legal background, unless some GPL-specific restriction is needed.” (francescolaffi in project VVV) | MPL     |
| **Permissiveness**       | The extent to which the license is “liberal” concerning restrictions on contributions, distribution, or usage | “The Apache License 2.0 is a pretty crummy license in general, and is not as permissive as people like to think. Apart from just general complexity, it also suffers from bookkeeping and project organization clauses, though I don’t mind patent clauses at all.” (apotheon in project Servo) | PD      |
| **Protectiveness**       | The extent to which the license contains attribution and liability clauses   | “The Unlicense doesn’t have a full legal code supporting it. The liability protections are especially weak. Compare to the legal code of CC0 and there’s really no competition whatsoever. CC0 has very strong liability protections, plus it has an absolutely crucial severability clause.” (NoahKunin in project Qu) | CC0     |
| **Compatibility**        | The extent to which the license is compatible with the licenses of related software | “According to the FSF, the GPL 2 is not compatible with apache 2 license while GPL 3 is. Choosing GPL 2 could cause a problem with integration of apache 2 licensed code/libraries. This interpretation isn’t shared by everyone, but myself and others (like the symfony framework folks) have gone with it.” (jrobeson in project Hugo) | GPL3    |
| **Swiftness**            | The extent to which the license can be quickly adopted                      | “The MIT license allows sublicensing and is thus fully compatible with the GPLv3 license. No ’consent’ is required.” (JeromSar in project Glowstone)                                                                 | APL     |
| **Prior use**            | If the license has been used in successful projects                          | “I chose the language of the Unlicense because it’s based on the language used by SQLite, which is very successful at getting itself put inside all sorts of other software.” (andreishab in project Qu)                                                                 | Unlicense |
| **Appropriateness**      | The extent to which the license is right for a specific type of product      | “Please do not use a CC license. Creative Commons specifically says: ‘Creative Commons licenses should not be used for software.’” (aaronbrethorst in project AwesomeMenu)                                                                 | Apache2 |

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Appendix V. Detailed results of machine learning analyses

Machine learning analyses for whole dataset with SMOTE\(^6\) [N =198]

| Predictor weights       | Algorithm 1 (LASSO only) | Algorithm 2 (Bagging of LASSO) | Algorithm 3 (ANN+LASSO) |
|-------------------------|--------------------------|--------------------------------|------------------------|
|                         | Run 1 | Run 2 | Run 3 | Run 1 | Run 2 | Run 3 | Run 1 | Run 2 | Run 3 |
| INFO                    | 10.00 | 10.00 | 10.00 | 9.86  | 9.85  | 9.84  | 10.00 | 9.75  | 9.75 |
| PROCEDURE               | 7.75  | 7.88  | 7.88  | 7.41  | 7.46  | 7.42  | 7.13  | 7.13  | 7.25 |
| UNIQUEPARTICIPANTS      | 9.00  | 9.00  | 9.00  | 8.85  | 8.86  | 8.84  | 9.00  | 8.88  | 9.25 |
| ADMINSIZE               | 5.88  | 5.88  | 5.88  | 5.27  | 5.03  | 5.09  | 7.88  | 8.25  | 7.50 |
| POLARIZATION            | 2.25  | 2.00  | 2.13  | 2.86  | 2.71  | 2.39  | 3.38  | 3.13  | 3.50 |
| BROWNFIELD              | 6.88  | 7.00  | 6.75  | 6.04  | 6.06  | 6.01  | 5.75  | 6.00  | 6.00 |
| PROJECT\_SIZE\_PERSON  | 5.00  | 5.13  | 5.25  | 3.89  | 3.86  | 0.96  | 4.13  | 4.38  | 4.38 |
| GINI\_FREQ              | 2.25  | 1.88  | 2.13  | 3.26  | 3.15  | 3.17  | 2.13  | 1.50  | 2.75 |
| PROJECT\_AGE            | 1.75  | 1.75  | 1.50  | 2.32  | 2.69  | 2.87  | 1.38  | 2.13  | 1.13 |
| OWNERSTART              | 2.25  | 1.88  | 1.88  | 2.74  | 2.68  | 2.91  | 2.88  | 2.00  | 2.00 |
| OWNERCONTRIB            | 2.00  | 2.63  | 2.63  | 2.52  | 2.66  | 2.50  | 1.38  | 1.88  | 1.50 |
| **Overall model metrics** |       |       |       |       |       |       |       |       |      |
| Accuracy of neural network (%) | 73.12 | 77.32 | 72.04 |       |       |       |       |       |      |
| Accuracy of LASSO (%)    | 69.35 | 68.27 | 67.23 | 70.43 | 71.43 | 72.76 | 72.24 | 75.40 | 73.24 |
| Correctly predicted “no-resolution” (%) | 71.63 | 70.83 | 68.59 | 73.40 | 71.96 | 73.80 | 73.80 | 77.88 | 75.88 |
| Correctly predicted “resolution” (%) | 67.07 | 65.71 | 65.87 | 67.47 | 70.91 | 71.71 | 70.67 | 72.92 | 70.59 |
| True positives           | 67    | 65    | 65    | 67    | 70    | 71    | 70    | 72    | 70 |
| True negatives           | 71    | 70    | 68    | 73    | 71    | 73    | 73    | 77    | 75 |
| False positives          | 28    | 29    | 31    | 26    | 28    | 26    | 26    | 22    | 24 |
| False negatives          | 32    | 34    | 34    | 32    | 29    | 28    | 29    | 27    | 29 |
| F1\_score               | 0.6833| 0.6749| 0.6662| 0.6905| 0.7093| 0.7217| 0.7161| 0.7424| 0.7224|
| MCC                     | 0.3996| 0.3720| 0.3492| 0.4156| 0.4349| 0.4632| 0.4520| 0.5198| 0.4768|

\(^6\) Note that the application of SMOTE results in change of data size due to oversampling of minority class (Chawla et al., 2002).

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Algorithm 4 (Ridge)

| Predictor weights              | Run 1 | Run 2 | Run 3 |
|--------------------------------|-------|-------|-------|
| INFO                           | 10.00 | 10.00 | 10.00 |
| PROCEDURE                      | 8.00  | 8.00  | 7.88  |
| UNIQUEPARTICIPANTS             | 9.00  | 9.00  | 9.00  |
| ADMINSIZE                      | 4.00  | 3.13  | 4.00  |
| POLARIZATION                   | 3.38  | 3.00  | 3.00  |
| BROWNFIELD                     | 7.00  | 7.00  | 7.13  |
| PROJECT_SIZE_PERSON            | 5.50  | 5.50  | 5.38  |
| GINI_FREQ                      | 2.88  | 3.88  | 3.25  |
| PROJECT_AGE                    | 1.25  | 1.63  | 1.75  |
| OWNERSTART                     | 1.50  | 1.63  | 2.13  |
| OWNERCONTRIB                   | 2.50  | 2.25  | 1.50  |

Overall model metrics

| Accuracy on neural network (%) |       |       |       |
|--------------------------------|-------|-------|-------|
| Accuracy of LASSO (%)          | 68.11 | 70.51 | 69.07 |
| Correctly predicted “no-resolution” (%) | 67.63 | 70.51 | 69.71 |
| Correctly predicted “resolution” (%) | 68.59 | 70.51 | 68.43 |
| True positives                 | 68    | 70    | 68    |
| True negatives                 | 67    | 70    | 69    |
| False positives                | 32    | 29    | 30    |
| False negatives                | 31    | 29    | 31    |
| F1_score                       | 0.6776| 0.7017| 0.6816|
| MCC                            | 0.3712| 0.4195| 0.3913|

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Appendix VI. Qualitative comparative analysis

To gain further insight into relationships among variables detected in ML, we rely on fuzzy-set qualitative comparative analysis (QCA). QCA employs fuzzy-set analysis algorithms to describe conjunct (joint) relationships between variables and the outcome in an easy-to-interpret manner (Fiss, 2007; Greckhamer, 2016; Ragin, 2008). By treating each variable as a set, with fuzzy membership of cases allowed, each record is treated as an element of one or more sets (i.e., a record could lie at the intersection of different sets).

Set theoretic methods such as QCA function on the assumption that the influence of causal variables (in our case, discussion group size, informational intervention, and issue type) on a specific outcome (dispute resolution or attribute-based mechanism) depends on the way in which the causal variables are combined rather than the level of the individual variable. Note that the associations derived from ML and QCA need not be causal, and are at best indicative of the causal paths connecting key variables to resolution (or non-resolution). Recently, QCA has been increasingly used in the business and management literature (e.g., Bell, Filatotchev, and Aguilera, 2014; Crilly, 2011; Fiss, 2011; Judge, 2015; Schneider, Schulze-Bentrop, and Paunescu, 2010; Witt and Jackson, 2016).

We used QCA to gain further insight into possible configurations of variables identified by ML that are (a) associated with resolution and non-resolution; and (b) associated with attribute- and alternative-based discussion. In the QCA approach used here, each case is coded as either “in” or “out” of a set, being assigned the value of 1 or 0, respectively. For issue type, resolution outcome and attribute-based mechanism, we used the results of our qualitative coding to calibrate our cases. In order to determine statistically meaningful cut-offs for discussion group size and informational intervention, we first calculated the z-norm for these variables and used the sign of the value thus obtained as a means of dichotomization. This method gave us cutoffs at 12 and 34, respectively, for discussion group size and informational intervention. These cut-offs were used then to calculate (1) full membership and (2) non-membership (Kent, 2008; Ragin and Rubinson, 2011).

From these calibrated data, QCA generated a truth table with $2^3 = 8$ rows, as three causal variables were used in the analysis (Ragin, 1987). This table represents all possible combinations of causal variables and each row is associated with a specific combination. Next, the number of rows in the truth table is reduced with a cut-off for the number of cases required for a solution to be considered and the minimum consistency level of the solution. The consistency level represents the proportion of cases that exhibit a given configuration of causal variables as well as the outcome as compared to the number of cases that exhibit the same configuration of causal variables but a different outcome (Ragin and Sedziaka, 2013). We set the lowest acceptable consistency in our analysis at the level of $\geq 0.80$ (e.g., Ragin and Sedziaka, 2013) and a requirement of at least one case for a solution to be considered.
In the next step, the truth table rows were logically reduced to simplified combinations with application of the Quine-McCluskey algorithm, which is based on Boolean algebra. We applied the algorithm based on counterfactual analysis of causal variables described in Ragin (2006, 2008). This algorithm differentiates the solutions into parsimonious and intermediate based on “easy” and “difficult” counterfactuals.

We used the \texttt{fuzzy} package in Stata (Longest and Vaisey, 2008) to perform our QCA analysis. Following the conventions in management research (e.g., Crilly, Zollo, and Hansen, 2012; Fiss, 2011), we report three measures of coverage (Ragin, 2008), namely, “raw coverage” (indicating which share of the outcome is explained by a certain alternative path), “overall solution coverage” (indicating how much is covered by the solution term) and “unique coverage” (indicating which share of the outcome is exclusively explained by a certain alternative path).

The QCA results for the full sample (Table 1, this appendix) indicate that resolution occurs either when the governance dispute involves a large number of discussion participants and low information intervention, or when the governance dispute involves a small number of discussion participants and high procedural intervention. These results suggest that the effective interventions for promoting resolution differs in large versus small discussion groups.

Next, we conducted QCA analysis separately on greenfield (Table 2) and brownfield (Table 3) issues. For brownfield issues, resolution occurs either when the governance dispute involves a large number of discussion participants and low information interventions, or when the dispute involves high procedural intervention and low information interventions. For greenfield issues, in addition to the paths to resolution in brownfield issues, resolution also occurs when the governance dispute involves a large number of discussion participants and high procedural intervention.

These results point to three robust patterns in our sample. First, large discussion group size and high procedural interventions appear as two alternative paths to resolution, suggesting a functional equivalence between them. Second, for greenfield issues, however, large discussion group size and high procedural interventions also appear together. This additional path to resolution constitutes the qualitative difference between greenfield and brownfield issues. Relatedly, within greenfield cases, we found that imbalance of participation was also a predictor of resolution, but given the low predictive accuracy of machine learning models for greenfield issues, we would treat this result with caution. Third, informational interventions are associated with lower chances of resolution, which may be because such interventions increase as the discussion drags on without resolution, or they add more information to an already confusing discussion.
Table 1. Configurations for resolution (Full sample)

| Solutions           | 1a | 1b | 2a | 2b | 3a | 3b |
|---------------------|----|----|----|----|----|----|
| Discussion group size | ●  | ●  | ●  | ●  | ●  | ●  |
| Procedural intervention | ● | ● | ● | ● | ● | ● |
| Informational intervention | ● | ● | ● | ● | ● | ● |
| Consistency         | 0.90 | 0.92 | 0.80 |
| Raw coverage        | 0.22 | 0.27 | 0.39 |
| Unique coverage     | 0.15 | 0.14 | 0.27 |
| Overall solution consistency | 0.87 |
| Overall solution coverage | 0.63 |

Table 2. Configurations for resolution (greenfield)

| Solutions           | 1a | 1b | 2a | 2b |
|---------------------|----|----|----|----|
| Discussion group size | ● | ● | ● | ● |
| Procedural intervention | ● | ● | ● | ● |
| Informational intervention | ● | ● | ● | ● |
| Consistency         | 0.69 | 0.71 |
| Raw coverage        | 0.26 | 0.22 |
| Unique coverage     | 0.26 | 0.22 |
| Overall solution consistency | 0.70 |
| Overall solution coverage | 0.48 |

Table 3. Configurations for resolution (brownfield)

| Solutions           | 1a | 1b | 2a | 2b |
|---------------------|----|----|----|----|
| Discussion group size | ● | ● | ● | ● |
| Procedural intervention | ● | ● | ● | ● |
| Informational intervention | ● | ● | ● | ● |
| Consistency         | 0.63 | 0.71 |
| Raw coverage        | 0.26 | 0.30 |
| Unique coverage     | 0.11 | 0.14 |
| Overall solution consistency | 0.66 |
| Overall solution coverage | 0.40 |
## Appendix VII. Comparative case summaries

| Project  | Genesis | Procedural intervention | Information intervention | Reflective agency | Switch | Resolution outcome |
|----------|---------|-------------------------|--------------------------|------------------|--------|-------------------|
| **WordPress** | Greenfield Large discussion group size (N = 18) Resolution | One participant asked what license the current project is under. | Seven of the 14 contributors expressed agreement. However, one owner of the project question disagreed with the choice of GPL licenses and suggested MIT. More joined in and suggested other alternatives. One owner pointed out that Creative Commons licenses are for art work rather than code. | One owner observed that PHPCS is based on MIT and is very similar in terms of attributes, and that MIT and WTFPL also share similar attributes. | Participants switched debating over a few license alternatives to looking for the most permissive license. | Opinions converged on MIT and one owner created a license file, adopting MIT. Afterward, a participant came to express his consent. |
|          |         | One of the owners answered that the project currently had no license and initiated a vote for GPLv2, directly calling 14 contributors in the project to participate. | “No. Are there any issues with GPL? Yes. Personally, whenever having an option to, I would always choose more permissive license, such as MIT.” | “I am a fan of WTFPL, but as ‘serious professional,’ MIT is essentially WTFPL sans F words 😊.” | | |
|          |         | The owner made a unilateral decision after considering all the inputs from participants. | “IANAL, but the difference between FreeBSD and MIT is very small, but MIT is incompatible with FreeBSD (it’s more permissive, but the difference is minor, and I doubt anyone would care about it), so ABXD couldn’t use MIT without replacing |
|          |         | “Thanks for the inclusion 😊, although votes in, my 2 cents worth would be MIT as chosen, yippee. Think it suits a coding standard perfectly.” | |
| **Oh-my-fish** | Greenfield Small discussion size (N = 4) Resolution | One participant suggested that the project could benefit from having a license. | After the owner revealed his preference, other participants chimed in by adding information for different license options. Although there were only four participants, they covered a broad range of possible licenses. | Not applicable | Not applicable | The owner made a unilateral decision after considering all the inputs from participants. |
|          |         | Another participant disagreed with such a need. | “IANAL, but the difference between FreeBSD and MIT is very small, but MIT is incompatible with FreeBSD (it’s more permissive, but the difference is minor, and I doubt anyone would care about it), so ABXD couldn’t use MIT without replacing. | | | “Unless someone disagrees, I’ll create an issue in the next hours pinging everyone that has contributed to this project to ask for their permission to add an MIT license to this project.” |
everyone. Doesn’t look like an issue here.” Xfox

| Project          | Genesis | Procedural intervention | Information intervention | Reflective agency | Switch | Resolution outcome |
|------------------|---------|-------------------------|--------------------------|-------------------|--------|--------------------|
| Elegant-mind     | One owner of the project started a license discussion and another owner joined in and debated over GPL2, LGPL, MIT license as alternatives. “I would like to start a license discussion. Is it OK for you that we publish our enhancements under LGPL instead of GPL2?” | In the middle of the heated debate, one participant closed the discussion, but he reopened it again. | The owner who initiated the discussion offered her concerns over MIT and GPL licenses. Other participants joined in and offered their opinions about other licenses. The debate went on about the advantages and disadvantages of each of the proposed license alternatives. “The problem with MIT is that you won’t get back the changes. Sometimes it does work fine, for example with PostgreSQL, sometimes not.” Sjstoelting | Absent | Absent | There was no conclusion about which license would be the most suitable; the issue remained unresolved. |
| Greenfield Small discussion group size (N = 7) No resolution | | | | | | |
| Vis.js Brownfield Large discussion group size (N = 16) Resolution | One owner of the project noticed that the current license is not compatible with many other licenses. He then suggested a reconsideration of license and listed attributes that are important for the community. The owner who opened the issue used the label function at GitHub to call for EVERYONE to participate. The other owner called on 12 contributors to express their opinions. Guided by the considerations put forth upfront, participants started sharing information about different licenses that could potentially fulfill the listed considerations. The other owner suggested dual license as a solution. “Presumably you’ve seen this: http://choosealicense.com/ Warmest regards, Dan” Dweese | | Not applicable | Not applicable | Owner of project decided to adopt a dual license of Apache and MIT. “Ok guys, we have finally updated the NOTICE and LICENSE files to a dual license solution. Vis.js is now officially dual licensed as of |

Electronic copy available at: https://ssrn.com/abstract=3567391
### Resolution process

| Project   | Resolution process | Reflective agency | Switch | Resolution outcome |
|-----------|--------------------|-------------------|--------|--------------------|
| **Drawille** Brownfield Small discussion group size (N = 5) No resolution | One participant suggested a change in license. “I was wondering whether the choice of AGPL was intentional, given it restricts the use in many projects that can’t change their license to use it. Will it be possible to consider a more permissive license?” | Another participant inquired about difference between AGPL and GPL, the owner showed up to explain his rationale behind the current license of choice. One more participant joined in, sharing some facts. One other participant joined in and started criticizing the person who opened the discussion. “This is complete nonsense. please do not spread FUD (fear, uncertainty, and doubt). You have absolutely no clue about copyright which you just proved.” | Absent | Absent | The rest of the discussion became a battlefield for debating whether a particular fact/opinion by someone is valid. No resolution was reached. “Github has a feature to mute threads. Feel free to use that for this thread.” |
| **Toxcore** Brownfield Large discussion size (N = 50) No resolution | One owner suggested changing the license from LGPLv3 to GPLv3 so that the product can be compatible with Apple store's requirements. Many participants joined in by expressing what attributes they consider the most important. For example, one would like to maximize market share, the other argues for freedom, yet another supports permissiveness. One camp of participants repeatedly went back to the original license LGPLv3, and was not willing to deviate from it, despite all the arguments from the other camp. “I’d like a permissive license such as ISC, but LGPL is less harmful than GPL any day, and would | Participants started to reflect upon the key attribute they were after when suggesting a particular license and the shared attributes among several alternatives. “IANAL, but after reading the MPL and Apache v2, the two alternatives suggested in this thread, I believe they are compatible, although it seems several contributors | | | The two camps (practical vs. ideological) fundamentally disagree with each other on what the primary attribute of the license should be. No resolution was reached. |
slightly please the BSD crowds, such as myself.” Zlacki

object to this on matters of substance.” Drew Crawford

the rights to icons and artwork (for brand name).” Mckenney
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