Universal Mechanisms in the Growth of Voluntary Organizations

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PACS. 87.23.Ge – Dynamics of social systems.
PACS. 89.75.-k – Complex systems.

Abstract. – We analyze the growth statistics of Swedish trade unions and find a universal functional form for the probability distribution of growth rates of union size, and a power law dependence of the standard deviation of this distribution on the number of members of the union. We also find that the typical size and the typical number of local chapters scales as a power law of the union size. Intriguingly, our results are similar to results reported for other human organizations of a quite different nature. Our findings are consistent with the possibility that universal mechanisms may exist governing the growth patterns of human organizations.

Introduction. – The developments of the last decade and a half in the former Eastern Block countries show that democratization and market reforms do not automatically generate healthy democracies and healthy market economies. Several studies suggest that the reason for this failure may be that well-functioning societies\textsuperscript{1} are fostered by the existence of a dense web of voluntary organizations which facilitate the creation of a “social capital of trust” among the members of the society. Indeed, many studies support the importance of institutional settings for the maintenance of healthy societies. A telling example is a study of the functioning of democratic institutions in the 27 regions of Italy, suggesting a correlation between a dense web of small voluntary organizations and a dynamic civil society\textsuperscript{1}. Specifically, in regions where people are embedded in a rich environment of decentralized civic networks, there is an increasing likelihood that the individuals will be able to cooperate in endeavors of mutual benefit\textsuperscript{2}. It would appear then that voluntary organizations promote the creation of a “social capital of trust” that helps serve the functions of (a) overcoming the anonymity of life in large societies, which may breed “free-rider” behavior\textsuperscript{3}, and (b) overcoming the difficulties in partitioning the exploitation of public resource\textsuperscript{4}, such as use of public water resources, limitation of air emissions, or determination of fishing quotas.

Because of their societal importance, research on voluntary organizations has been very active, including many different aspects such as (i) competition between voluntary organizations and other organizations\textsuperscript{5}, (ii) the impact of social networks in membership recruitment\textsuperscript{6}, (iii) social background of members\textsuperscript{7}, and (iv) the ability of voluntary organizations
to overcome “free-rider” behavior \[8\]. Despite this research activity, one area that has not been pursued concerns the quantitative characterization of the growth dynamics of voluntary organizations.

Here, we use concepts and methods of statistical physics \[9,10\] to quantify the growth of voluntary organizations. Specifically, we test the possibility (i) that the statistical properties of fluctuations in the output of a system yield information regarding the underlying processes responsible for the observed macroscopic behavior \[9,10\], and (ii) that the precise details of the interaction between the subunits comprising the system may play virtually no role in determining the macroscopic behavior of the system \[10\]. A striking example is the behavior of response functions in the vicinity of the liquid-gas critical point (the temperature and density at which liquid and gas become indistinguishable fluids) \[9,10\]. Close to their respective critical points, very different liquids—such as water, a polar molecule that forms hydrogen bonds, and argon, an inert atom—become extremely sensitive to disturbances yet their responses to those disturbances have identical spatial and temporal scale-invariant properties.

**Results.** – We analyze a database \[11\] that provides a detailed resource for the study of the growth statistics of a range of different Swedish voluntary organizations—including trade unions \[12\], temperance movements \[13\], free churches \[14\], and the social democratic party \[15\]—during the 50 yr period 1890–1940. We concentrate our study on trade unions for three reasons. First, there are over 10,000 local chapters (or sections) comprising 60 trade unions, while there are only 5 free churches, 5 temperance movements and 1 political party in the database. The larger number of trade unions enables us to make a more significant statistical analysis of the growth process for the organizations. Second, a number of studies \[16\] indicate that Swedish trade unions played a very important role in the democratization process in Sweden, making their study particularly relevant. Third, unions are a particularly

![Fig. 1 – Historical data for total number of union members in Sweden. (a) Time evolution of Swedish population, work force, and unionized work force for the period 1900–1940. In the subsequent analysis, we deflate the number of members of a union—its size—by the population growth, to remove the effect of population growth on the analysis. (b) Probability density function of the size Swedish trade unions for all years and all unions. The distribution can be well approximated by a log-normal fit (full line in figure), which suggests, according to Gibrat’s theory \[18\], that the growth is a random multiplicative process. For subsequent analysis, we partition the data into 4 bins according to union size, as illustrated by the figure.](image-url)
interesting type of voluntary organization as the decision to join a union is not an easy one: A prospective new member would ideally balance (i) the benefit of avoiding social pressure from fellow workers and (ii) hoped-for long-term benefits of membership, against (i) the investment of time and money into the organization, and (ii) the risk of losing the job or of being discriminated against.

We start by defining the annual growth rate—that is to say, the size fluctuation—of a union,

$$g(t) \equiv \log \left( \frac{S(t+1)}{S(t)} \right),$$

where $S(t)$ and $S(t+1)$ are the number of members of a given union in the years $t$ and $t+1$, respectively, deflated by Sweden’s total population. We find that the statistical properties of the growth rate $g$ depend on $S$; the magnitude of the fluctuations $g$ will decrease with $S$ since large organizations have smaller relative fluctuations. We partition the trade unions into bins according to their number of members—the union size (Fig. 1). Figure 2(a) suggests that the conditional probability density, $p(g|S)$, has the same functional form, with different widths, for all $S$. To test whether $p(g|S)$ has a functional form independent of union size, we plot the scaled quantities: $\sigma(S)p(g/\sigma(S)|S)$ versus $g/\sigma(S)$. Figure 2(b) shows that the scaled distributions “collapse” onto a single curve [9, 10], consistent with the functional form

$$p(g|S) \sim \frac{1}{\sigma(S)} F \left( \frac{g}{\sigma(S)} \right).$$

We next calculate the standard deviation $\sigma(S)$ of the distribution of growth rates as a
Fig. 3 – (a) Dependence of the standard deviation of the distribution of growth rates on number of members of the union. The fact that power law dependence of the standard deviation on size holds over three orders of magnitude—from unions with 40 members to unions with 40,000 members—suggests that this finding is not spurious. The straight line is a power law fit to the region $40 \leq S \leq 40,000$ yielding an exponent estimate $\beta = 0.19 \pm 0.05$. (b) Functional form of the distribution of growth rates. We plot the cumulative distribution of the scaled growth rates from all bins. The cumulative distribution, which yields the probability of finding values larger than a certain threshold, is obtained by integrating the probability distribution function between the threshold value and infinity. The figure confirms that the distribution is not Gaussian, but may be consistent with either an exponential or stretched exponential dependence in the tails.

function of $S$. Figure 3(a) demonstrates that $\sigma(S)$ decays as a power law

$$\sigma(S) \sim S^{-\beta},$$

with $\beta = 0.19 \pm 0.05$.

We next address the question of how to interpret our empirical results. We first note that a union is comprised of several local chapters, spread around the country. A reasonable zeroth-order approximation is that the number of members of the different local chapters comprising a given trade union will grow independently; so the growth of the size of each union as the sum of the independent growth of local chapters with different sizes. In a recently-proposed model [17, 18], the subunits comprising the organization grow by an independent, Gaussian-distributed, random multiplicative process with variance $\nu^2$. Existing subunits are absorbed when they become smaller than a "minimum size", which is a function of the activity they perform. Subunits can split into two new subunits if they grow by more than the minimum size for a new subunit to form. The model predicts $\beta = \nu/[2(\nu + \bar{w})]$, where $\bar{w}$ is the width of the distribution of minimum sizes [17].

Internal organization of the unions. – As trade unions have a complex internal structure, it is natural to inquire what are the statistical properties of the set of local chapters comprising a given union [17, 19, 20]. To this end, we quantify how the internal structure of a trade union depends on its size. Specifically, we calculate the conditional probability density $\rho(\xi|S)$ to find a local chapter with $\xi$ members in a union with $S$ members; Fig. 4(a). The model predicts that $\rho(\xi|S)$ obeys the scaling form [17]

$$\rho(\xi|S) \sim \frac{1}{\xi_i(S)} F_1 \left( \frac{\xi}{\xi_i(S)} \right),$$

(4)
Fig. 4 – (a) Probability density function of number of members of a local chapter, conditional on the size of the union it belongs to. We plot our results for two bins of union size. The figure reveals two interesting points: (i) the typical size of the local chapters increases with union size, (ii) the functional form of the distribution appears to be independent of union membership. (b) Scaled probability density function of scaled local chapter size conditional on union size (see text immediately following Eq. (4) for details). The data for the four bins collapse onto a single universal curve, suggesting that the structure of different unions is independent of union size except for a scale factor.

where $\xi_t(S) \sim S^\alpha$ is the typical size of a local chapter in a trade union of size $S$, and $F_1(u)$ appears to decay as a stretched exponential or a power law for $u \gg 1$. As a test of the scaling hypothesis [4], we plot the scaled quantities $S^\alpha \rho(\xi|S)$ versus $\xi/S^\alpha$ and obtain a good data collapse, that is, all data points fall onto a single universal curve; Fig. 4(b). To estimate $\alpha$, we use the fact that Eq. (4) implies that the typical number of local chapters in a trade union with $S$ members increases proportionally to $S^{1-\alpha}$ with $\alpha = 0.32 \pm 0.05$, while the typical number of members of these local chapters is proportional to $S^\alpha$ with the independent estimate $\alpha = 0.30 \pm 0.05$; Figs. 5(a),(b).

Discussion. – Which characteristics of a voluntary organization are important for the creation of social capital is a subject of debate in the literature [21]. One may reasonably hypothesize that the size of the subunits will be negatively correlated with their capacity for creating social capital, since members in large subunits will likely (i) not be able to create strong links among one another, and (ii) not be able to participate in the governing process as fully as the members of small subunits. Our results support this hypothesis and suggest that large organizations—because they typically consist of larger subunits—will be less effective in creating social capital than small organizations. This result may find support in the current trend in high-tech firms to organize projects around small teams that split, when they become too large, in order to facilitate cooperation.

Our findings are also of note for other reasons: First, our approach differs from the statistical methods traditionally used in macrosociology, which typically assumes that systems are linear and in an equilibrium state [22]. It also stands in contrast to the view that sociological explanations ideally would only make reference to individual agents and their actions ("methodological individualism" [1]). We show that techniques successfully used in statistical physics can be applied to a central sociological topic—voluntary organizations—to reveal nontrivial patterns and relationships.

Second, an intriguing aspect of our findings is that they provide evidence for growth
dynamics similar to those found for other organizations, such as business firms [23]. This similarity is rather surprising as the reasons for the growth of a voluntary organization are quite different from those for a business firm. In particular, the profit motive—perhaps the most important factor in the growth of business firms—is not evident for voluntary organizations. The similarity between the empirical laws describing the growth of voluntary organizations and business firms [23], and the fact these two types of organizations are apparently so different, raises an intriguing analogy between the growth of human organizations comprised of many animate interacting units and the physics of natural systems comprised of many inanimate interacting units. Our findings are consistent with the possibility that universal mechanisms governing the growth of human organizations—such as the complex internal structure of units, stochastic growth, and a broad range of scales—are more important than the idiosyncratic characteristics of the system that are customarily believed to determine the system’s dynamics.

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We thank S. V. Buldyrev, C. Edling, P. Gopikrishnan, P. Hedström, M. Macy, and V. Plerou for stimulating discussions and A. L. Stinchcombe for numerous comments and suggestions. FL thanks STINT (97/1837) and HSFR (F0688/97). The CPS is supported by NSF and NIH.

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