How to evaluate the power exercised over a free software project? An application to the case of the Android project.

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Abstract

The rights and duties associated with a free software project are defined in a licence (GPL, LGPL, MIT, etc.). Beyond the licence, the decision-making procedures are more or less formally defined by the project's governance, whose openness can be measured (e.g. Open Governance Index). However, control over a project is also exercised through more subtle mechanisms of influence, such as the deployment of resources in accordance with a principle of do-ocracy. Our research therefore focuses on the following question: "How can we evaluate the power exercised over a free project?" To do so, we propose the use of a concentration index which, when combined with a governance index, allows us to propose an approach to analyse the economic power exercised in different forms on a free software project. An illustration is made on the Android project.

Keywords

open source, governance, concentration index, governance index, android.

1. Introduction

Open source software is driven by a user-driven innovation system. Companies have gradually become involved, enabling them to offer commercial solutions based on one or more free and open source software technologies. These strategies are referred to as open source strategies (Fitzgerald, 2006). One or more open source service providers may therefore develop alongside the free software project (Jullien and Viseur, 2021). Companies can implement different business models in line with their commercial strategy and with the governance of the free software project (Viseur and Charleux, 2019). Governance has been investigated extensively in the literature (de Laat, 2007; Markus, 2007; O'Mahony and Ferraro, 2007; Jensen & Scacchi, 2010) with a particular focus on its dimensions and on the process of formalisation. However, more diffuse forms of control also exist, for example through resource deployment (Schaarschmidt et al., 2015). They are therefore poorly integrated in the indices for measuring the openness of governance (cf. Laffan, 2011, 2012). Therefore, this article addresses the question: "How to assess the power exercised over an open project?" We propose the use of a concentration index, which, when combined with a governance index, allows us to propose an approach for analysing the power exercised in different forms over a free project.

2. Review of the literature

In this section we discuss the governance of free software projects, the control of free software projects and the economic power in a market, leading to the presentation of a concentration index that can be used to measure the power exercised over a free software project by its contributors.

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1. Governance of open source projects

Markus (2007) defines governance as "*the means of achieving the direction, control, and coordination of wholly or partially autonomous individuals and organizations on behalf of an OSS development project to which they jointly contribute*" (p.152). The governance of a free software project is defined on three levels (Jensen & Scacchi, 2010). The 'micro' level concerns individual project participants (e.g. actions, resources and interactions); the 'meso' level, project teams (e.g. collaboration, leadership, control and conflict resolution); while the 'macro' level applies to inter-project ecosystems (e.g. collaboration, authority, control and conflict resolution). While governance is often informal at the beginning of the life cycle of free software projects (de Laat, 2007; O'Mahony and Ferraro, 2007), it can become more formalized over time, first with the definition of formal internal project rules and then with its institutionalization (de Laat, 2007).

This evolution generally takes place through successive iterations (O'Mahony and Ferraro, 2007). Viseur and Charleux (2019) have proposed a typology of the governance of a free software project in the form of four ideal-types: informal logic (emerging project, rules conditional on the choice of a free software licence), commercial logic (strong control by an open source publisher), industrial logic (strong control by a consortium of companies) and community logic (open and meritocratic community). The issue at stake concerns in particular the control of access (in writing) to the source code directories or of the evolutions of the roadmap. Governance therefore tends to be formalised, and the structures put in place, and their rules, condition the greater or lesser openness of the free software project. Laffan (2011, 2012) has therefore focused on measuring the degree of openness of governance. Her Open Governance Index makes it possible in practice to quantify, on a scale of 0 to 100, from the least open to the most open, the degree of openness of a project in terms of transparency, decision-making, reuse and community structure (Laffan, 2011, 2012). This index thus comprises 13 metrics relating to 4 areas of governance: access to source code, the development process, the creation of derivative works and the community.

1.1. Control of free software projects

While governance structures are important for the control of a project, there are other strategies to influence its evolution to a greater or lesser extent. The open source provider, if it exists, can also develop its power of influence on the project. Thus, contributing to the source code of a project allows for indirect control of the project, by virtue of a "*do-ocracy principle*", because, on the one hand, the project tends to be governed by those who contribute, and, on the other hand, it allows the company to direct the project towards certain technologies (Capra et al., 2011). Schaarschmidt et al. (2015) thus distinguish between two ways of influencing the project: leadership (e.g. sponsorship or recruitment of influential members) and deployment of resources (e.g. development capabilities). Influence can thus be extended within or outside the governance structures themselves (Linåker et al., 2020).

What emerges here are more discrete methods of influence, as they do not necessarily result in the visibility of the company within the organisational structure of the free software project. The latter is often carried by a core team (Torres et al., 2011). By assigning developers to a project, but without necessarily integrating its governance, the company can establish a relationship of strength with this core team. Moreover, it increases its chances of gaining the respect of the community, and therefore of having more influence on specification and planning decisions (Daniel et al., 2018; Linåker et al., 2020). The company can therefore exert power over a project, even if its governance is closed, by hiring or funding important developers. Moreover, even with open governance, the company can extend its influence by directing developments to benefit its own objectives (Daniel et al., 2018; Linåker et al., 2020). In extreme cases, a coalition of stakeholders opposed to the governance of a free software project may decide to fork it (Viseur, 2012).

1.2. Economic power

The issue of economic power is well studied in economics (Sloman et al., 2015). It is closely linked to market structures (perfect market, oligopoly, monopoly), hence to their more or less competitive character. Measures of concentration of an industrial sector exist, making it possible to estimate its more or less competitive character. In this section, we will develop the Vankerkem index (Vankerkem, 1995) because, on the one hand, it is easily interpretable and, on the other hand, it has already been applied to the open source sector (Viseur, 2016).

$$CI = \sum_{i=1}^{n} \left(\sum_{j=1}^{i} p_j \right) \frac{1}{i} \frac{p_i}{p_1} \left(1 - \frac{p_{i+1}}{p_i} \right) \quad (1)$$

In the formula (1) presented above, *n* represents the number of firms active in the oligopolistic arena while p_i represents the market share of the i^{th} player in the oligopolistic arena. The sum p_j represents the coalition power within the oligopolistic arena formed by the first *i* firms. The quotient *1/i* is the probability, i.e. the risk, of coalition within the oligopolistic arena formed by the first *i* firms. The product of the two provides a measure of the concentration within the oligopolistic arena consisting of the top *i* firms, i.e. the coalition power weighted by the probability of occurrence. The following expression (p_1, p_i, p_{i+1}) estimates the probability that the oligopolistic arena is indeed composed of the first *i* firms taking into account the size of the firms given the similarity in size and the possible dimensional break with the first firm immediately outside the oligopolistic arena composed of the first *i* firms.

Table 1
Concentration index scale and equivalent market structure

Concentration index	**Equivalent structure**	
1.00	Monopoly	(100; ∞x0)
0.50	Duopoly	(50; ∞x0) (2x50; ∞x0)
0.33	Tripole	(33; ∞x0) (2x33; ∞x0) (3x33; ∞x0)
0.25	Quadropole	(25; ∞x0) (2x25; ∞x0) (3x25; ∞x0) (4x25; ∞x0)
0.10	Decapolis	(1x10; ∞x0) … (10x10; ∞x0)
0.00	Perfect market	(∞x0)

The Vankerkem concentration index provides a value between 0 and 1, thus an equivalent market structure. Thus a value of 0 corresponds to perfect competition (atomistic players) while a value of 1 corresponds to a monopoly (see Table 1).

2. Methodology and results

Several approaches have been proposed to estimate the dependence of a free software project on a provider, i.e. the power held by this provider. Indicators have thus been proposed. These include the bus factor (also called truck factor), the pony factor and the elephant factor (Ferreira et al., 2019; Goggins et al., 2021; Charleux and Viseur, 2019). We propose to divert the primary use of the Vankerkem index, i.e. to estimate the economic power of firms in a market, to estimate the power held by a set of providers in a free software project.

To illustrate our proposal, we will use, for the Android project and for the year 2012, on the one hand, the values provided by Laffan (2012) concerning the openness of governance, and, on the other

hand, the data provided by Sinha et al. (2012). The latter will allow us to calculate a share of contributors that can be used to calculate a concentration index. The latter can then be reduced to a decision structure: decision alone (CI > 0.75), decision sharing with negotiation (0.25 ≤ CI ≤ 0.75) or very low concentration of decision power (CI < 0.25).

Data on the number of contributors provided by Sinha et al. (2012) allow us to calculate the share of contributors from each of the companies involved in the Android project (see Table 2).

Table 2
Calculation of the share of contributors

Company	Number of contributors	Part of contributors
Google	285	53.47%
Intel	34	6.38%
Red Hat	32	6.00%
TI	19	3.56%
IBM	19	3.56%
Samsung	16	3.00%
SGI	15	2.81%
SuSE	14	2.63%
Oracle	13	2.44%
Nokia	7	1.31%
Sony Ericsson	6	1.13%
Total:	533	100%

These contributors' shares are then used to calculate a concentration index (Vankerkem, 1995; Viseur, 2016), i.e. 0.4897, reflecting a community equivalent to a couple of players, to be compared with the Open Governance Index calculated by Liz Laffan (2011, 2012), i.e. 23%, or 77% (i.e. 1 - OGI) if one wishes to obtain a comparable value reflecting rather the degree of closure of the project.

3. Discussion

In this section, we will discuss, on the one hand, the configurations that can be exercised within a free software project and, on the other hand, Google's position with regard to these different possible configurations.

3.1. Typology of forms of power

The combination of the concentration index and the governance index makes it possible to distinguish four distinct situations (see Table 3), where a concentration index greater than 0.5 reflects a situation where a service provider dominates the project in terms of production effort.

Table 3
Analysis of power over a project

		Open Governance Index	
		< 0.5	***≥ 0.5***
Concentration index	***> 0.5***	[1] Absolute power Governance is rather closed; furthermore, few companies contribute to the project.	[2] Diffuse power Governance is rather open; however, few companies contribute to the project.
	≤ 0.5	[3] Balanced power Governance is rather closed; however, the development effort is widely shared.	[4] Shared power Governance is rather open, in line with the sharing of the development effort.

Absolute power:

The first quadrant is typical of a mature free project managed by an open source publisher. The latter needs a strong alignment between the objectives of the free project and its own commercial objectives, which will generally result in a governance with a commercial logic (Viseur and Charleux, 2019), marked by a strong control and by taking on a significant part of the production effort. The community then loses importance (Jullien and Viseur, 2021), gradually dies out or becomes more oriented towards exploration tasks (Teigland et al., 2018). The risk of fork (Viseur, 2012) is greatly reduced given the domination by the open source publisher.

Diffuse power:

The second quadrant presents a risky configuration. Governance is indeed open but the production effort is largely concentrated in the hands of one or two players. A move towards absolute power cannot be ruled out. Control is more insidious here as the openness displayed by governance is a *trompe l'oeil*.

Balanced power:

The third quadrant presents a typical configuration, either of a project in consortium, with a governance with an industrial logic, or of a young project led by an open source publisher, with a commercial logic governance (Viseur and Charleux, 2019). In both cases, governance allows the management team to exercise strong control over the project. While the dynamism of the community directly benefits the consortium or its members, it can also lead to conflicts (Viseur & Charleux, 2021). The risk of a fork is all the higher when a rebellious coalition may have sufficient resources to ensure the sustainability of a new project. The case of LibreOffice.org is an illustration of this (Gamalielsson & Lundell, 2012, 2014).

Shared power:

The fourth quadrant represents the archetype of the truly open project in that governance is democratic (or meritocratic) and the development effort is shared. A service provider interested in investing in a free software project has a vested interest in the project enjoying this real independence from a possible focal company. The fourth quadrant therefore represents the ideal situation. The situation in the second quadrant would be more cautious, given the control by a provider related to the deployment of resources (cf. Schaarschmidt et al., 2015). Furthermore, it may indicate a project that is weakening, i.e. the flow of contributions is drying up.

3.2. The case of the Android project

In the case of the Android project, governance is closed but contributions come from a wide range of actors, which reduces the power structure to a situation equivalent to two contributors. The asymmetry of contribution between Google and the other actors is however obvious. The project is thus situated between absolute power (first quadrant) and balanced power (third quadrant). The ecosystem around the Android project is exposed to two threats. On the one hand, Google's domination of the project, whether through its presence in the decision-making structures or its development efforts, could weaken the dynamism of this ecosystem. On the other hand, Google is not immune to a coalition of minority contributors forking the project, the latter representing companies capable of deploying more resources on a project, as in the case of the OpenOffice.org fork (Gamalielsson & Lundell, 2012, 2014).

In practice, given the pace of innovation in the mobile device market and the diversity of hardware running on Android, Google has a real long-term interest in preserving the dynamism of the Android project, which too much control could call into question (cf. Fautrero and Gueguen, 2012, for a discussion of the Symbian case). As a technological platform (Gawer, 2014), Google has to demonstrate duality (Farjoun 2010), i.e. to reconcile, on the one hand, stability, especially for application developers needing stable APIs to make the best use of the hardware, and on the other hand, flexibility, for hardware manufacturers benefiting from improvements in the support of their technology but also for third-party mobile application developers benefiting from the revenues generated from the official app store.

4. Conclusion

In this paper, we propose an approach to analyse the economic power over a free software project. To do so, we reuse Laffan's (2011, 2022) open governance index and divert a concentration index from its initial use (measuring power in a market) to estimate the control over the project through the deployment of resources. This combination allows us to distinguish four configurations (quadrants) of power within a free software project useful to the open source publisher or new entrant in evaluating a free software project.

While the measurement of an open governance index is a matter of audit methodology and therefore requires manual work, the calculation of the concentration index lends itself to automation on the basis of data stored in open source directories. And, rather than the number of contributors, the number of contributions (number of lines of source code per contributor) could be used to calculate the concentration index. Perspectives include case studies based on more recent data and incorporating the temporal evolution of power within free software projects.

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