

# Open Concentration Index: Measure of Market Concentration in Open Source Industry

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## ABSTRACT

The market concentration is a measure of competition and, as such, is closely monitored by public competition authorities in the European Union or the United States. Among recent claims in Europe, we study the case of the mobile operating system Google Android, despite its open source quality and the fact it can as such be regarded as presenting no risk in terms of market dominance. In this research, we analyze the concept of market concentration. We suggest that when a dominant or significant participant is open, such as is the case for the Apache web server in the overall web server market, the negative effects of high concentration are mitigated. As such, a new market concentration metric is proposed that takes into account openness, as measured by the Open Governance Index of Liz Laffan. We thus combine a concentration index and a governance index described in literature to obtain Open Concentration Index suitable for open source context.

## Keywords

Open Source; Concentration Index; Governance Index; Governance; Competition.

## 1. INTRODUCTION

The market concentration is a function of the number of firms and their respective shares of the total production. It may be used as a measure of competition and, in consequence, is monitored by competition authorities. Higher concentration is presumed to lead to higher prices, lower innovation, and hence lower consumer welfare.

Some examples of abuse for a dominant position are famous in the IT industry and were linked to the history of open source software. A first one is Microsoft with the Windows operating system, the Internet Explorer browser and the Windows Media Player multimedia player. Microsoft applied vertical integration and bundling strategies in a way that was often considered as anticompetitive (Kühn *et al.*, 2005; Viseur, 2013). For example, in 2004, the European Commission had ordered Microsoft to disclose to competitors the interfaces required for their products to be able to interoperate with Windows operating system (EU, 2004). Moreover Microsoft was also required to offer a version of

its Windows operating system without Windows Media Player to computers manufacturers. In addition, Microsoft was fined 497 million euros for abusing its market power in the European Union. A second one is Google with its search engine and the Android operating system. Concerning the search engine, the European Commission's preliminary conclusion was that Google favored its own comparison shopping service. For Android: *"Since 2005, Google has led development of the Android mobile operating system. Android is an open-source system, meaning that it can be freely used and developed by anyone. The majority of smartphone and tablet manufacturers use the Android operating system in combination with a range of Google's proprietary applications and services. These manufacturers enter into agreements with Google to obtain the right to install Google's applications on their Android devices. The Commission's in-depth investigation will focus on whether Google has breached EU antitrust rules by hindering the development and market access of rival mobile operating systems, applications and services to the detriment of consumers and developers of innovative services and products."* (EU, 2015b).

In order to monitor the market concentration, concentration indexes were developed by researchers (e.g., Herfindahl index, Rosenbluth index, Linda index or Vankerkem index) (CCE, 1971; Linda, 1976; Vankerkem, 1995).

Google Android is a particular case due to its open source quality. The concentration trend in favor of large modular open source projects was already known late in the nineties. Indeed Eric Raymond wrote: *"Some very successful projects become 'category killers'; nobody wants to homestead anywhere near them because competing against the established base for the attention of hackers would be too hard. People who might otherwise found their own distinct efforts end up, instead, adding extensions for these big, successful projects. The classic 'category killer' example is GNU Emacs; its variants fill the ecological niche for a fully-programmable editor so completely that no competitor has gotten much beyond the one-man project stage since the early 1980s. Instead, people write Emacs modes"* (Raymond, 1998).

In this research, we would like to explore three issues. What is the consequence of concentration in open source sector? What are the causes of concentration in open source sector? How to measure concentration in open source sector? In a first section, we present the Vankerkem's concentration index and discuss its application to open source software. In a second section we propose a weighted concentration index more suitable for open source products. In a third and last section, we resume and discuss our findings.

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OpenSym '16, August 17 - 19, 2016, Berlin, Germany

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ACM 978-1-4503-4451-7/16/08..\$15.00

DOI: <http://dx.doi.org/10.1145/2957792.2957796>

## 2. BACKGROUND

### 2.1 Vankerkem's Concentration Index

The Vankerkem's concentration allows to measure the concentration while making allowance for the risk of coalition in the oligopolistic arena.

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

Figure 1. Vankerkem's concentration index.

This concentration index is distinguished by its consideration of the risk of coalition. In the formula (Figure 1),  $n$  is the number of companies in the oligopolistic arena and  $p_i$  is the market share of the  $i^{th}$  firm. The  $p_j$  sum represents the coalition power inside the oligopolistic arena that is constituted by the  $i$  first firms. The  $1/i$  ratio is the probability, i.e. the risk, of coalition inside the oligopolistic arena that is constituted by the  $i$  first firms. The product of the two elements represents the concentration inside the oligopolistic arena that is constituted by the  $i$  first firms, i.e. the coalition power weighted by the probability of occurrence. The following  $(p_1, p_i, p_{i+1})$  market shares product represents the probability that the oligopolistic arena is constituted by the  $i$  first firms by taking into account the differences in size (similarity and dimensional break).

Table 1. Concentration Index scale

Concentration degree	Equivalent structure	
1.00	Monopoly	(100; $\infty \times 0$ )
0.5	Duopoly	(50; $\infty \times 0$ ) (2x50; $\infty \times 0$ )
0.33	Triopoly	(33; $\infty \times 0$ ) (2x33; $\infty \times 0$ ) (3x33; $\infty \times 0$ )
0.25	Quadropoly	(25; $\infty \times 0$ ) (2x25; $\infty \times 0$ ) ... (4x33; $\infty \times 0$ )
0.10	Decapoly	(10; $\infty \times 0$ ) (2x10; $\infty \times 0$ ) ... (10x10; $\infty \times 0$ )
0.00	Atomistic structure	( $\infty \times 0$ )

The CI value is of 0 to 1 (Vankerkem, 1995). The value provides an equivalent market structure (e.g., duopoly). The value 1 corresponds to perfect competition (atomistic structure) and the value 0 to a monopoly (see Table 1). In practice, when the economists observe markets, they are first interested in the market structure, i.e. the way the markets are organized (Stiglitz *et al.*, 2007). The structure that is the basis of the competition model is perfect competition. This structure is atomistic; the price and quantity are determined by the law of supply and the law of demand. In contrast, the monopoly structure is characterized by the absence of competition. Only one company, in a position of power, supplies the entire market. When several companies feed market, there is some competition; the structure is oligopoly.

### 2.2 Concentration and Open Source

The concentration reflects the success of an open source project. The literature dedicated to open source has identified a set of

success factors (usually measured by the sizes of the user base and developer base). These factors (still discussed) are a low complexity, a high modularity, a permissive license, a large number of translations, a clear allocation of responsibilities and the existence of an organizational sponsor (Viseur, 2013). The success of open source projects may also be viewed as a consequence of commoditization (Ven *et al.*, 2007), while more and more free and open source technologies became "good enough" for companies.

*Apache HTTP Web server* - The Apache HTTP open source project saw its market shares increased between 1995 and 2005. Afterwards, the market share slightly decreased, because of competition from commercial major competitors (e.g., Microsoft IIS) or specialized open source projects (e.g., Nginx). So, do we have to think that there is no problem with market concentration in open source sector ?

*Google Android mobile operating system* - Android, facing to Symbian, Windows and iOS, has quickly achieved a high market share, with an upper limit of 80%. The Vankerkem's concentration index for smartphones manufacturers is 0.16, and there are new entrants from very competitive Chinese market (where the CI is 0.14). The Vankerkem's concentration index for operating systems is 0.69. The operating system markets is more and more concentrated that smartphone market, with a risk of abuse of dominant position in applications market, for example. Is it really a problem ? We could think that is not a problem because Google Android is an open source project and can be reused by whoever wants.

### 2.3 Governance Openness

In practice, there are various levels of openness among open source projects (governance issue). Apache appears as a structured community with open governance. At the opposite, the open core model, where only a kernel and some modules are open source, the full software being mainly privative, leaves no room for community. Any community activity is expected and the power is concentrated between the hands of the open core editor.

In order to address the governance issue, we may use the Open Governance Index. The Open Governance Index "quantifies how open a project is in terms of transparency, decision making, reuse, and community structure" (Laffan, 2012). The OGI comprises 13 metrics across the four areas of governance: the access ("availability of latest source code, developer support mechanisms, public roadmap, and transparency of decision making"), the development ("ability of developers to influence the content and direction of the project"), the derivatives ("ability for developers to create and distribute derivatives of the source code") and the community ("community structure that does not discriminate between developers"). Android ranks as the most closed project examined by Laffan (2012), with an OGI score of 23%<sup>1</sup>. By comparison, the OGI score for Symbian is 58% and the one for Meego is 61% (Symbian and Meego are two famous mobile operating systems that were in competition with Android). In particular, Laffan (2011) highlights the unilateral Android project decision-making processes, the closed code committer process, the closed contributions process model, the opaque decision-making and control process around the Android Compliance Program or the lack of intention to move towards a more open governance model.

<sup>1</sup> Look at Laffan (2011) to get more details about computation.

### 3. OPEN CONCENTRATION INDEX

We propose to create a weighted concentration index, called Open Concentration Index, based on Vankerkem's Concentration Index and on Laffan's Open Governance Index in order to measure the concentration impact on competition in an open source context. For that we introduce in Vankerkem's Concentration Index formula a market share that is weighted by the Open Governance Index :

$$WMS = MS \times (1 - OGI)$$

WMS means weighted market share ; MS, market share and OGI, Open Governance Index. OGI equal to 0% means that the software is private (e.g. Microsoft Windows for mobile systems); OGI equal to 100% means that the software is open source and that the community benefits on a democratic governance.

Here is an example of Open Concentration Index (OCI) computed for mobile operating systems, i.e. Android (76.6%), iOS (19.7%), Windows Phone (2.8%) and Blackberry OS (0.4%). The source is IDC International Data Corporation (data for 2014 Q4).

$WMS_{iOS}$	$\sim MS_{iOS}$	$OGI_{iOS} \sim 0$
$WMS_{WindowsPhone}$	$\sim MS_{WindowsPhone}$	$OGI_{WindowsPhone} \sim 0$
$WMS_{Android}$	$= 0.766 \times (1 - 0.23)$	$OGI_{Android} = 23\%$
$\rightarrow$	$CI_{MobileOS}$	$= 0.69$
$\rightarrow$	$OCI_{MobileOS}$	$= 0.45$

While the classical concentration index provides an equivalent structure that is gradually approaching an imperfect monopoly, the open governance index provides a structure that is closer to perfect duopoly. That one is better to reflect the nature of competition in the mobile operating systems market. Indeed Android (i.e. Google) faces competition backed by powerful companies (i.e. Apple and Microsoft). Especially iOS enjoys a stable position, strengthened in the high end line of products. Moreover the availability of Android source code due to its open source quality allows alternative Android integrators (e.g. Cyanogen) and smartphones manufacturers (e.g. Xiaomi) to retrieve the software then to fork and modify it in order to support their needs and their customers. The forked versions of Android would thus account for around 20% of the global Android ecosystem (Price, 2015).

### 4. DISCUSSION

*Results* - The Open Concentration Index (OCI) provides a realistic view of the concentration in a market that is dominated by an open source technology. It integrates the more or less open nature of governance and thus incorporates the real market power held by the open source editor or by the organizational sponsor.

*Coalition risk and open source* - Is that meaningful to use a concentration index characterized by the risk of coalition ? What would be a risk of coalition among open source projects ? First, large companies now embrace the open source model (e.g., Google with Android or Microsoft with .Net). These companies have a certain economic power and open source can help to further disseminate their technologies and standards (Adatto, 2012). The modulation of openness over time can lead to

situations of economic power through widely disseminated technologies and standards. Secondly, the open source technologies are increasingly used in the development of applications. Thus a survey from Black Duck Software reported that 78 percent of respondents were running their businesses with open source software, and two-thirds were building software for their customers that is based on open source software (Blackduck, 2015). The Open Concentration Index thus allows to follow the dynamic of competition in the market.

*Open innovation and market concentration* - The generalization of this index is possible. In practice, open source has been generalized to other products as software with the concept of open source innovation (Pénin, 2012). This echoes the paradigm of open innovation, within which collaborative practices are carried out in a generally proprietary way through the exchange of Intellectual Property Rights (Chesbrough *et al.*, 2006). Even within proprietary industries, there are different openness degrees. For example, in the IT industry, beside open source, it is common to open the APIs of Web platforms and applications ; it fosters collaboration and enables the development of innovative ecosystems (Viseur, 2014). The creation of an Open Governance Index able to embrace this open modality diversity would therefore make sense.

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