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IMPACT OF OSS ON SOFTWARE MARKETS- AN EVALUATION

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Abstract

Open Source Software (OSS) is typically viewed as a cooperative approach for software development and hence, more of a technology rather than a business model. Yet, there is an increasing number of profitable activities around the OSS ecosystem, proving that OSS is not only an innovative model of production, but also a sustainable business model. OSS creates value both on the supply and demand sides and an increasing number of firms are deploying their strategies around this value with considerable profits.

Although it seems that OSS does have an impact on software markets, there is little scientific evidence for that and no evaluation on the degree of influence for software markets. Towards this direction, this paper examines OSS economic attributes and their correlation with software markets' special characteristics that affect competition. Competition under the scope of OSS is further explored by identifying the new dynamics formed in software markets. In order to further validate our results, the HHI concentration index is applied to three widely used software market segments.

Keywords: *Open Source Software, Software Market Competition, Concentration Index, Economics Of Open Source Software*

1 INTRODUCTION

During the last years, OSS has reached an outstanding diffusion and adoption rate. (Varian *et al.*, 2003) noted that open source software has achieved a 'critical mass' sufficient to assure users that it will be available and improved for the years to come.

When Richard Stallman first set the Free Software Definition (FSD) (Stallman, 2002), Free Software (FS) was considered more as an ideological movement against commercial exploitation of software. However, from the FSD was made clear that free software was a matter of liberty not price. The recasting of "Free" Software as "Open Source" Software (OSS) emphasized on the importance of making source code freely available, implying that a company can choose to make source code freely available and still serve its own business interests as a for-profit organization.

Since then, several thousands of open source projects exist worldwide, a few of which have developed products that have become market leaders or credible challengers in market niches. The open source ecosystem (ie. open communities, standards, and technologies) has matured to a point where there are growing numbers of business solutions delivering real business value today. At the same time, more and more IT and business decision-makers are identifying, pursuing, and succeeding with initiatives that employ elements of that ecosystem to achieve meaningful immediate and sustained business benefits.

This paper identifies open source software economic attributes and their impact on software markets. The impact of OSS on competition in software markets is further discussed and validated by the application of the HHI concentration index on three software market segments: operating systems, web browsers and web servers.

The structure of the paper is as follows: Section two gives an overview of the characteristics and competitive dynamics of the software market. Section three describes the impact of OSS economic attributes on the dynamics of software markets. Section four discusses the observed market behaviour because of OSS. Section five validates the impact of OSS in software markets, by applying the HHI concentration index in a subset of the market. Conclusions and future research are presented in Section six.

2 SOFTWARE MARKET ECONOMIC ATTRIBUTES

An analysis of the software market reveals special attributes that impact competition and create the business dynamics of the market. Following (Varian *et al.*, 1999), (Kooths *et al.*, 2003) and (Wichmann *et al.*, 2002) the most prominent features of software markets are:

- *High development costs and low marginal costs of production*: most effort is necessary during the development and pre-launch testing, while digital products can be copied any number of times with minimal costs.
- *Economies of scope in production*: tested and validated pieces of code can be reused in other programs as well
- *Positive network externalities on both the demand and the supply side*: the utility of a software product increases with the number of users using it (demand side). It also increases with the number of software suppliers utilizing it for building new application software (supply side).
- *Lock-in effects and switching costs*: Once users have familiarized themselves with a certain software product they will be reluctant of bearing the switching costs to another software product, of uncertain quality. Thus users are “locked” in a product that may be of a lower quality than its competitive substitute.
- *Significance of patents and licenses*: Are widely used by software firms in their revenue models.
- *Importance of Standards*: software that doesn’t comply with prevailing technologies and standards, becomes obsolete.

The economic attributes of software discussed create the competitive dynamics of software markets. Firms may compete for prices, quality and innovation. In some cases firms may compete for the monopoly. Network effects and lock-in effects, together with high fixed cost create favourable conditions for a potential monopolist and a tendency for high concentration. Network externalities on the supply side also raise competition among platform firms for producers of applications and/or other complements. Sellers of complementary products consequently want to see lower system prices, and have various ways to exert pressure to accomplish this (e.g. collaboration, integration, etc.). This sort of competition can be a very powerful force and a way to mitigate market’s concentration inefficiencies.

Moreover, network and lock-in effects are most favourable for firms that first enter a market segment and consequently create the appropriate critical mass of users. Because of these first mover advantages, competition *for* the market (the network of users) is likelier than competition *in* the market (quality). Short innovation cycles and technological progress also provide favourable market entry opportunities for new suppliers and threaten the dominance of established companies. The size of the market entry barriers however, varies with the significance of the network effects on the supply and demand sides.

Finally, standards involve a form of complementarity, in that are often designed to allow for seamless interconnection of components. Standards are determinative for the diffusion of a software product and thus are often a source of high competition among firms. According to Bessen (Bessen *et al.*, 1994) there are three forms of competition in standards setting: (a) the “standards war”, where firms compete to determine the standard, (b) “standards negotiation”, where two or more firms want a standard, but disagree about what the standard should be, (c) “standards leader”, where one firm leads with a proprietary standard and the other firms want to interoperate with the existing standard.

3 OSS ATTRIBUTES THAT IMPACT SOFTWARE MARKETS

Open source software has proven to create economic value, despite its apparent incompatibility with the ubiquitous private property regime. The value of open source is twofold and stems not only from the non-discriminatory availability and absence of licensing fees, but also from the option of making modifications to the software, enhancing their characteristics and utility.

A careful examination of the OSS special attributes yields some interesting results concerning the correlation among economic attributes of software and open source software. In the following paragraphs economic attributes of software are examined under the scope of OSS economic values:

High development costs & economies of scope in production: OSS code is characterised by high modularity, an attribute that facilitates code reuse. Moreover, the OSS Community contributes with tested pieces of code written for a particular software, or are reused from other software products. In any case, these elements offer valuable resources for development cost savings and economies of scope in production. From a strategic perspective, utilizing open source provides an opportunity to free up money for innovation and differentiation.

Network externalities & lock-in effects: Software is an experience good and OSS enables a potential user to experience new software without paying license fees. Thus if a product is of high quality, zero costs are a marketing strategy for firms entering a market segment. The product is usually tested and experienced from the network of “community users”, who create the initial critical mass for the dissemination and establishment of the product. OSS will overcome lock-in effects of proprietary software, when switching costs are valued less than the cost of the substitute software by the user.

Two-sided markets: Firms involving in platform markets can take advantage of OSS to achieve lower prices for potential suppliers of complementary products and subsequently create a positive network effect on the supply side. Platform firms may also, generate revenues from non-OSS applications, that complement well established OSS platforms (Economides *et al.*, 2005a).

Competition as an innovation race and competition for the market: OSS community products are characterised by rapid release circles and acceleration of development process (Raymond, 1999a; Spinellis *et al.*, 2004). The development and release rates are a key element for innovation and if correctly exploited by potential entrants can yield the determinative advantages of a first mover.

Significance of patents and licenses: Software has non-rivalry in consumption. What is more open source software doesn't exclude users by code hiding and license fees. Thus OSS can be characterised as a public good. Patents and licenses are also of great importance for OSS, although in a completely different way. Innovative license schemes are created mainly to ensure that intellectual rights are not misused.

Importance of standards: OSI actively supports open standards (Tieman, 2006). Software adopters have been developed to enable the cross-platform functioning and compatibility of OSS with proprietary products (for example Mozilla Firefox and OpenOffice can run on Windows, etc.) and therefore OSS is characterised for interoperability and portability. This enables both users and application suppliers to avoid dependencies and lock-in effects with specific vendors.

4 OSS AND COMPETITION

The conclusion derived by the findings of the preceding section, is that OSS does have an impact on software markets. Yet, the question that remains is whether OSS can affect competition and software market structure, which has a tendency for concentration. The case of Microsoft's monopoly in the market of operating systems is the most prominent example.

Microsoft's prevalence, however, was not only the result of a product's high quality or advertising, but a consequence of the network externalities and lock-in effects of software goods. As discussed in section

three, OSS has the ability to mitigate these effects, yet it is not proven that OSS can alter market structure towards competition.

An analysis of the software market yields some interesting results that should be taken into account in order to answer the question regarding the impact of OSS on competition:

Existence of a large number of successful OSS business models: Many firms have added OSS in their product’s value chains. This may involve existing firms that altered their business models, or new entrants that have build their business models around the OSS ecosystem. An extending literature explains the different business models deployed by various firms (Bonaccorsi *et al.*, 2004), (Dahlander, 2007), (Fitzgerald, 2006), (Ghosh, 2006), (Hecker, 1999), (Koenig, 2004), (Kooths *et al.*, 2003), (Krishnamurthy, 2003). The innovative elements of the OSS business models that differentiate them from the traditional models lie mainly on three elements:

- the collaboration and support of the OSS Community,
- flexible licensing schemes, complying with the OSS community values and approved by the Open Source Initiative (OSI)
- innovative revenue models not based upon licensing fees.

New OSS oriented firms entering the software industry, with rising revenues: There is an emerging number of successful firms that have based their business models entirely on open source software. Their products may involve Linux distributions (ie. Red Hat, Novell), enterprise information systems (ie. Alfresco, SugarCRM, JBoss (acquired by Red Hat), host services (ie. Google, Amazon), database management systems (MySQL), other kind of services, i.e. consultancy, integration, customisation, etc (Collab.net), etc. These firms have adopted OSS business models and have seen remarkable revenues.

In the case of operating systems sector, Red Hat has achieved considerable growth in revenue during the last years. Red Hat’s revenue model is based on subscriptions to integrated packets of the Linux distribution, support and services. Figure 1 illustrates the annual revenue percentage rates of three competing firms in the field of operating systems: Red Hat, Microsoft and Novel. The annual revenue rates were extracted from the firms’ official websites respectively ("Red Hat "), ("Microsoft,"), and ("Novell,"). Red Hat’s growth rates are quite impressive and show a promising future for the company. Microsoft is in a rather steady position, while Novell is much behind from both firms.

Recently, however, Canonical Ltd. has also made an impressive entrance with the popular Ubuntu Linux that seems to compete Red Hat Linux in market shares ("The Open Source Barometer," 2008).

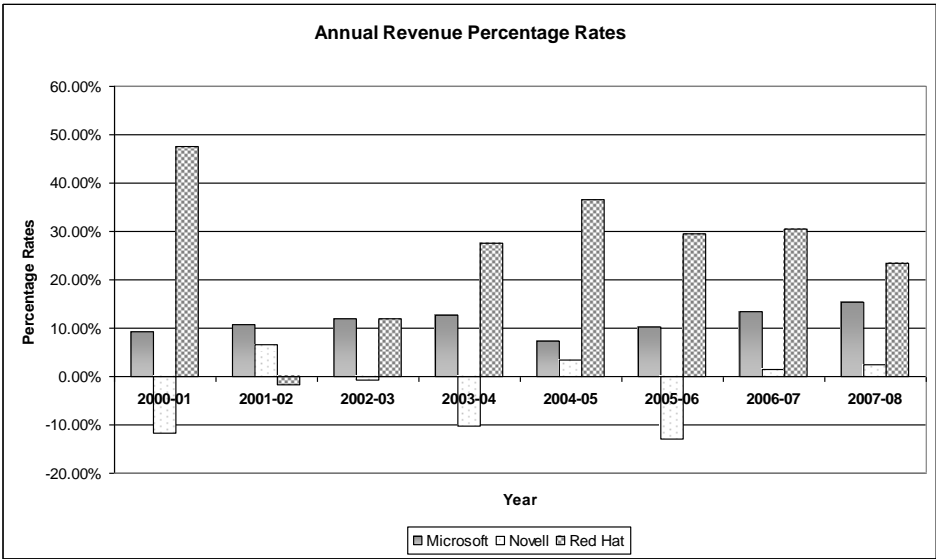


Figure 28: Annual growth rates for three competing companies: Red Hat, Microsoft, Novell.

Incumbents of software industry deploy their strategies towards OSS: Market leaders like IBM, SUN, HP Oracle, SAP, etc. are competing in support for OSS.

- IBM joined the Apache community and became a contributor in order to help Apache produce early open source reference implementations of new Web technologies like the Apache HTTP server, XML tools, etc. IBM on return used Apache HTTP server as a key infrastructure component for its successful WebSphere product. IBM also enjoys an excellent relationship with the Apache community (Capek et al., 2005).
- Hewlett Packard (HP) has made a significant investment to deliver open source and Linux “primed for business advantage,” with more than 2,500 of its developers focused on Linux and open source projects, customer education centres worldwide, open source printer drivers provided to communities, open source tools, utilities, libraries, and packages, etc. The latest count has HP selling more than 2 million Linux servers and generating almost US\$9 billion in cumulative Linux server revenues worldwide. HP’s open source and Linux offerings are encapsulated in the HP Open Source Integrated Portfolio (OSIP), a collection of software, middleware, services, operating systems, and platforms designed to tailor customers’ IT infrastructure according to their business needs (“HP Open Source Integrated Portfolio,”; “Open Source and Linux from HP,”).
- SUN has also adopted an OSS policy by opening a number of widely used products like OpenSolaris, Java, Netbeans, OpenOffice, OpenSPARC, etc. SUN is strongly supporting open standards and has created servers based on Open Application Programming Interfaces- APIs. Java technology, for instance is functioning on computers as well as mobile devices and to platforms like Solaris, Linux, HP-UX, AIX, Tru64 UNIX, Windows, Mac OS X, etc. SUN’s strategy is to establish a good relationship with OSS community and attract suppliers for applications build on its infrastructure and middleware software. SUN has recently acquired MySQL, which is considered an important asset from the open source software stack.
- Oracle introduced a “support and service offering” for Red Hat’s open source Linux operating system in fiscal 2007 in order to compete with firms who offer support for the Linux operating system, including Red Hat, Novell and Canonical Ltd., others in the sale of Unix operating systems like IBM, Sun Microsystems, HP; and with Microsoft in the sale of Windows Server operating systems. Oracle recently made a strategic move by acquiring SUN.

Strategic alliances of IT industry firms that support standardization and compatibility among systems (especially with OSS technologies): Firms of IT Industry also compete in achieving partnerships that will ensure compatibility of future applications to their infrastructure software, and vice versa application providers seek alliances with established platform firms. Partnerships are predicated on common standards basis.

Microsoft, for instance, in October 2006, formally partnered with Zend to improve PHP performance on the Windows platform predicated on an open approach. At the Microsoft Open Source Lab (OSSL), programmers continue to develop implementations of PHP-based open source applications on Windows and provide the source code back to the community. Product groups within Microsoft such as SQL Server have independently reached out to the PHP community to create software that provides programmers more choices (“PHP on Windows: Community Involvement Improves Performance,”).

Also, in 2006 Microsoft and Novell announced a “patent cooperation” agreement that exempted Novell’s Linux customers from patent lawsuits from Microsoft against Linux. The deal was carefully worded to avoid collision with GPL2. Also, Microsoft would pay Novell \$240 million for discount coupons for its customers to get them to switch to Novell SuSE Linux instead of other Linux distributions. The Microsoft-Novell alliance is designed to improve interoperability of Windows with SuSE Linux but also is intended to slow Red Hat. On the other hand Red Hat allied with Sun Microsystems to advance the adoption of open source Java – and slow down Microsoft’s .NET.

Microsoft changes its strategy towards OSS: From the strategic partnerships with OSS oriented firms, one can deduce that Microsoft doesn’t act like a monopolist, but feels the threat of competitive OSS products. Moreover, Microsoft following IBM, has taken more actions towards OSS, such as the

initiation of OSS community (Port25), the creation of two OSI approved licenses (Microsoft Public License-MPL and Microsoft Reciprocal License- MRL), etc.

Competition among OSS products OSS products compete with each other fiercely for developers, distributors and customers. Developers want to be associated with products that are likely to have a major impact. Distributors would like to devote resources only to products that are likely to become very successful. Customers want to use products that they can rely on.

There are two levels of competition: the product category level and the distribution level (ie. the distributors of Linux are in aggressive competition with each other). Competition among Linux distributors is especially interesting. In 2002, a consortium of Linux distributors founded United Linux in an attempt to create a common code base and an effective competitor to Red Hat, which had established a dominant position- especially in the American market. A survey conducted by Alfresco ("The Open Source Barometer," 2008) using data provided by the 25,000 of the Alfresco community members gives an insight of the user's preference for various software stacks. In particular among Linux distributions, most popular are Linux-Ubuntu and Red Hat Linux by 31%, with the Debian and Novell Suse Linux following with 14% and 11% respectively.

Software as a Service: IT spending is dominated by services rather than products. Package software accounts for only 6% while IT services accounts for 24% of total IT spending for 2007 (Tully et al., 2008). This is due to the new trend in software market for per-use services that result from new technologies established, like Software as a Service (SaaS), service oriented architecture (SOA) and Web 2.0 applications. OSS can become the commodity infrastructure software, upon which firms will compete for the applications and services. For instance, Google, Amazon and Yahoo have built their applications on OSS and use Linux servers. None of these providers have to charge licensing fees, or to invent new licensing schemes for OSS as their profits don't stem from software but services.

The above facts give an indication of an increasing competition among software firms. Proprietary firms feel the threat of the increasing demand for OSS products and change their strategies towards OSS, while competition among OSS based firms is also strong. Moreover, software market has acquired many new entrances due to the existence of OSS.

5 EVALUATION OF OSS IMPACT ON COMPETITION

In order to validate our hypothesis regarding competition, the Herfindahl-Hirshman index (HHI) is deployed and applied to three software market segments, the operating systems, the web servers and the web browsers. These segments are considered the most representative cases of the software market, since they correspond to widely adopted software among all categories and levels of users.

HHI is defined as the sum of squares of all companies' market shares and is an indication of market concentration (Baye, 2006). More specifically, if s_i is the market share of firm i , then HHI is defined as

$\sum_{i=1}^n s_i^2$, where n is the total number of firms in the market. If w_i is the sales of firm i , and w the total sales

of the market, then market share s_i of firm i is defined as the fraction w_i / w . Market share can be measured in terms of sales, revenue, number of employees, etc. As s_i are expressed in terms of percentages, HHI ranges from $1 / n$ to unity. Equivalently, the index can range up to 10,000, if percents are used as whole numbers, as in 75 instead of 0.75. The maximum in this case is $100^2 = 10,000$.

The behaviour of HHI rests in the fact that the market shares are squared prior to being summed, thus giving additional weight to firms with larger size. Thus, values of HHI closer to unit mean high concentration (in case of HHI equals 1 means a monopoly market structure) and values closer to $1 / n$ indicate a competitive industry with no dominant players.

Into the context of the present work the market shares are defined in terms of the usage or adoption rates of competitive products. In the following sections each market segment is examined separately.

5.1 Web Servers

For web servers, data were extracted from the Netcraft Web Server Survey. The survey has run since 1995, exploring the Internet and all web sites. An HTTP request is sent to each site monthly, determining the web server used to support the site, and the operating system through careful inspection of the TCP/IP characteristics of the response. The methodology of calculating the final results are described in detail at the Netcraft's site (Netcraft, 2009).

Data used are on a per year basis, from 1995 until 2008. During the years 1995 and 1996, there is the birth of Internet and web servers and market is still unstable. In 1995 Apache server made its appearance in the market having the first mover's advantage over Microsoft who followed in 1996. Since then Apache has conquered the market and increased the gap in market shares from its major competitor Microsoft. Since 2006, however, there is a decline in Apache's market shares, while Microsoft's shares present an upcoming. This may be due to the strategic alliance of Microsoft with PHP, as described in section 5. Yet, on the same time there are new entrances in the market that gain important shares.

Applying the HHI on the data, fetches the results as shown on Figure 2.

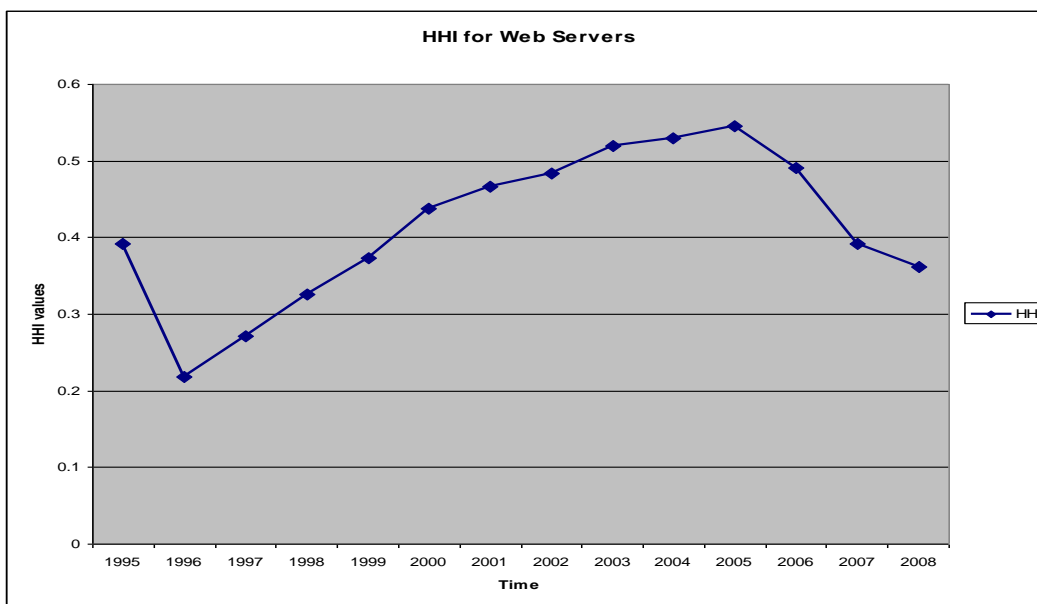


Figure 29: HHI for Web Servers based on data from Netcraft Web Server Survey.

As illustrated in Figure 2, there is a prominent decline since 2005, which implies a raise in the competition. This is in agreement with the appearance of new entrances and the convergence of the market shares of the two leaders. Yet, during the decade 1996 to 2006 there was an increasing concentration, as Apache had considerably larger shares than its followers.

5.2 Operating Systems

In the case of operating systems, the dataset was collected from W3Schools' log-files, over a five year period and on a quarterly basis. W3Schools is a website for people with an interest for web technologies, with tutorials and references related to web development subjects, including HTML, XML, CSS, and JavaScript. The site keeps statistical information on a monthly basis for the web browsers and the corresponding operating systems from its log-files (W3Schools_OS).

Although, this is only a part of the actual data for operating systems market shares, the high activity of the site (W3Schools_statistics) and the type of population visiting the site, creates a credible statistical sample for the overall trends of the segment. W3Schools keep record of operating systems and their versions, which are illustrated in Figure 3. The dominance of Windows XP is obvious and although there is a decline in its market share, Windows Vista has not yet achieved a high level of adoption.

In order to calculate HHI, the data were grouped by the different versions otherwise the results would be biased towards competition. The results are shown in Figure 4. Finally, the results from applying the HHI on the above data are shown on Figure 5.

It is apparent that the concentration of this market is considerably high, with values reaching 0.9 which is very close to unity. However, there is an overall decreasing trend, which is explained by the entrance of new products and their increasing market shares.

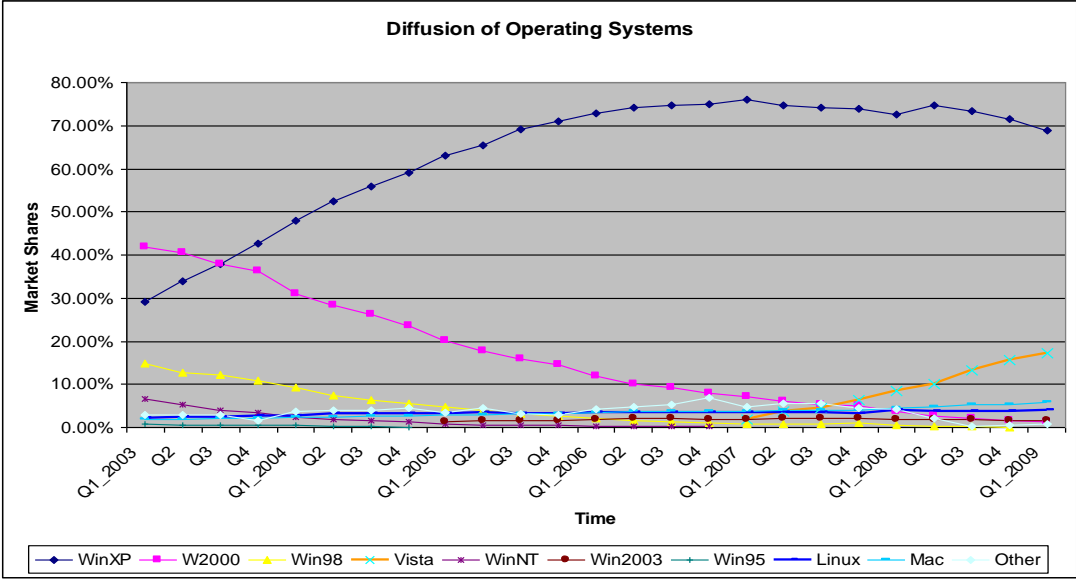


Figure 30: Diffusion of operating systems and their versions.

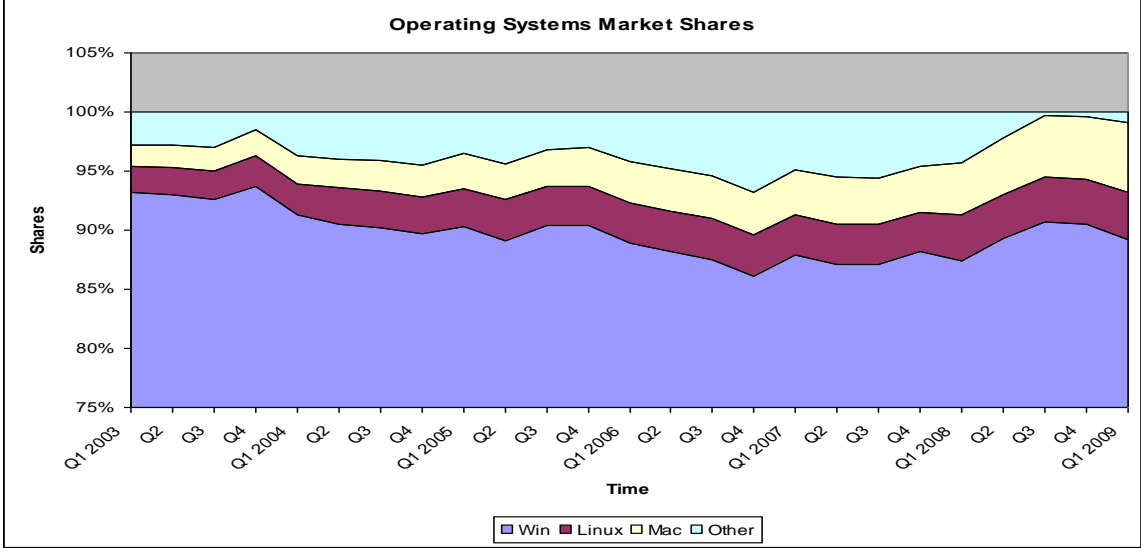


Figure 31: Operating Systems grouped by suppliers

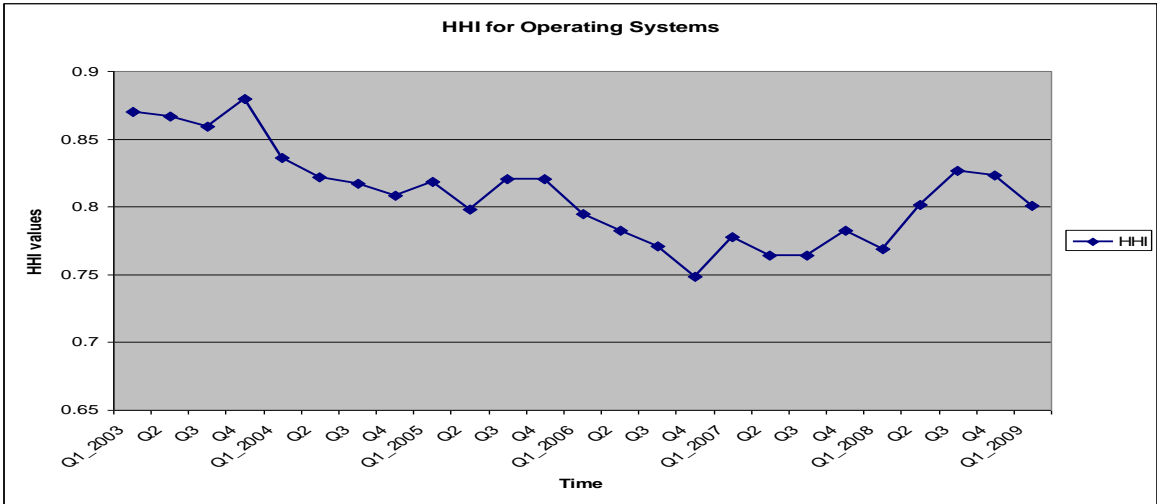


Figure 32: HHI for Operating Systems

5.3 Web Browsers

While the two previous cases refer to infrastructure software, the web browsers market is a quite important segment, as it is an application widely used by all ages and groups of population. The data used are also from the W3Schools survey (W3Schools_Browsers). Yet, a second dataset is also used in order to validate our results from the W3Schools portal.

The second dataset is extracted from the Market Share portal of Net Applications (MarketShare). The data are collected from the browsers of site visitors to an exclusive on-demand network of live stats customers. The data are compiled from approximately 160 million visitors per month. The information published is an aggregate of the data from this network of hosted website statistics. The site unique visitor and referral information is summarized on a monthly, weekly, daily and hourly basis.

Results of HHI application on both portals' datasets are presented on Figures 6 and 7.

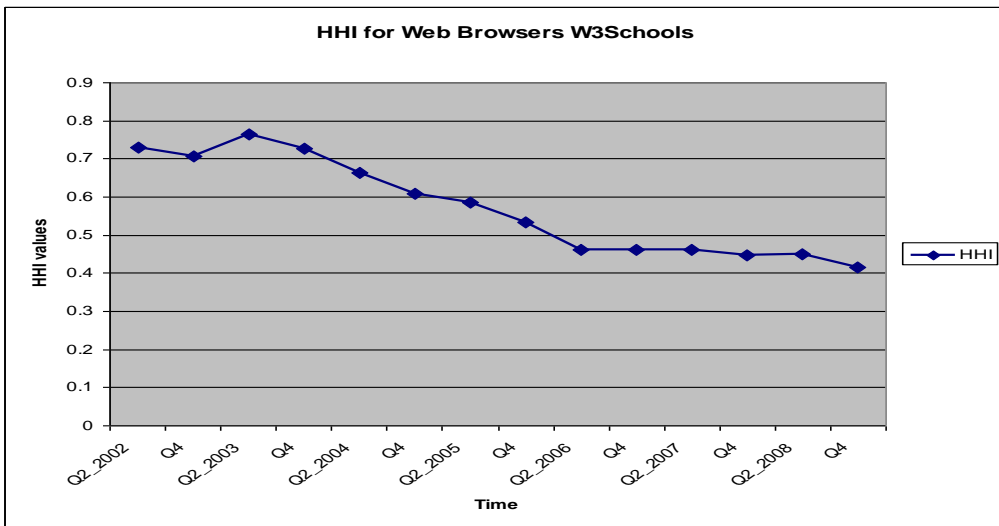


Figure 33: HHI for web browsers, dataset extracted from W3schools portal

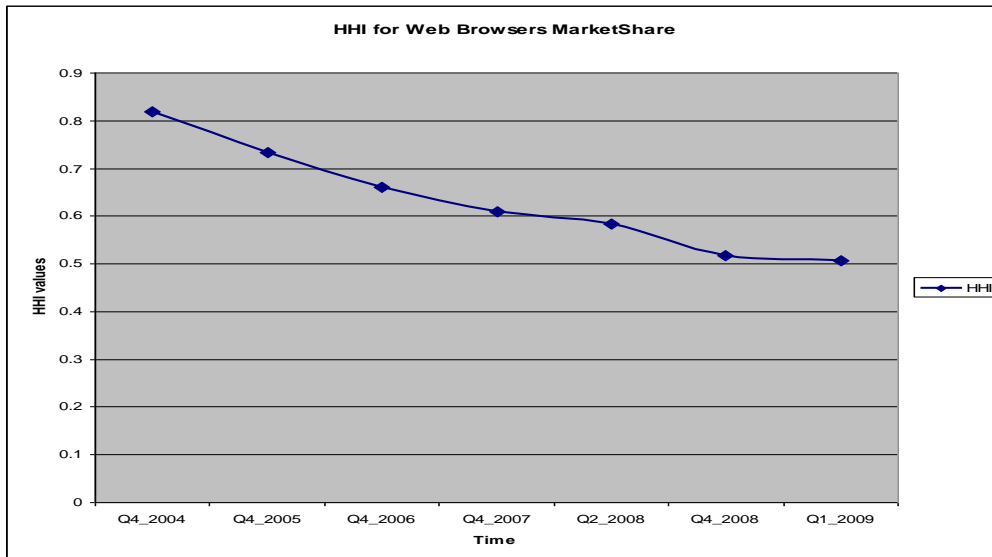


Figure 34: HHI for web browsers, dataset extracted from Market Share portal

Although there are some differences on the datasets of the two portals, the HHI values yield similar results. In both cases, concentration was high over the first years, as Internet Explorer was bundled with the dominant Windows operating system. Since 2005, however there is a dramatic decrease in concentration, with the upcoming in shares of other products like Firefox, Chrome, Safari and Opera, which are open source software.

5.4 Comparison

In overall, the results elicited by the application of HHI in the three cases above are summarized as:

- In all three cases markets are concentrated, which is in accordance to the software market attributes. Also in all cases, there is a decline in concentration which implies an increase in competition.
- The less concentrated market is the web servers market, where the leading product is open source Apache. New entrants, like Google GFE, also have built their technologies on open source Linux.
- The most concentrated market is the operating systems market, where Windows have dominated the market. However, there is also a decline in concentration, by the increasing shares of open source Linux and Mac OS as well as Vista's slow rates of adoption.
- In the web browsers market, the decreasing rate is more dramatic, since the arrival of a number of open source browsers, with open source Firefox leading.

6 CONCLUSIONS

Software markets have certain attributes like network externalities and lock-in effects that create unfavourable conditions to competition. Many software industry firms have reacted to the limitations of the market by altering their strategies towards OSS. Also, many firms have entirely built their business models around the OSS ecosystem, with successful results.

The question that rises is whether OSS is the appropriate solution for the software market's inefficiencies. An analysis of OSS economic characteristics shows that OSS can impact software markets competitive dynamics. The results can be verified by observation of the markets overall evolution towards the support and promotion of OSS by the leaders of software industry.

Impact of OSS on competition, can be further validated by the application of HHI index on adoption rates of software over specific time intervals. In order to test the OSS impact on software market, three important market segments that are most widely used over all groups of population were examined.

Although, software market does seem to decrease in concentration due to the existence of OSS, there is still way for achieving higher competition. A further research on other market segments can also improve our view of overall competition. However, external factors like collaborations and mergers may affect the current situation towards better or worse conditions for competition. It is thus of high interest to investigate the competitive dynamics in software markets, by creating relevant economic models that will take into account all possible factors that may affect competition.

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