# Institutional and Entrepreneurial Engagement in Commons-Based Peer Production

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This study examines how various ways of organizing online collaboration affect the structure of the engagement network in commons-based peer production. The main interest is in testing whether loosely structured collaborative practice, without defined roles and leaders, leads to less centralized engagement. We use network analysis to uncover and compare three endogenous network attributes in two online music production communities, where participants produce public goods mainly through two strategies: ad-hoc collaboration and team-based collaboration. The analysis reveals that the introduction of formal structure in collaboration does not necessarily lead to greater centralization. In fact, more loosely structured collaboration can result in higher centralization, whereby a small number of participants emerge as focal points for the productive output of the community.

*Keywords: commons-based peer production, online communities, network analysis, online collaboration*

Commons-based peer production (CBPP) communities are online communities organized by peers with a common interest that rely on openly shared resources to produce user-generated content (Benkler, 2006). CBPP users engage in collaborative practices that often entail a collective purpose, such as the exploration and promotion of various forms of online collaboration toward a creative output. The traditional understanding of collective undertakings is that a degree of organization is necessary, as there are some serious limitations to how much a group can scale in size before it become inefficient (Marwell & Oliver, 1993). However, scholars from multiple disciplines have argued that new communication technologies are questioning conventional wisdom on organizational form (Ganesh & Stohl, 2010; Shumate & Lipp, 2008). Online peer production communities that are self-organized can successfully challenge the necessity for formal organization (Benkler, 2006; Johnson, 2008).

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Date submitted: 2015–06–15

[1] We want to thank Mike Linksvayer from Creative Commons for helping collect the ccMixter data. We also want to thank Anwitaman Datta from Nanyang Technological University, who supervised the collection of the Kompoz data.

Examples of CBPP can be found in Wikipedia and Linux, whose products serve a more functional purpose. These are not the only forms of CBPP. This study focuses on remix, a form of CBPP that focuses on entertainment and cultural expression. Remix is a process of reusing open content to create derivative works. In its essence, remixing is similar to a collage—an element that has been altered from its original state by adding to, removing from, or changing its content to create a new media form (Lessig, 2008). Though remix with physical objects is often difficult and expensive, digital technologies have made it more accessible through the capacity to support user-generated content (Cheliotis, Hu, Yew, & Huang, 2014). A variety of media content has been remixed: text, image, video, and music. We are witnessing the growth of remix culture. Take Scratch as an example: It is an online community created by the MIT Media Lab in which anybody can create their own interactive stories, games, and animations. As of December 2015, 29.5% of Scratch's recently shared projects were remixes.

In this article, we aim to produce a general understanding of remix as collective action but with a focus on remix in music. Because of the popularity of music remix practices and the associated ownership issues that could traditionally inhibit reuse, music remix has been and is still of great importance in testing new models for collaborative production (Benkler, 2006). Remix is an important form of CBPP for the following reasons. First, users in remix communities are motivated by the objective of open sharing and reuse of cultural information goods to contribute to public goods. Second, potential contributors to remix are encouraged to create additional value above that of the original content through reuse.

In music remix communities, participants are encouraged to draw from various media sources, creatively reuse them, and release their work into the public domain (Manovich, 2005). See Figure 1 for an illustration, which shows that author spinningmerkaba took two samples to create a new song and labeled it with a Creative Commons (CC) license so others can reuse this work. As we found in the community, spinningmerkaba's work was reused by another author.

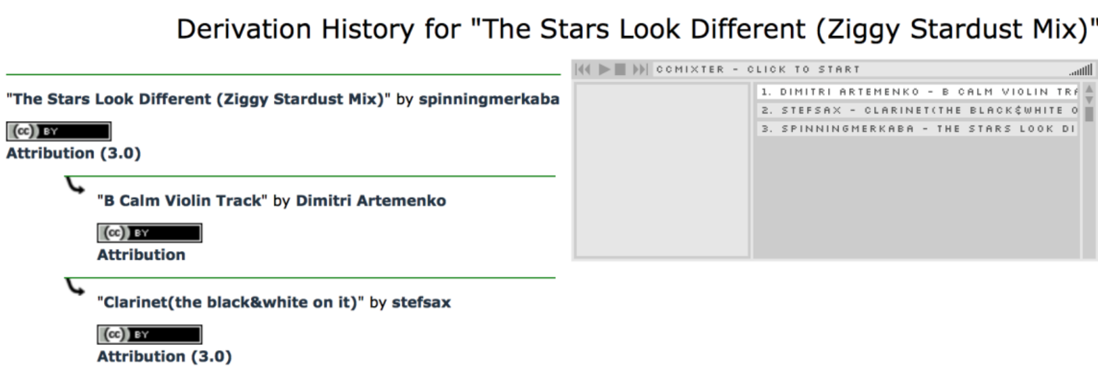



***Figure 1. Illustration of remix. Source: http://ccmixter.org/files/jlbrock44/52765.***

What remains underexamined is how various ways of organizing remix influence collaboration patterns (Shaw, 2012). Remixing may happen in teams. It may also be enacted individually and in a completely uncoordinated fashion, which can be construed as ad-hoc collaboration: A user finds another user's creation online and then decides to reuse that in a new work. A question remains of whether structured engagement in teams rather than solitary creation is preferable, and if so, why. Some communities place less faith in the loosely structured ad-hoc collaboration that the Internet facilitates and opt for the transfer of traditional modes of engagement to the online realm, for example, by introducing team-based collaboration with role assignments that predate the Internet as a collaboration space.

Loose organizational forms, and even purely ad-hoc participation in collective endeavors, have been much celebrated in recent literature. In these forms, modern communications technology helps individuals eschew hierarchy and centralized command in favor of flat structures, broader participation, and distributed production. We wish to test whether a relative lack of structure leads to less centralization. To this end we applied the mode of engagement from the collective action space (Bimber, Flanagin, & Stohl, 2005) to conceptualize two distinct ways of organizing CBPP—institutional and entrepreneurial—and conducted social network analysis to empirically test how two CBPP communities where participants produce public goods using mostly different strategies demonstrated different collaboration structures.

Findings suggest that engaging in CBPP takes effort and that CBPP members will not engage indiscriminately. They tend to reciprocate each other's remix initiative. Despite recent claims about the value of loosely coordinated entrepreneurial online action, the introduction of some structure to peer production can be beneficial. Specifically, providing participants with the tools to self-organize (e.g., by defining roles in subprojects) can lead to less centralized engagement; on the other hand, providing no such tools could result in participant engagement that coalesces around community leaders who exert a disproportional influence on the output of the community. Formal organization is thus not necessarily associated with centralized engagement. The opposite may also be true, depending on the organizational form and whether it has more elements of entrepreneurial engagement.

## Community-Based Peer Production as Collective Action

Collective action refers to actions undertaken by individuals or groups in pursuit of a collective good (Marwell & Oliver, 1993). Traditional theory of collective action argues that formal organizational structure could facilitate solving communication and coordination problems and thus could be adopted as one means of overcoming central problems exacerbated in larger groups, such as free-riding (Olson, 1965). Formal organization refers to "a vertically-integrated structure, command and control decision-making at the top, highly differentiated roles, and a high value placed on institutional maintenance" (Bimber et al., 2005, p. 369). A formalized hierarchical structure stresses group interests and the necessity for clear leadership to call up people for collective aims.

Recent literature has found that collective action could occur in the absence of formal organization (Fulk, 2001; Ganesh & Stohl, 2010). Empowered by new technologies, anyone can initiate a collective effort and call for other participants without constraints of time and space (Castells, 2012). As an important organizational innovation that emerged from Internet-mediated social practices, peer production can be initiated by anyone and challenges the necessity for formal organization (Benkler, 2006; von Hippel & von Krogh, 2003). However, CBPP can take on both formal and informal structures (Bimber, Flanagin, & Stohl, 2012).

To respond to challenges posed by new technologies, Bimber et al. (2005) suggest reconceptualizing collective action as a set of communicative processes that cross between private articulations and public discourse. This reconceptualization entails three basic requisites: a means of identifying people with relevant, potential interests, a means of communicating that is commonly perceivable, and a means of coordinating, integrating, or synchronizing contributions. Acquiring, distributing, and coordinating become central issues in the contemporary media environment. Although the inspiration for this reconceptualization stems primarily from observations in online political discourse, we find the same elements present and pertinent to peer production, a form of collective action geared toward the production of media content.

To examine how various ways of organizing peer production influence collaboration structures, we introduce the mode of engagement from the framework of collective action space proposed by the same authors (Flanagin et al., 2006). This framework is designed to uncover the conditions in which people will cross the private-public boundary and make their actions visible to relevant others (Flanagin, Stohl, & Bimber, 2006). In particular, their conceptualization of the mode of engagement speaks to the focus of the current research, which is to examine whether peer production in relative isolation or in teams will be more likely to elicit contributions from participants.

The mode of engagement refers to the extent to which "participants' individual agendas may be enacted within the group context" (Flanagin et al., 2006, p. 36) and appears on a continuum from entrepreneurial to institutional. In entrepreneurial engagement, participants have a high degree of autonomy and are not constrained by a central authority. In institutional engagement, members' actions are steered toward a central organizational purpose, with individual members having little or no say over what that purpose will be.

CBPP is touted as a different paradigm for the collective organization of production that evolves through interest-based peer collaboration networks and open sharing of media resources. It has a high reliance on open licensing so that anyone can reuse and build upon the common resources to produce user value (Benkler, 2002; Bollier, 2007). After completing production, they can decide how to publish each work with what license. How to collect, distribute, and make use of relevant information is crucial for CBPP, as it is for any form of collective action conceptualized by Bimber et al. (2005).

CBPP is typically associated with entrepreneurial engagement, in which users self-organize collaboration based on commonly available resources (Benkler, 2006). However, CBPP could be organized in other ways, including ad-hoc collaboration and team-based collaboration (Manovich, 2005). The collective aims of CBPP communities tend to be similar in that their efforts are motivated by the desire to collaborate to produce publicly available content. However, differences in organizing CBPP influence how people contribute to collective action. This study applies the mode of engagement put forth by Flanagin et al. (2006) to produce a comparative network analysis of two online communities that produce music with shared resources and that exhibit many similarities in their overall approaches and common interests but that differ crucially in their organization of production. The goal is to examine how different ways of organizing peer production may affect the structure of collaboration.

## The Engagement Network in CBPP

The mode of engagement defines a crucial element of organizational structure: "Participants' capacity to shape the goal of the organization and how those goals are pursued" (Bimber et al., 2012, p. 109). As Flanagin et al. (2006) claimed, a more traditional conceptualization of organizational structure favors semifixed, predictable structure in shaping behaviors; however, contemporary collective action requires a more casual method that emphasizes what people are doing and how their behaviors are related to relevant others. The conceptualization of engagement in collective action space captures its relational structures. This study proposes that the dynamics of online collective action need to be examined through a network perspective.

A network perspective focuses on connections and social relations among organizational members mediated by their contributions to the collective. Applying network analysis to collective action uncovers who are more likely to collaborate with whom to provide public goods. Moving beyond characteristics of collective action contributors, network analysis examines relational properties of interconnected entities (Monge & Contractor, 2003). It analyzes a set of actors at multiple levels: node level, dyadic level, triadic level, and community level. With recent methodological advances, network perspective has significantly contributed to the understanding of online collaboration structures (Cheliotis & Yew, 2009).

A CBPP community can be understood as a network of people interacting, exercising influence, imitating and innovating based on common resources and creative reuse. To study how different ways of organizing individual contributions affect the dynamics of collective action, we introduce the concept of an *engagement network*. An engagement network consists of nodes, which represent social actors, and links, which represent instances of contribution by a social actor to another actor's initiative. It is a directed network because contribution flows from the first contributor to the second, and so forth. It is also a valued network, with edge weight indicating the frequency of engagement. The engagement network captures how individuals in a CBPP community support each other's initiatives toward free culture (Benkler, 2006). The existence of a tie indicates the action of making one's peer production effort visible to relevant others.

The structure of a CBPP engagement network is closely related to the mode of engagement, as the two identified modes define how individuals collaborate with each other. In this study, we also consider engagement to appear on a continuum from purely institutional to purely entrepreneurial, with most real-world examples falling somewhere in between. To counter what the reader may perceive as an artificial entrepreneurial-institutional dichotomy, Flanagin et al. (2006) state that even in a highly centralized organization, individual participants may still shape the collective agenda and that most organizations have hybrid engagement. Hybrid modes of engagement have been found in presidential campaign organizations and international advocacy organizations (Flanagin et al., 2006; Kavada, 2012).

Along the continuum of engagement, in organizations and communities falling near institutional engagement, organizational hierarchy plays a significant role in developing organizational procedures to reduce volatility and increase predictability of individual members' actions, whereas in those falling near institutional engagement, individual members are granted some autonomy and may design collective efforts in ways that are not controlled by any central authority (Bimber et al., 2012). In CBPP communities, engagement is never purely entrepreneurial. One often-cited example is Wikipedia: Although in principle anyone can edit a page based on interest or expertise, community leaders and the Wikimedia Foundation have developed quality control and conflict resolution structures. The listed rules and guidelines in Wikipedia also suggest a hybrid approach that combines elements of both entrepreneurial and institutional engagement (Johnson, 2008).

We focus here on comparing and contrasting two distinct ways of organizing CBPP (ad-hoc and team-based) to uncover how these modes of organizing collaboration affect the structure of the engagement network. *Ad-hoc* collaboration relies more on entrepreneurial engagement because it does not require sustained, coordinated effort (Cheliotis & Yew, 2009; Stone, 2009). People are given enough autonomy to decide whose work to reuse and what license to use. This enables an individual to have a distinct voice in the collective agenda, allowing him or her to move easily from task to task. *Team-based* collaboration is more characterized by institutional elements. Participants are committed to a team goal that requires enduring coalitions under well-defined leadership. They have assigned roles dividing labor within the team. A clear boundary between private (within team) and public communication exists, which may make collective action more costly (Flanagin et al., 2006).

The formation and maintenance of an engagement network is inherently interdependent in CBPP. The structure of the engagement network can be explained by endogenous factors, which are structural features internal to a network (Monge & Contractor, 2003). Endogenous factors capture how relational properties of the network influence its self-organization (Contractor, Wasserman, & Faust, 2006). To analyze the structure of a CBPP engagement network, we examine three basic endogenous structural tendencies in a network: density, reciprocity, and centralization (Hunter, Handcock, Butts, Goodreau, & Morris, 2008).

### ***Density of the Engagement Network***

Density is the proportion of all possible ties between participants that are actually present in the network (Hanneman & Riddle, 2005). Network density is generally inversely related to network size: As size increases, density decreases (Wasserman & Faust, 1994). The reasons are at least twofold: First, the number of connections one person can have is limited; second, it is easier for people to know each other in smaller communities. Though density has always been included as a covariate in the analysis of networks, little is known about what other factors affect density.

This study focuses on uncovering the relationship between ways of organizing collective action and collaboration density. Density thus is viewed as a dependent variable. In online collaboration networks where cues are often missing, forming collaboration ties takes effort and thus does not occur indiscriminately. As discussed earlier, the literature on traditional forms of collective action concludes that hierarchical structures facilitate collective endeavor (Olson, 1965). In other words, people are more likely to work together in communities with formal structure. This indicates higher density in collective action networks where contributors are organized through formal structure.

In a CBPP engagement network, density captures the number of interactions that actually occur between participants vis-à-vis the theoretical maximum. When institutional engagement dominates, CBPP members' actions are more firmly steered by a group agenda and performed under formalized participant roles. This may lead to high commitment for members to engage with others regularly. More so, members will be more likely to collaborate with other members because of the division of labor in projects. Compared to entrepreneurial engagement driven primarily by individual interest, institutional engagement tends to attract more collaboration between members who possess certain skill sets. This suggests a denser structure where the CBPP engagement mode has more institutional features. We propose that:

*H1: Density in the CBPP engagement network is positively associated with the degree of institutional engagement.*

### *Reciprocity of the Engagement Network*

Reciprocity is the extent to which existing ties in a network are reciprocated (Hanneman & Riddle, 2005). Certain networks, such as friendships or partnerships, are inherently symmetrical. Relationships built upon remix are asymmetrical. It is quite likely that an individual chooses to remix a music piece by someone who possesses greater expertise or authority and that this second person is unlikely to reciprocate the remix. Understanding what affects network reciprocity thus is important.

At the dyadic level, network exchange theory suggests that the bargaining power of individuals depends on the extent to which they are included in communication and other exchanges within the network (Monge & Contractor, 2003). Individuals forge network ties based on their need to obtain and exchange information or material resources from others and their ability to exchange with others (Homans, 1974). The asymmetry in such network links may lead to power imbalances. Individual actors can minimize such imbalance by creating joint dependence, that is, by reciprocating network ties (Gulati & Sytch, 2007).

In a CBPP engagement network, reciprocity captures the degree to which individual members reciprocate each other's CBPP initiatives. The higher the reciprocity, the higher the stability of contribution. An engagement network with higher reciprocity facilitates collective action. Institutional engagement entails patterned normative rules and practices of production to be followed by all participants (Bimber et al., 2005). Individual contributors are thus placed in a social system that emphasizes formal and informal communication channels through which they become familiar with each other's expertise and collaboration procedures. They are thus more likely to engage in repeated communication and sustained collaboration. In this case, members will tend to reciprocate each other's initiatives. Therefore, *H2: The degree of reciprocity in the CBPP engagement network is positively associated with the degree of institutional engagement.*

### *Centralization of the Engagement Network*

Centralization is the degree of inequality or variance in a network as a percentage of that of a perfect star network of the same size (Hanneman & Riddle, 2005). Traditional literature on collective action has suggested that organizations with higher centralization are more likely to achieve success (Marwell & Oliver, 1993). However, it is not clear from the literature how methods of organizing collective action affect centralization in the engagement network.

In a directed network, the inequality can be examined through indegree and outdegree levels. Indegree centralization in a CBPP engagement network captures the distribution of incoming ties for all nodes, and outdegree centralization captures the distribution of outgoing ties. The higher the centralization, the lower the variability in node centralities. Indegree and outdegree centralizations can be illustrated by the in-star and out-star structures (Figure 2), which indicate that CBPP members tend to collaborate around a small number of key contributors. The presence of *k* stars in a network indicates the propensity for individual nodes to be connected with others who do not have direct ties with one another (Atouba & Shumate, 2010). The few central nodes thus play the role to coordinate unlinked others into effective collective action.

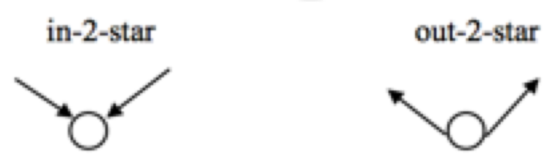



***Figure 2. Illustration of in-2-star and out-2-star.***

Literature on collective action suggests that ad-hoc collaboration results in more autonomy and lower centralization, whereas team-based collaboration results in higher centralization. Institutional engagement implies the definition of formal roles, including leadership that sets the agenda for all or some of the participants (Bimber et al., 2005). We expect this to lead to greater centralization in the engagement network as participants coalesce around few project leaders. Thus, we propose:

*H3: The degree of centralization in the CBPP engagement network is positively associated with the degree of institutional engagement.*

## Background of the Two CBPP Communities Under Study

The current study is based on data collected from two communities that engage members in open musical collaboration, ccMixter and Kompoz. All shared content on the two communities is licensed under CC licenses. Members engage in producing new music by (re-)using resources available in their community. Remix networks in these communities differ from other types of peer production and online collaboration in that it is through the reuse that innovation and creativity are enabled (Stone, 2009).

Initially set up in 2004 as a platform for a *Wired* magazine remix contest, ccMixter aimed to drive adoption of CC licenses. The community outlived the initial contest by focusing on ad-hoc and contest-driven remixing. The content on ccMixter evolves through the production of iterations of a song, often by self-selected contributors. Apart from the occasional organization of contests (participation in which is also purely voluntary and interest driven), there is no structure in collaboration. Members produce new contributions by mixing and matching existing content at will.

Launched in 2009, Kompoz has grown faster than ccMixter and stresses explicit project collaboration. Members in the same project collaborate toward a final version of a specific music piece. In each project, project creators (the de facto leaders) and other contributors have clearly defined roles. The mode of engagement is hybrid in both of ccMixter and Kompoz. However, by virtue of organizing production in teams with well-defined roles, Kompoz leans more toward institutional engagement.

To further explicate this, it is useful to make a distinction between two levels of observation: micro and macro. Macro-observation provides a picture of how collaboration is structured at the community level, where leaders and administrators set rules for engagement, steering the community toward broad collaboration patterns; micro-observation enables us to uncover specific collaboration mechanisms underlying the efforts of individual contributors. This distinction adds structure to our analysis of hybrid CBPP communities while acknowledging the instrumental role of community leaders, the affordances of community-wide collaboration practices, and the agency of individual contributors.

Table 1 provides a detailed summary of the modes in both communities.

***Table 1. Mode of Engagement in ccMixter and Kompoz.***

| | | |
|---|---|---|
| Macro | Entrepreneurial | Kompoz:<br>A member can create at will a new public project and become the founder, with other members being able to join the same project. Though Kompoz has had several contests, they did not really take off. |
| | Institutional | ccMixter:<br>Time-limited contests initiated by community administrators in community, inviting other members to contribute according to pre-defined rules. |
| Micro | Entrepreneurial | Kompoz:<br>A member can choose to upload a track to any public project.<br>ccMixter:<br>A member can upload new and/or remix existing tracks in the shared pool at will. |
| | Institutional | Kompoz<br>Whether members' new uploaded tracks can be accepted into a project is decided by the founder.<br>The founder of a public project can choose to delete an uploaded track and thus nullify a member's contribution (and consequently his/her membership to the project team)<br>Only the founder can decide and publish the final version of the product in a project, announcing that the project is finished. |

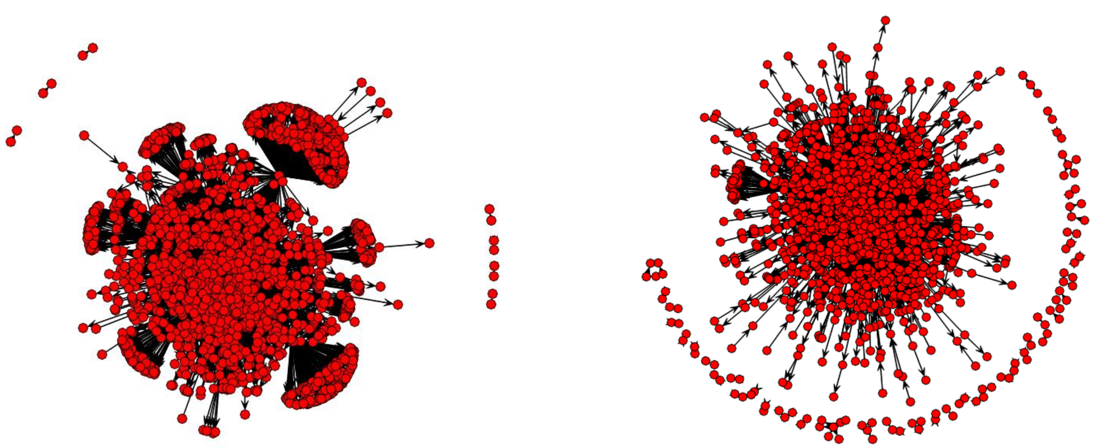
In ccMixter, the mode of engagement at the macrolevel is primarily characterized by institutional elements, as production is driven by community-wide remix contests. Only community administrators can create a contest and invite people to contribute. Administrators play a clear agenda-setting role to decide what music samples can be used as source material, what is the singular focus of a contest, how long a contest will last, and what outputs will win (Stone, 2009). In Kompoz, the primary form of engagement is project creation, and any member can start a new project with any focus. Project founders have a high degree of autonomy to design their projects in ways that are not bounded by any community constraints. Member initiative matters most. Though there were some contests on Kompoz, they did not attract much traffic. By the time of data collection, Kompoz had only four contests. Kompoz is thus more entrepreneurial at the macrolevel.

At the microlevel of individual participation, Kompoz is characterized by a hybrid of engagement with exhibits of more institutional elements. On one hand, community members have some agency for which projects they contribute to. On the other hand, the creator of a new project has some degree of authority to manage other members and their contributions (see Table 1). Project creators can recruit a specific talent, decide what music tracks to incorporate into the final output, or delete an uploaded music sample that does not fit the project agenda. In this sense, project creators play the role of gatekeepers to ensure all project members follow preset rules and norms defined by the leadership. In ccMixter, the mode of engagement at the microlevel is purely entrepreneurial, because there is no institutional structure setting rules and regulations for remixing. Members will remix any track available, without the need for any coordination or communication among members. They can join or leave a remix initiative at any time.

Data from ccMixter were obtained in collaboration with community administrators. Private data were removed at data collection. The data from Kompoz were obtained by crawling the website for all public teams and user profiles, which were also cleaned of personally identifiable information. Collected data include the number of contributors to each community, contributors' individual contributions, and their membership in project teams in Kompoz.

In ccMixter, the relationship that defines engagement is the remixing of another's contributions, which carries an idea through multiple iterations and helps to introduce it to more people. If A is the author of one original work, which is remixed by B, then there is a directed link (graph edge) from A to B signifying the transfer of ideas and content. In the Kompoz network, links point from project founders to project members. A creates a project. If B uploads at least one music track, B will automatically become a member of the project team. A link from A to B signifies this relationship from the initiator to follow-up contributors. Such a link is the semantic equivalent to a link in the ccMixter network.

The engagement networks were thus constructed for both communities, enabling the analysis of the entire population of each community. The two communities are comparable in size. Kompoz had 1,357 members actively contributing, with 4,319 unique links between them. The ccMixter engagement network had 1,697 active contributors and 4,846 unique links. See Figures 3 and 4 for network visualizations. These show that ccMixter evolved around key actors, whereas Kompoz's network tended to be flatter with more reciprocal ties. Details of the network patterns will be provided in the next section.



ccMixter engagement network Kompoz engagement network

***Figure 3. Engagement network visualizations.***

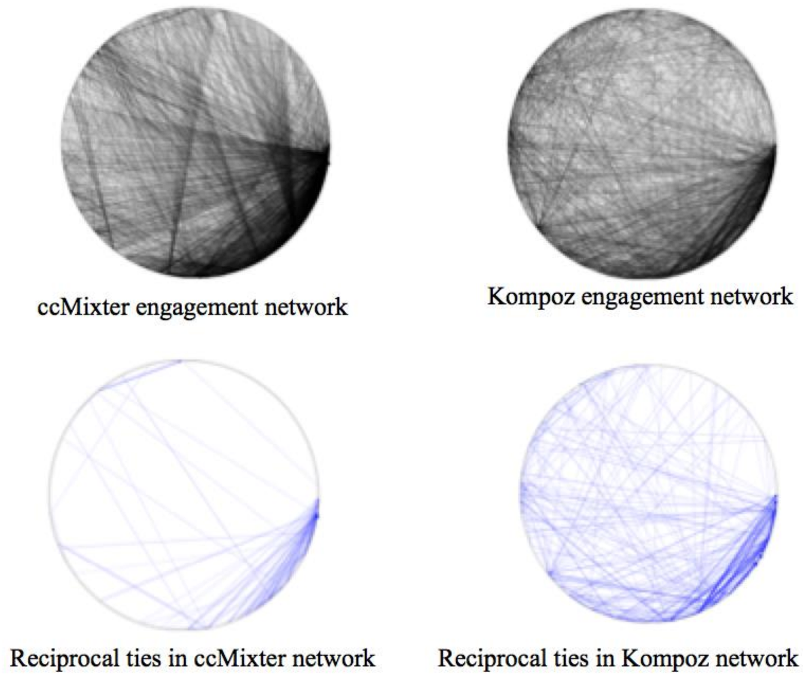



***Figure 4. Comparing network visualizations of ccMixter and Kompoz.***

**Data Analysis**

Data analysis was conducted in three steps. First we computed descriptive statistics to highlight features of the engagement networks in both communities. We then applied the univariate conditional uniform graph test (CUG) to examine whether density, reciprocity, and centralization depart significantly from those in similarly sized random networks to assess whether basic structural properties of the ccMixter and Kompoz engagement networks differed from what would be produced by chance alone, and to assess whether they differed from each other. Finally, exponential random graph models (ERGM) were used to estimate three key structural parameters in the networks under study. All analyses were conducted in R. ERGM fits the data when the *t* values of all parameters are lower than 0.01, indicating the standard error of each estimated parameter is within a tolerable range (Snijder, Pattison, Robins, & Handcock, 2006). A specific parameter is significant when the *t* value is within 1.96 standard errors of the estimated parameter. The parameter estimate could range from 0 to infinite.

ERGM was conducted as follows: To test H1 on structural tendency of density, "edges" was used as the parameter, measured by the number of ties in the network. To test H2 on structural tendency toward reciprocity, a "mutual" parameter was added to the ERGM, measured by the number of pairs of actors *i* and *j* for which both ties from *i* to *j* and from *j* to *i* exist. To test H3, we examined indegree and outdegree centralizations, adding in-2-star and out-2-star parameters to the ERGM. The in-2-star parameter was measured by the number of distinct ties a node receives from two other nodes; the out-2-star parameter was measured by the number of distinct ties from a node to two other nodes.

## Results

### *Descriptive Measures for Each Network*

As of data collection, the total number of registered members in ccMixter was 12,776, and 17% of them (2,145) were active users who had uploaded something to the community (referred to here as *authors*). Of these active users, 1,697 had remixed at least one work of another author or had at least one work remixed by another author, accounting for 79% of active users and 13% of all members. The number of isolates (active members who did not remix another member's work) was 448, accounting for 4% of all members and 21% of active members.

In Kompoz, the number of registered members was 11,431. Of these, 4,223 (37%) were active users who had created projects, and 1,357 (32% of active users and 12% of all members) had created projects that attracted active contributors. In Kompoz, isolates are members who created projects that did not attract any contributions. Because a user can start more than one project, it is possible that, say, A created two projects and only one project was successful in attracting contributions. 3,438 people set up empty projects, and 572 of them set up empty and successful projects. Thus the number of isolates was 2,866 in Kompoz, which accounted for 25% of all members and 68% of active users.

***Table 2. Descriptive Statistics of ccMixter and Kompoz Engagement Networks.***

| Network attributes | Kompoz | ccMixter |
|---|---|---|
| Vertices | 1,357 | 1,697 |
| Edges | 4.319 | 4,846 |
| Engagement density | .0024 | .0017 |
| Degree of reciprocal engagement (%) | 8.4 | 2.4 |
| Instances of reciprocal engagement | 333 | 115 |
| Out-degree centralization (%) | 10.9 | 21.0 |
| In-degree centralization (%) | 6.9 | 7.7 |

The following indicators range from 0 to 1: engagement density, reciprocity, in-degree centralization, and out-degree centralization.

Table 2 summarizes the descriptive findings. The Kompoz engagement network exhibited higher density (0.0024) than ccMixter (0.0017). Low density is generally a common characteristic of many real-world networks. The average frequency of collaboration was relatively high in ccMixter (1.95) compared to Kompoz (1.48). It indicates on average ccMixter members collaborated more often than Kompoz members. However, reciprocal ties were much more common in Kompoz (0.084) than in ccMixter (0.024), given network size and number of links present. Both indegree and outdegree centralizations were relatively higher in ccMixter (0.077 and 0.21, respectively) than in Kompoz (0.069 and 0.109, respectively). These indicate that at the macrolevel, the structures of collective action in CBPP communities already point in a direction that supports the hypotheses. We will now proceed to produce more rigorous statistical tests of the respective hypotheses.

### *Comparison of Network Structures*

First, CUG tests were conducted to provide a general assessment of the CBPP networks. CUG tests allow us to simulate graphs with the same attributes as an observed network and compare whether key attributes of observed networks are relatively low or high. For both networks, CUG tests were conducted in the following sequences: First, the CUG test was conducted on density, conditioned on network size; second, it was conducted on reciprocity, conditioned on density; finally, the test was conducted on indegree and outdegree centralizations, conditioned on density.

CUG tests on density and reciprocity showed the same results for both networks: Density in the observed engagement network was lower than we would expect based on network size, and reciprocity in the observed network was higher than randomly generated networks with the same densities. This suggests that collaborative production takes time and resources; therefore, CBPP members will not collaborate indiscriminately. Furthermore, it shows in both communities that members tend to reciprocate each other's initiatives.

CUG tests on indegree and outdegree centralizations showed that both values were larger than expected. None of the randomly generated 1,000 graphs with the same density had centralization as high as in ccMixter and Kompoz. This is a surprising finding, as an online community is often characterized by less hierarchy where members are attracted by decentralized communication and coordination (Benkler, 2006; Bimber et al., 2012).

***Table 3. Parameter Values for Converged Models for ccMixter Engagement Network.***

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Edge | -6.39 (.01)*** | -6.43 (.02)*** | -6.79 (.34)*** | -7.03 (.52) *** |
| Mutual | | 3.40 (.07)*** | 2.90 (.54)*** | 3.28 (63.37) |
| In-2-Star | | | .04 (.0001)*** | .04 (.02)* |
| Out-2-star | | | | .03 (.04) |
| BIC | 71599 | 71270 | 68884 | 64800 |

*** $p < .001$, ** $p < .01$, * $p < .05$. For each model, parameter estimates were reported with standard errors included in the parenthesis.

The finding that the microlevel engagement networks observed in both communities exhibited more extreme structures motivates us to further examine whether centralization is related to the mode of engagement. ERGM was conducted to compare how different ways of organizing CBPP affect the structures of the engagement network. ERGM findings can be found in Tables 3 and 4, which summarize estimates, standard errors, and statistical tests of the structural parameters for all the models. For all the models, the Bayesian information criterion (BIC) is a criterion for model selection. Models with lower BIC values are preferred.

***Table 4. Parameter Values for Converged Models of Kompoz Engagement Network.***

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Edge | -6.05 (.02)*** | -6.22 (.02)*** | -6.78 (.12)*** | -6.88 (.23)*** |
| Mutual | | 4.52 (.10)*** | 4.52 (.15)*** | 3.54 (3.68) |
| In-2-star | | | .05 (.0009)*** | .05 (.02)* |
| Out-2-star | | | | .04 (.006)*** |
| BIC | 60929 | 59679 | 57472 | 55359 |

*** $p < .001$, ** $p < .01$, * $p < .05$. For each model, parameter estimates were reported with standard errors included in the parenthesis.

The first ccMixter model showed that edge was negative and significant (-6.39, SD = .01, $p < .001$), indicating a low baseline propensity to form collaboration. The second model showed that, holding the number of edges constant, the observed ccMixter network had a stronger tendency for reciprocity (3.40, SD = .07, $p < .001$). Testing higher-order structural parameters, we found that in-2-star was positive and significant (.04, SD = .0001, $p < .001$). This suggests that a small number of participants produce works that are disproportionately popular for remixing, holding the number of links and reciprocal collaborations constant. This suggests a more pronounced core-periphery structure in ccMixter than is expected by chance alone. Furthermore, out-2-star was added into the model. It was positive but nonsignificant (.03, SD = .04, $p = .56$), indicating that the centralization tendency of a small group of ccMixter participants disproportionately active in remixing others' work was not significant.

The ERGM of the Kompoz network generated somewhat different results. The first model was also negative and significant (Edge = -6.05, SD = .02, p < .001). The second model was significant too (Mutual = 4.52, SD = .10, $p < .001$). When the In-2-star was added into the third model, it was positive and significant (.05, SD = .0009, $p < .001$). In the final model, the out-2-star was positive and significant (.04, SD = .006, $p < .001$).

To test the hypotheses, the parameter coefficients of the optimized model (the one with the lowest BIC) were used to compare the network structures of ccMixter and Kompoz (see the right-most columns in Tables 3 and 4). Goodness of fit in both optimized models suggests that the indegree and outdegree distributions of the observed networks were consistent with simulated networks. Other distributions followed the same patterns, indicating that our choice of models was appropriate. The coefficients are log odds, which can be interpreted as the probability of tie formations with the increase or decrease of one parameter while holding other parameters constant. The best-fit equations for tie formation in both networks are listed below:

$$Y_{\text{tie\_formation\_in\_ccMixter}} = -7.03X_1 + 3.28\,X_2 + .04\,X_3 + .03X_4,$$

$$Y_{\text{tie\_formation\_in\_Kompoz}} = -6.88X_1 + 3.54\,X_2 + .05X_3 + .04\,X_4,$$

where $X_1$ = change in the number of ties in the observed network; $X_2$ = change in the number of reciprocal ties; $X_3$ = change in the number of in-2-star groups; and $X_4$ = change in the number of out-2-star groups.

H1 tested whether an engagement network will demonstrate a denser structure when engagement has more institutional features. Taking the value for *edge*, in the ccMixer model as an example, the coefficient -7.03 is the log of odds in the engagement network. This indicates when all other network parameters in model 4 were controlled for, the possibility of tie formation between any two ccMixter members was exp(−7.03) / [1 + exp(−7.03)], which can be rounded to 0.09%. The corresponding probability in Kompoz was 0.10%: marginally higher. Considering the descriptive findings on density, the results point to the direction of H1 without providing strong support for it.

H2 tested whether the engagement network will demonstrate higher reciprocity when engagement is characterized by more institutional elements. Both networks showed a strong tendency toward reciprocity, but the tendency in Kompoz was stronger. This means that the tendency toward reciprocity is strengthened by the institutional engagement. Together with the descriptive finding that the observed reciprocity in Kompoz was nearly three times as high as ccMixter, H2 received some support.

H3 tested whether the engagement network would demonstrate higher centralization when engagement was characterized by more institutional elements. To examine the structural tendency toward centralization, we examined structural effects at the triangle level, adding in-2-star and out-2-star in the final models. The effect of indegree centralization was positive and significant for both networks. The effect of indegree centralization was stronger in Kompoz, indicating a stronger tendency for members of Kompoz to be followed up on other initiatives by at least two more peers. Outdegree centralization was positive but not significant in ccMixter, although it was positive, similarly sized, and significant in Kompoz. However, we noted earlier in the descriptive findings that ccMixter exhibits overall higher indegree centralization than Kompoz, and twice as high outdegree centralization. How can we untangle the findings on centralization?

It will be helpful to return to the distinction between macro- and micro-observations. On one hand, the descriptive values showed the centralization trend at the macro (whole network) level. Both indegree and outdegree centralizations were higher in ccMixter, consistent with the depiction in Figure 3 that shows a few large star formations. High outdegree centralization in ccMixter is likely attributable to popular contests, where one work was remixed by many different community members. On the other hand, ERGM results showed centralization trends at the microlevel. Findings indicate that Kompoz, with more institutional elements of organization at this level, has a stronger tendency toward centralized structure, whereas ccMixter exhibits higher centralization at the macrolevel, where, by virtue of the community-organized contests, it operates in a more institutional manner at that level. H3 therefore received some support in both networks, but only insofar as we were able to make a distinction between institutional and entrepreneurial engagement at the macro (network or community) and micro (individual, small group, or team) levels of engagement.

## Discussion

This study applied the mode of engagement from the collective action space framework to CBPP and examined the effect of organizational structure on collective action in CBPP communities. With social network analysis, three basic network structures were tested and compared: density, reciprocity, and centralization. Results are interpreted and discussed here through the lens of collective action theory.

Density indicates the extent to which members are connected through their contributions to the same project in Kompoz and their remixes in ccMixter. Lower density means nodes are spatially knitted and that the network lacks cross-linkage, which is adverse to information diffusion. Density in Kompoz was marginally higher than in ccMixter, indicating that Kompoz members are more likely to receive musical ideas from others, or that they are more conducive to collective action. Another observation is there are three times as many reciprocal ties in Kompoz than in ccMixter. Reciprocity can be interpreted as a sign of equal willingness to join others' initiatives, or as an indication that some members tend to treat each other as peers, with respect to their abilities to jumpstart projects worth contributing to.

The institutional mode of engagement in Kompoz encourages members to create their own projects and invite others to contribute to virtual bands. The founder of each project has a responsibility to review all uploaded music tracks to identify valuable contributions. Through this process, the founder can also identify contributors' talents and may choose to join projects created by valued contributors in return. Together with other means of social interaction (such as e-mail, chat rooms, and blogs) afforded by Kompoz, members will be more likely to notice who has made contributions to what project and will become more familiar with other members. All this will facilitate mutual communication, leading to greater reciprocity and higher network density. It would thus appear that having more institutional elements benefits collective action in general and for commons-based peer production in particular.

One possible reason for the observed lower reciprocity and lower network density in ccMixter could be the absence of means for the self-organizing of members or the relatively high reliance on centrally organized contests. Members of ccMixter may be more self-selective, as they are not encouraged to contribute to specific teams or to reciprocate with one another. The community also lacks the means to exploit weak ties among members, as there is no supported mechanism for inviting others to a new endeavor. As an earlier study discovered (Cheliotis & Yew, 2009), contests in ccMixter could provide incentives for members to upload their work; however, this engagement tends to be one-time participation, and the majority of the uploads remains unremixed.

ERGM results on reciprocity also suggest a positive correlation between reciprocity and the possibility of collaboration in both communities, and the correlation in Kompoz was higher. Given that, in only the two optimized ERGMs reciprocity was insignificant, we cannot say for sure the reciprocity in Kompoz has a stronger effect on collaboration. However, this indicates that members in Kompoz are more likely to support each other's CBPP initiatives. Higher reciprocity helps to reduce dependence asymmetry for developing higher trust and forming more equalized attention, which are conducive to collective action.

With regard to the structural tendency toward centralization, descriptive findings were counterintuitive. In the CBPP engagement network, higher outdegree centralization indicates a greater imbalance in influence between participants, whereas higher indegree centralization is a sign of a greater imbalance in volunteerism among more active and less active participants. Influence in the engagement network refers to the case where some participants are more effective initiators of influential engagements than others. Volunteerism refers to a spirit of contributing to the efforts of others, following up, and participating in many different initiatives of other community members. The higher centralization in ccMixter is likely attributable to an imbalance in seniority and influence between members, which is more pronounced in a setting where engagement is ad hoc and entrepreneurial. It is also attributable to the centralized organization and promotion of community-wide contests that focus activity around specific material to be remixed.

The effect of having more influential members (i.e., the effect of outdegree centralization) on facilitating collaboration in ccMixter was not significant; however, having more active remixers (i.e., the effect of indegree centralization) has a positive impact. This indicates that even though there are some central members in ccMixter, exploiting their power toward mobilizing more contributors for collaborative production might be difficult. Although the centralization in Kompoz was lower, the effects of indegree and outdegree centralizations were both positive and significant on mobilizing collaborators to build up a common resource pool.

Findings on centralization taken together indicate that in Kompoz, providing people with the tools to self-organize eventually leads to less centralized engagement overall (at the macrolevel). Providing no such tools may result in the de facto leaders of a community needing to coordinate all actions, leading to higher centralization. Elements of formal organization at the microlevel (such as in teams with assigned roles) are thus not to be associated with centralization of engagement, depending on the organizational form and whether the engagement has more entrepreneurial features.

ERGM findings showed a stronger effect of centralization in facilitating tie formation in Kompoz than in ccMixter. This suggests that there are still some benefits to institutional ways of mobilizing contributors for online collaboration. This could be understood by the following summary of institutional engagement: more structured roles provided to potential contributors, normative rules of performing tasks, and sustained collaboration among peers. Therefore, this study concludes that, despite of the values of loosely coordinated entrepreneurial online action in providing autonomy for participants, the introduction of some structure to a community's mode of engagement can be beneficial to online collective action.

After adding centralization parameters, the effect of reciprocity became insignificant in both communities. This suggests that centralization may have greater explanatory power than reciprocity in tie formation mechanisms. In a network, when a node faces the decision of forming a tie, it needs to decide whether to reciprocate an existing tie or to reach out for a new connection. In CBPP communities, it seems more likely that members reach out to form new ties that constitute star structures than to form reciprocal ties.

This study has several limitations. First, the data were not representative of all CBPP communities, which constitute a diverse population. We should exercise caution in generalizing these findings. However, by studying two CBPP communities with divergent organizing philosophies but the same objective of collaborative music production, this study contributes to the limited knowledge of organizing collaboration in CBPP.

The second limitation is the lack of analysis of the mode of interaction. This study focuses on the mode of engagement, which allows us to empirically compare and contrast how institutional and entrepreneurial modes of organizing collective action influence the structures of CBPP collaboration. This helps to compensate for the lack of comparative studies on the organizing of online collaboration in the CBPP literature. Future study will examine both the mode of engagement and the mode of interaction in the collective action space to uncover how they influence each other to drive successful collective action. For example, a study could collect communication network data to measure features of two interaction modes through network attributes. Another might launch a survey launched to measure how users in each community perceive the community's structure, the level of trust among peers, communication frequency, and perceived efficacy for both individuals and communities.

The third limitation is that the network analysis was constrained by the data, which were collected from the traces of electronic communication in both communities. To safeguard participant privacy, identifying information and other personal details were removed. Therefore, no user attributes were added in ERGM. Furthermore, because of the large number of nodes and links in the datasets, only two parameters of centralization were added to the ERGM. This is because higher-level network parameters tend to have poor convergence with a big network data set (Wang, Robins, Pattison, & Lazega, 2013). Future work will include other relevant factors and collect longitudinal data to analyze the evolutionary mechanisms of CBPP engagement networks, particularly how institutional and entrepreneurial engagements affect the sustainability of collaboration.

Last but not least, this study was able to provide only a small glimpse into the dynamics of collective action. The value of SNA has been stated earlier, but we acknowledge that SNA can answer only certain questions, such as those about underlying network mechanisms and the effect of node attributes on tie formation. To a certain extent relying on SNA sacrifices the richness of user data, particularly how users perceive the structure of a community and each other's CBPP efforts.

The theoretical framework of the collective action space has been tested through survey and interview data by analyzing how users perceive the alignment of collective and individual agendas. This current study, however, was not designed to measure user perceptions. Instead, it focused on the mode of engagement and relied on observation and interpretation of electronic traces of communication, measuring structures and behaviors of collective action participants in CBPP. The effort of applying network analysis to uncover the engagement patterns between individual members is not to deny the value of survey as a valid method in such research but to complement what can be done by survey. It also calls for further research to examine whether there is consistency between user perception and the resultant engagement structures. Through the use of mixed methods, inferences can be made of the relationship between various modes of engagement and the likelihood of collective action to occur.

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