Density Dependence Without Resource Partitioning: Population Ecology on Change.org

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CSCW '17 Companion, February 25 - March 01, 2017, Portland, OR, USA
ACM 978-1-4503-4688-7/17/02.
http://dx.doi.org/10.1145/3022198.3026358

Abstract
E-petitioning is a prominent form of Internet-based collective action. We apply theories from organizational population ecology to investigate whether similar petitions compete for signatures. We use latent Dirichlet allocation (LDA) topic modeling to identify topical niches. Using these niches, we test two theories from population ecology on 442,109 Change.org petitions. First, we find evidence for density dependence, an inverse-U-shaped relationship between the density of a petition's niche and the number of signatures the petition obtains. This suggests e-petitioning is competitive and that e-petitions draw on overlapping resource pools. Second, although resource partitioning theory predicts that topically specialized petitions will obtain more signatures in concentrated populations, we find no evidence of this. This suggests that specialists struggle to avoid competition with generalists.

Author Keywords
population ecology; competition; e-petitions; civic engagement; online activism

ACM Classification Keywords
H.5.3 [Information Interfaces and Presentation (e.g., HCI): Group and Organization Interfaces]: Computer-supported cooperative work

Figure 1: Examples of similar petitions. It is easy to find many petitions against the Yulin dog meat festival.

Background

E-petitions are a prominent form of online political participation [4, 6]. On Change.org, one of the most popular e-petition platforms, one petition condemning the Yulin dog meat festival in Guangxi has collected 4,431,005 signatures. That said, Change.org is host to millions of other petitions including dozens of other petitions against dog meat consumption (see Figure 1) and many thousands of petitions about animal rights. As Figure 2 shows, signature counts on Change.org are very unequal and most petitions receive only a small number of signatures.

Why do some petitions collect many signatures while most do not? Nearly all prior studies of petition success have sought to explain this in terms of features of petitions or signatories. These studies have considered the role of social information, personality traits of signatories, features of petition platforms, and exposure to social media [7, 5].

Taking a very different approach, a small body of work in social computing has built on “ecological” theories from sociology and organizational studies [2]. Studies in this vein seek to model how competitive and complementary dynamics in populations of online communities might influence levels of participation and survival [10, 9, 8]. We hypothesize that these dynamics can help explain e-petition success as well. In particular, we use data from a population of online petitions drawn from Change.org to test two of the most important theories from population ecology in organization studies: density dependence theory (DDT) [3] and resource partitioning theory (RPT) [2].

Population Ecology of E-Petitions

We extend the literature on organizational population ecology to study e-petitions. Within organizational population ecology, a *niche* represents the space occupied by an organization within a broader industry or field. Dynamics of competition and complementarity influence the survival or success of organizations within niches. A niche is *dense* when it has a large, competitive population. Density dependence theory suggests that population size within a niche can have a positive effect on success as the niche gains legitimacy. However the positive effect lasts only up to a point after which competitive forces are stronger than complimentary ones. Therefore the cumulative relationship between population size and success is inverse-U shaped [3].

On an e-petition platforms, individual petitions can be thought of as competing over resource pools needed to obtain signatures. Although the individual act of signing may be easy, doing so requires the scarce resources of time or attention of potential petition singers. At high levels of petition density, a niche may become more competitive as these become more scarce. Because petition creation is easy, it may also be the case that there are many petitions in sparse, non-competitive niches. Therefore, following DDT, we predict: **H1: The relationship between petition niche density and number of signatures is $\cap$-shaped.**

We also test resource partitioning theory (RPT) [2]. Populations of organizations contain a mixture of specialists and generalists. A more concentrated population has a less equal distribution of signatures. RPT offers an explanation of how populations become concentrated. Generalists can grow very large because they can utilize a broad range of resources. If specialists can succeed, then concentration increases as the population contains both specialists with fewer signatures and generalists with many. However if specialists cannot succeed, there would be fewer specialists and the distribution of signatures would be more equal. Petitions can include many topics (generalists) or narrowly focus on only one or a few (specialists). Therefore, following

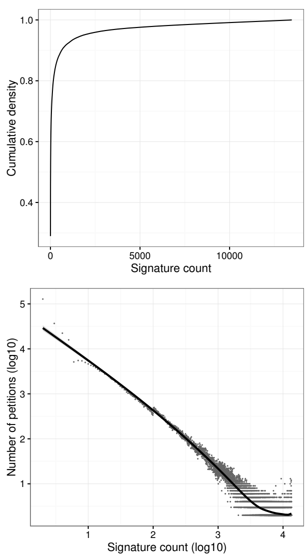

Figure 2: Signatures are distributed across petitions following a power law. The top panel shows the proportion of petitions that have received fewer than the number of signatures described in the x-axis. The bottom panels is a log–log plot of signatures by number of petitions that have received that many signatures.

RTP, we predict: **H2: Specialized petitions will receive more signatures in more concentrated niches**.

Data & Methods

Over three days in late December 2015, we downloaded all petitions from the Change.org API that were posted between January 16, 2007 and December 24, 2015. We removed non-English petitions, petitions with 480 characters or less of petition content, and petitions whose text was classified as spam by the Akismet API. Our final dataset includes the remaining 442,109 petitions.

Ecological approaches to studying online communities often use membership or topic overlap to identify competition between online communities [10, 9, 8]. This offers an imperfect test of theories from organizational ecology because it does not operationalize the concept of a niche. Both DDT and RPT – two of the most important theories – are theories about features of niches and their correlates.

We use LDA topic modeling, an unsupervised machine learning algorithm, to construct 100 niches [1]. The intuition behind our approach is that an LDA topic will represent a group of words that distinguish coherent groups of petitions. Because they use similar language, petitions within a topic likely appeal to related sets of preferences, claims, and issues. Because LDA is a mixture model, each petition "belongs" to every topic with varying degrees of membership that are determined by how well each petition's words match the words in each topic.

Our unit of analysis is the petition. Our use of LDA allows us to construct continuous measures of our independent variables: density, concentration, and specialization. The Herfindahl-Hirschman index (HHI), an inequality statistic, of a petition's topic memberships measures specialization. A topic's density is the total mass of petitions assigned to it. Its concentration is the HHI of the distribution of signatures. We compute topic-level measures from the set of petitions created within each month. We measure density and concentration for a petition by taking the sum of topic densities and concentrations weighted by the petition's topic memberships.

We use negative binomial regression to test our hypotheses with control variables for organizational backing and topic membership and with random intercept terms for creator and month created.

Results

We find evidence for **H1**, that the density of petitions in a topic has a $\cap$-shaped relationship with average number of signatures. Our model has a second-order coefficient of density of -29.5 ($\sigma = 3.62$). Figure 3 shows the expected number of signatures for a median petition with different levels of density.

We do not find evidence for **H2**, our hypothesis that more specialized petitions would have more signatures within more concentrated niches. Given our large sample, this null effect is well estimated. According to post-hoc power analysis, our sample size is sufficient to generally identify effects on signature count as small as 1% of a standard deviation at significance level 0.05 well over 999 times out of 1000.

One threat to the validity of these findings is the underlying validity of the niches we construct using LDA. To address this concern, we validated topical niches by reading petitions sampled from the topics and coding them as corresponding to a coherent issue area. Recomputing our measures of density and concentration using only the 34 we deemed most valid did not substantively effect our results.

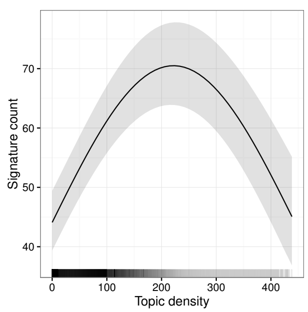

Figure 3: Marginal effects plot showing model-predicted signature counts for petitions across the observed range of petition-level topic density. 95% confidence intervals are shown. Lines at the bottom of the graph show the distribution of our data across the range of topic density.

Discussion

Our support for **H1** suggests that petitions compete over limited resources. That said, Figure 3 also shows that most petitions in our dataset occupy more sparse niches where a complementary relationship between petitions exists. Our results do not address the fact that petition creation and petition signing may be linked to external events that increase the attention and potential signatories available in a topical niche. We uncover no evidence to support **H2** and find that specialized or focused petitions do no better in concentrated topics. Perhaps concentrated environments are not better for specialist petitions.

Our application of LDA topic models to operationalize population ecology theory opens a range of possibilities for for exciting future work. Textual environments with possible complementary and competitive dynamics include Internet memes, online communities, journalism, and education. Second, designers of systems for cooperative work should consider how ecosystems may change as they grow and whether increasing competition may undermine collaboration.

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