

## How Much is the Whole Really More than the Sum of its Parts? $1+1=2.5$ : Superlinear Productivity in Collective Group Actions and implications for organisation design

Didier Sornette

We present a new analysis of a representative sample hundreds of open source software (OSS) projects that show how development activity of successful open innovation projects occurs in productive bursts. We quantify a superlinear growth of production intensity ( $R \propto c^b$  as a function of the number of active developers  $c$ , with a median value of the exponent  $b=4/3$ , with large dispersions of  $b$  from slightly less than 1 up to 3. For a typical project in this class, doubling of the group size multiplies typically the output by a factor  $2^b=2.5$ , explaining the title. This superlinear law is found to hold for group sizes ranging from 5 to a few hundred developers. We propose two classes of mechanisms, interaction-based and large deviation, along with a cascade model of productive activity, which unifies them. In this common framework, superlinear productivity requires that the involved social groups function at or close to criticality, or in a "superradiance" mode, in the sense of the appearance of a cooperative process and order involving a collective mode of developers defined by the build up of correlation between the contributions of developers. In addition, we report the first empirical test of the renormalization of the exponent of the distribution of the sizes of first generation events into the renormalized exponent of the distribution of clusters resulting from the cascade of triggering over all generation in a critical branching process in the non-meanfield regime. We document a size effect in the strength and variability of the superlinear effect, with smaller groups exhibiting widely distributed superlinear exponents, some of them characterizing highly productive teams. In contrast, large groups tend to have a smaller superlinearity and less variability. The productive bursts underlying these results on a super-linear productivity are important because they contribute to an overall enhanced effectiveness of the workforce. Thus, it is in the projects' (and managers') interest to design organisations that will enable and benefit from bursts of activity and creativity. Based on observations of OSS projects, we generate six design principles to help managers deal with organisational challenges in open innovation: 1) transparency; 2) self-censored clans; 3) emergent technology; 4) problem front-loading; 5) distributed screening; and 6) modularity.

References:

D. Sornette, T. Maillart and G. Ghezzi,

How Much is the Whole Really More than the Sum of its Parts?  $1+1=2.5$ :

Superlinear Productivity in Collective Group Actions,

PLoS ONE 9(8): e103023. doi:10.1371/journal.pone.0103023 (15 pp) (2014)

(<http://arxiv.org/abs/1405.4298>)

A. Saichev and D. Sornette,

Super-linear scaling of offsprings at criticality in branching processes,

Physical Review E 89, 012104 (2014)

(<http://arxiv.org/abs/1305.0684>)

Georg von Krogh, Thomas Maillart, Stefan Haefliger and Didier Sornette,

Designing organizations for productive bursts, working paper (2014)