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INFLUENCE OF NETWORK EFFECTS ON THE DIFFUSION OF INFORMATION SYSTEMS: THE CASE OF OPEN SOURCE

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Resumo

No mundo actual a importância dos Sistemas de Informação na infra-estrutura sócio-económica torna relevante o estudo deste mercado. Esta tese procurou fazê-lo tanto do lado da oferta, através do feedback de alguns dos principais fornecedores de software, como da procura, através do estudo de uma amostra de empresas. Foram objecto de estudo os Sistemas Operativos e *Office Suites* para computadores pessoais e a análise da concorrência entre o Software *Open Source* e o Software Proprietário, embora as hipóteses e conclusões da tese possam estender-se a outras categorias de software. Do lado da oferta concluiu-se que na competição entre dois modelos de negócio, Software *Open Source* e o Software Proprietário, ambos podem criar inovação e garantir a sobrevivência no mercado das empresas que se baseiam nos mesmos. Do lado da procura concluiu-se que neste mercado outros factores para além da imagem de marca, características do produto ou preço têm influência nas decisões de compra. Factores como o efeito de rede, custos de mudança ou *lock-in* influenciam a decisão de compra protegendo o incumbente e diminuindo o nível concorrencial do mercado, tornando mais difícil às alternativas concorrenciais conquistarem mercado ao incumbente apenas com base na oferta e preço.

Keywords: Sistemas de Informação, *Open Source Software*, Efeito de Rede, Custos de Mudança, Análise Concorrencial, Decisão de Compra de Sistemas de Informação

Abstract

In the actual world with the importance of the Information Systems in the socio-economic infrastructure, becomes relevant the study of this market. This thesis tried it, on the supply side through the feedback of some of the main software suppliers and on the demand side through the study of a sample of companies. The subject of study was the Operating Systems and Office Suites for personal computers and the analysis of competition between Open Source Software and Proprietary Software, although the thesis hypotheses and conclusions may extend to other software categories. On the market supply side we concluded that in the competition between two business models, Open Source Software and Proprietary Software, both can create innovation and ensure the survival in the market of the companies that use these business models. On the demand side, we concluded that in this market factors other than brand image, product features or price have influence in the purchasing decision. Factors like network effects, switching costs or lock-in have influence in the buying decision protecting the incumbent and decreasing the market competition level, making it difficult for the competitive alternatives based only on offer and price to gain market share to the incumbent.

Keywords: Information Systems, Open Source Software, Network Effects, Switching Costs, Competition Analysis, Information Systems Buying Decision

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Abbreviations List

AiW	Apple iWork
AM	Apple MacOS
AN	Actual Needs
APN	Actual and Potential Needs
CML	Caixa Mágica Linux
CWPO	Corel WordPerfect Office
Df	Degrees of freedom
DNE	Direct Network Effect
EPOO	EPressCorp OneOffice
IAPMEI	Small and Medium Size Enterprizes Support Institute
IBM	International Business Machines
IBMLSS	IBM Lotus SmartSuite
ICS	Information and Communication Systems
IE	Internet Explorer
IS	Information Systems
KEDKO	KDE KOffice
LNE	Local Network Effect
ML	Mandriva Linux
MSOFF	Microsoft Office
MS-Office	Microsoft Office
MW	Microsoft Windows
NSL	Novell SuseLinux
OFFS	Office Suite
OFHD	Office Suite Homogeneity Degree
OFNE	Office Suite Network Effect
OFWLK	Office Suite Weak Lock-in Knowledge
OFWLLF	Office Suite Weak Lock-in Legacy Files
OOOO	OpenOffice.org OpenOffice
OSC	Open Source Cheaper
OSHD	OS Homogeneity Degree

OSNE	Operating System Network Effect
OSS	Open Source Software
OSSBG	OSS Better Globally than PS
OSSBS	OSS Better Support than PS
OSWLPA	OS Weak Lock-in Peripherals and Applications
OSWLPCK	OS Weak Lock-in Personal Computer and Knowledge
PC	Personal Computer (desktop or notebook)
PS	Proprietary Software
RHL	Red Hat Linux
SCEOF	Switch Costs Easiness Office Suite
SCEOS	Switch Costs Easiness OS
SGC	Software Global Costs
SGI	Supplier Global Image
SSM	Soft Systems Methodology
SSO	Sun StarOffice
WLL	Weak Lock-in Legacy (Files and Applications)
WLPD	Weak Lock-in Path Dependence

I. Introduction

The present research work tries to understand the factors beyond the development of markets that are each year more relevant for the world socio-economic infrastructure. These markets, Information and Communications Technologies, have specifics characteristics that put them in the called Network Economy and have been developed through a mix of consumer choice, suppliers offer adopted as standards or several kinds of independent organizations decisions and definitions. In this days everybody talks about iPods, Windows, Open Source, Office, 3G, GSM, 4G, Wi-Fi, Blue-Ray, DVB-H, Flash, Browser, IPTV, mpeg, mp3, pdf, png, HDMI, Bluetooth, USB, social networks, etc., etc.

All this constitute the basis of the infrastructure that is the basis of the actual Information Society. This infrastructure is in constant creation and development. Research about the way it works and develops is as important as research in other sectors of activity and the results as important to consumers, suppliers and authorities like Governments and Regulators. This research work tries to make a small contribution to the knowledge in this area by studying the decision process of consumers considering the theoretical frame studied for this kind of markets and also by receiving feedback from market suppliers and their opinions about their business model and further developments they expect in the markets where they are present.

After the 80's of the XX century with the development of the communications and information technologies markets, researchers verified that in these markets the consumer evaluation of the products and services improves with the number of consumers in the market using these products and services. This was not explained with the traditional economic theories. In these markets the consumers constitute a network whose value rises with the number of consumers in the network. Each consumer by belonging to the same network raises the network value and creates a positive externality that corresponds to the concept of network externality or network effect. With these considerations, the academic community started to research these markets in a more systematic way. From this concept, new concepts in the same context appear like switching cost, path dependence or lock-in.

Later on with the Open Source Software (OSS) model getting more and more importance in the market, research was made to try to understand all the factors behind a software model based in the sharing of code and free licensing.

As a result of all this research, new theories create a new research field called Network Economics, of which this thesis will study the consumer decision process between incumbent standards and alternative standards, and more specifically between proprietary standards and Open Source standards in the Information and Communication Systems (ICS) market. Since the main subject of analysis will be Operating Systems and applications for personal computers we will call it IS (IS) market, even if many of the conclusions will be applicable to the ICS market, namely for instance the smartphones market where some suppliers offer to the market smartphone versions of the same Operating System and applications. This thesis will also study the business models and innovation models of the market suppliers for each of the standards that exist in the market.

The objective of this thesis is to study how the consumer choices in the IS market are made and how these market was created and develop influenced by these consumer choices and suppliers' decisions and business models. The study of these factors will contribute to a better knowledge of market trends that will help to forecast the market evolution.

The empirical research of the thesis focuses on the competition between Open Source Software and Proprietary Software in the IS market. In this kind of competition we have the classification showed in Table 1, of which the thesis will study the Open Source free licensing software (Linux, OpenOffice, etc.) versus the Proprietary paid licensing software (Windows, MS-Office, etc.). The thesis will focus on Operating Systems for personal computers and Office Suites because they are the type of software most widely known.

Table 1. Access code and licensing type in the IS market

Analysis Object		**Code Access**	
		Open Source	Proprietary
License Type (Gratuity)	Yes	**Linux OpenOffice**	**Internet Explorer MS-Media Player**
	No	**Windows CE (Shared Source License)** ***Considering only access to source code***	**MS-Windows MS-Office**

1.1. Research motivation and relevance

The thesis will study the consumer's process decisions and supplier's strategies in the IS market. These agents, together and by their interactions, will define the market evolution, market standards and as consequently the world technological infrastructure.

As showed above this kind of markets have some specific characteristics like network effects, switching costs and lock-in to name a few that make them different from other markets studied in the economics and management areas.

The main motivation behind this thesis is the development of research in the following areas:

1. Influence of company management and consumers decisions on the creation and development of the network effects, switching costs and lock-in in the IS market;

2. Impact of the network effects, switching costs and lock-in on the market evolution, including the choice between Proprietary Software and Open Source Software.

The thesis has relevance because it will focus on some topics with small research development like the analysis of the consumer decision process in their choice of IS products and services, the influence of management strategies in the development of the IS market and the creation of the effects that influence the development of these markets in a different approach from the actual research about these subjects, grounded mainly on economic theory and modeling and rarely in a Management or IS research perspective.

The thesis relevance comes from the knowledge contributions that it will give to both academic and non-academic world.

For the academic world this thesis will allow:

1. Identification of the factors that influence the strategies adopted by the software suppliers when they considered the IS market situation and its characteristics;

2. Explanation of how the consumer chooses between incumbent and alternative software standards;

3. Prospective analysis of all these strategies and decisions impact on the evolution of the IS market.

To the Non-academic world this thesis will also have some contributions:

1. Offer additional knowledge to regulation organizations to allow them to better evaluate the IS market and its evolution and to better regulate while maximizing consumers and suppliers benefits;

2. Offer additional knowledge to buyers and suppliers in the IS market to better support their decisions, and better create their expectations and forecasts about the market evolution.

1.2. Research design and Research questions

The research design of this thesis will include the needed steps to fulfill the thesis objective. The thesis objective is the study of how standards in the IS market are defined and how these markets are created and develop, influenced by factors like network effects and the decision process of consumers and suppliers in the market.

Following the objectives of this thesis, and taking in account the literature review and the state of art of this research field, several research questions can be made that this thesis will address. The research questions are:

1. Which factors have influence on the buying process decision and the option between Proprietary Software and Open Source Software in the IS market?

2. How likely are Open Source Software solutions to be free to the user?

3. Can the free licensing of software allow the Open Source Software suppliers survival and their innovation in the market?

1.3. Document structure

This thesis will be presented in the following chapters, which will include:

1. Literature review: the state of art in this research field;
2. Research questions: questions that will make the thesis contribution for this field of research;
3. Hypotheses presentation and modeling: hypotheses taken from the literature review and where this thesis will be grounded and their modeling;
4. Data collection and analysis: explanation of the methodology of data collection and analysis for each of the research questions;
5. Expected results and contributions: the results that are expected from the research of this thesis and the expected contributions of this thesis to the knowledge of the academic and no-academic worlds;
6. References: list of the research documents included in the literature review.

II. Literature review

2.1. Introduction

The literature review presents the main concepts in the Network Economy field like the network externality or network effect that occurs when the consumers constitute a network and the value to the consumer of that network will rise with the number of consumers in the network. Other concepts are switching costs, the cost of switching between different technologies or standards; and lock-in, which occurs when the switching costs are too high that can lock-in the consumer in the actual technology even if that technology is already obsolete.

How these factors influence the consumer's choice, particularly the choice between Proprietary Software (PS) and their standards and Open Source Software (OSS) and their standards will also be analyzed.

2.2. Network externality or network effect

In some markets the consumer's utility of the products and services that he consumes rises with the number of consumers that already consume that product or service.

For instance, as the number of consumers with 3G mobile phones increases, the value for the actual or potential consumer of the 3G network also increases because more benefits they get by being able to make video calls with a larger number of consumers or have access to a larger 3G multimedia services range. Katz and Shapiro

(1985) calls this effect the **network effect** or **network externality** and this concept was the starting point to a new range of concepts in this research field. These two authors consider that two categories of network effect can exist in a market:

1. **Direct network effect**, when the rise of the consumer utility is the result of more consumers consuming the same product or service. That is the case of mobile telecommunications and fax communications.

2. **Indirect network effect**, where the rise of the number of consumers in a network raises the offer of complementary products and services (Katz and Shapiro 1985) and (Economides 1996). That is the case in the Operating Systems (Windows, MacOS, and Linux) and its software and peripherals.

Following the introduction of the concepts of direct and indirect network effects by Katz and Shapiro (1985) there was some discussion about if these effects create inefficiencies in the market. There existed some consensus that the inefficiencies can happen with the first category of effect as will be showed.

In this discussion we have on one side the works like Church, Gandal and Krauze (2002) and on the other side works like Liebowitz and Margolis (1994, 1995a and 1996), with the first ones considering that the market inefficiencies can also happen in markets with indirect network effects and the second ones considering that in a market with indirect network effects the inefficiencies aren't created, only mere perturbations in the market evolution can happen and governments shouldn't intervene. These authors published papers criticizing the US Government anti-trust action against Microsoft, because this action was conceptually grounded on the theory that in markets with indirect network effects inefficiencies can happen and Government must intervene.

Church, Gandal and Krause (2002) paper was made by modeling the computers and software markets, markets where indirect network effects exist. To these authors the rationality applied to the markets with direct network effects can be applied to markets with indirect network effects. In a hardware/software market with scale economies in the software production, free entry of software suppliers and consumer preference for the software variety, the network effects in the market can create market inefficiencies. These inefficiencies happen because the marginal consumer in his choice of a network, in this case through the buying of a computer with some operating system (a standard), doesn’t take in consideration the benefits that his choice gives for the users of that operating system. In this case the benefits are an incentive to the production of a larger software variety for that standard by the software companies when they see the number of consumers in the network rising. Because the marginal consumer making the decision entry to some network, doesn’t consider in his choice the benefits he offer to the actual users in the network, that result in a network with a dimension inferior to the socially efficient network that is created when the marginal consumer take in account that benefits.

Clements (2004) also concluded that direct network effects can create market inefficiencies with less convergence to a standard that in the social optimum, as showed above, while the indirect effects can create excessive incentives to standardization than in an optimum because software companies will choose the market and standard with the bigger network to raise the dimension of that network and their weight in the market, creating a market inefficiency. Network effects benefiting the incumbent can be considered as a barrier of entry, that while allowing a new entrant it the market makes it difficult to surpass market share values much above 10% (Cabral 2007).

But while that be the case for products of similar quality and features, it can be possible that higher quality products that arrive later to the market can have success in a market with network effects, depending on the consumer trade-off between network effects benefits of a larger installed base versus the choice for a lower installed base product with less network effects benefits but where the are benefits from the higher quality and features of the product are larger (McIntyre 2011).

In some industries like the videogames research concluded that if network size has influence on the market development through network effects, the hardware quality has also a large influence because it allows the development and introduction of a larger number of more high quality games that have a stronger influence on the market through indirect network effects. As such for a player with a smaller network size, hardware quality and the choice of better software developers to introduce better and if possible exclusive games can result in a strong indirect network effect that will allow the surpassing of the network effect disadvantage (Gretz 2010).

2.2.1. Two-sided network effects

Rochet and Tirole (2003) developed the definition of two-sided markets, a more precise development of the direct and indirect network effects. For these authors, "a market with network externalities is a two-sided market if platforms can effectively cross-subsidize between different categories of end users that are parties to a transaction". In two-sided markets the sales and profits of the entire platform (Windows Media Server and Windows Media Player or Adobe Acrobat and Adobe Acrobat Reader or Credit Card merchant installation and customer credit card) will depend of the way of the cross-subsidization between the two markets. There are two reasons why platforms may be unable to perform such cross-subsidization:

1. If both sides of the solution are bought by the same company, like a Acrobat solution or video streaming solution for use inside an organization;

2. If monetary transfers between the two sides of the market prevent the cross-subsidization;

But in the end almost all the network markets are two-sided because companies are very careful in the way they decompose prices and which part to attract and end users are very sensitive of the way the costs are allocated.

Parker and Alstyne (2005) also studied the network markets and developing the Rochet and Tirole (2003) research with a model where three kinds of situations can be present. First, even if there is only one company in the market, that company can invest in a product that is to be given for free all time. Second, in markets with content providers and end consumers, a company can offer a good for free in either of them. And third, product coupling across markets can increases firm profits but at same time increase consumer welfare.

The authors distinguish between intra-market and inter-market network externalities. The first ones are the traditional and the second ones consider the two-sided complementary markets where a company present in both sides can subsidize the price in one side of the market and profit on the other side internalizing the two-size externalities. For instance, the importance for Microsoft of integrating the Windows Media Player (WMP) in the Windows Operating System is that by doing it the WMP will be the default media player for almost all the user of Windows (around 90% of the market) and put pressure in the content builders to choose Windows Media Servers as the solution to make media content. The choice of the side to subsidize will depend on the cross elasticity and sizes of each side, with one of the sides covering the costs of subsidizing the second one by increase demand that is induced from the subsidized market.

When considering content providers and end consumer markets, the choice of which market to subsidize depends of the network externalities. If high, it's chosen the market that contributes more for the demand of the complement, as the media players for the media servers or document readers (like Acrobat Reader). If not very high is possible to charge prices in both markets with one of the prices subsidized as in the videogames markets where console have artificially low prices.

Regarding the consumer welfare, it's positive for the consumer because even with efficient price setting across both markets, the company cannot capture the entire consumer surplus and that benefits the consumer.

2.3. Standards

A standard is a range of specifications that allow the compatibility between different products from different suppliers. These specifications allow that phones, mobile phones and fax communicate with each other; that all the DVD, CD, DAT readers can read DVDs, CDs and DAT tapes; that is possible to exchange MS-Office files or run "Windows compatible" applications. As such, the standards allow market compatibility. There also exist standards outside the IS market but that standards are out of the scope of this thesis.

In markets with network effects like the IS market, usually a convergence to some standard happens and will benefit to the companies that use this standard in their products or services. When considering the competition between standards certain definitions must be considered regarding the standard categories. The standards can be sponsored or not sponsored (Katz and Shapiro 1986). The first ones are owned; give property rights to the owners of the technological patents. These standards are created by one company or an association of companies. The non-sponsored standards can be created by choice of the suppliers in the market or independent organizations and don't have proprietary rights.

There is also exists a difference between the *de facto* standards and *de jure* standards. The first ones are created because of a competition process while the second ones are created through the consensus between the participants in the market.

2.4. Switching costs and lock-in

After the option for some technology or standard, the network choice, the consumer will naturally have costs if in the future he wants to switch to a new network, even if this new network technology and standard is superior to the technology and standard of the actual network. These costs, called **switching costs**, growth with the dimension of the actual network because the consumer who switch will lose the network effect benefits of the actual network**.**

If the consumer does not switch to the new network with better technology, the actual network will keep the same dimension even with a technology inferior to the technology of the alternative network. If the actual network keeps its dimension, more consumers will be attracted to it because the consumer will have a higher utility by choosing the network with the biggest dimension. The switching decision delay that happens because of the switching costs can **lock-in** the market with a technology or standard technically inferior (Farrel and Saloner 1985, 1986).

Several categories of switching costs can be considered. Klemperer (1987) created a model of switching costs where three categories of switching costs were considered with examples for each of them:

1. Transaction costs (uninstall of actual standard solution and installation of new standard solution);

2. Learning costs (learning how to work with a new equipment, operating system or software application);

3. Contract costs (loss of client fidelity points, brand club points or a support contract).

Richard Langlois and Paul L. Robertson (1992) also studied this subject and defined three categories of switching costs when the switch causes problems of compatibility:

1. Value loss of specialized complementary assets of the actual standard (software and peripherals for instance) with the option for a new standard;

2. User data conversion for the new standard;

3. Experience and skills loss and learning costs with the option for a new standard, also known as psychic switching costs.

A recent research about switching behavior offer similar results with the switching between suppliers being influenced by the consumer satisfaction with the actual supplier, switching costs, habit strength and alternatives attractiveness. The first three factors have a negative influence on the switching intentions. Alternative attractiveness has a positive influence on switching intentions (Chuang 2011).

2.5. Path dependence and positive feedback

Paul David (1985) and W. Brian Arthur (1989) studied the market lock-in, developing the concept of **Path Dependence**. Paul David introduced the concept that small historical events have influence over the development and innovation of a market. Showing as an example the QWERTY keyboard, the most used actually in typewriter machines and computers, David made reference to a US Navy study about the impact of the computer keyboard layout on the productivity that concluded that the PYFGRL keyboard layout introduced by August Dvorak in 1932 allow a greater productivity. However there was a path from the first typewriter machine, QWERTY, that was built to slowdown the typing speed to avoid damage to the machines. Actually, without that problem, the market is “closed” (lock-in) this keyboard layout. The companies don’t want to make a different, even if more productive layout, because the standard in the market is the QWERTY layout and consumers probably will not buy a different type of keyboard.

William Brian Arthur (1989, 1990) in his working papers “Competing Technologies, Increasing Returns, and Lock-in by Historical Events” and “Positive Feedbacks in the Economy” studied standards competition as the Beta versus VHS videotape standards and alternating current (AC) versus direct current (DC) energy standards. This economist considers that lock-in showed up in markets with network effects because not only small historical events lead to the domination of the markets by standards even if inferiors, an effect similar to the QWERTY keyboard, but also because this effect was reinforced by the called **positive feedback**. The positive feedback is created by the raise in the demand induced by the networks effects that will raise the production level in markets that benefit from scale economies, lowering costs and prices. That effect reinforce again (positive feedback) the market and the standard growth. On the other hand, with the growth of the network user base, more and more consumers choose the most attractive network, the network with more users. With these combined effects the strong company will be strongest, and the weak company weaker … “The winner takes it all”.

A consequence of this result is that, by showing that certain markets can become "closed" (lock-in) in lower quality technologies or standards, the author gives a justification for regulators intervention in these markets to obtain an improvement in the social welfare.

Liebowitz and Margolis (1990, 1994, 1995 and 1995b) didn't agree with the David and Arthur conclusions and published several working papers against these conclusions. Liebowitz and Margolis (Liebowitz and Margolis 1990, 1994, 1995 and 1995b) agreed that there exist markets with network effects and that a consumer when buy some product or service in that markets, choosing a standard, take as an choice factor, beyond price and features, the benefits of the network dimension by trying to guess the dimension of the markets. Liebowitz and Margolis (Liebowitz and Margolis 1990, 1994, 1995 and 1995b) also agreed that when consumers choose a network they can become locked-in in that network, not wanting to switch to another alternative network even if that alternative network standard is better, because of the switching costs. But the authors don't expect that this happens in reality. To explain this, we must consider separating the lock-in concept between strong lock-in and weak lock-in (Liebowitz 2000).

They started by considering two categories of switching costs that can turn in market lock-in:

1. Compatibility cost of the consumer with himself when switching to a new standard. The compatibility costs include habits change, learning and compatibility of the new standard with the standard he actually uses in applications like word processor or spreadsheet (weak lock-in).

2. Compatibility with the others. For instance, buying a Macintosh loosing application compatibility with colleagues and friends that use Windows standard (strong lock-in).

If a company introduces a new superior technology in a market with the objective of developing a network based on that new technology his success will depend in the first place on the new technology benefits for the consumer that must be higher than the cost for the consumer of loosing compatibility with himself when switching. But even if that condition is satisfied there exist network effects caused by the compatibility with other consumers in the network where the consumer actually is (strong lock-in). In this case the network dimension is relevant, market share is relevant, and a company offering a new standard will have difficulty to win over the incumbent standard. The consumer don't switch to the new network because he is afraid that others consumers also don't switch.

In markets with weak lock-in, the consumers will switch if the benefits of the new standard are higher than the switching costs (compatibility of the consumer with himself), protecting less the incumbent standard. While the strong lock-in can cause economic inefficiencies that doesn't happen with the weak lock-in. With weak lock-in if the switching costs are high and the switch to a new improved standard doesn't have higher benefits to the consumer that means that the consumer and the society are better with the incumbent standard and the consumer made the right choice when he doesn't switch. Liebowitz (2000) considered that they didn't know real cases of strong lock-in, and that research about it with examples like the QWERTY keyboard or Beta versus VHS had some methodological flaws. They consider that with the strong lock-in a real lock-in in the market can happen with the first company to dominate the market conquering it (Liebowitz 2000).

Considering the point of view of companies that are “trapped” in their own products path dependence in a market environment with radical changes, Park (2011) considers that while some companies don’t survive that changes, many companies have success in adoption to the new market trends not only in the same domain where they have their products, but also by expansion to cross businesses to regain their dominant position.

Katz and Shapiro (1994), while considering that inefficiencies caused by network effects can happen also have some reservations regarding government intervention:

1. “... the degree of market inefficiency doesn’t show up clearly ... there exist many market answers to solve the problem without government intervention.”

2. “... the government sometimes doesn’t have the incentives to improve the situation. One plausible hypothesis for this is the government preference to serve the actual generation of manufacturers and customers by blocking or imposing high costs to emergent technologies.”

3. “... even if the government decision-makers wanted to maximize the community benefits, maybe they don’t have enough information to try to define a market standard for instance.”

2.6. Standards competition and compatibility

In markets with network effects the consumer will make is choice considering the number of consumers already using the product or service in that market and his expectation of the number of consumers in the market in future (Katz and Shapiro 1985). Some questions arise regarding the competition in these markets. How can a company enter in a market with this kind of characteristics?

If the consumer gives more value to products and standards with bigger market penetration, a company who want to enter in that market must choose the predominant standard offering compatibility with it, in a more secure strategy regarding the network effects but loosing innovation and differentiation advantage? Or can the company choose a differentiation strategy, introducing a product so innovative that the consumers will give more value to that innovation than to the network effects benefit of the actual standard?

2.6.1. Suppliers decisions and definition of standards

Overall, the companies with bigger dimension, better brand image and a bigger customer base choose to defend their standard and are against the creation of compatibilities or universal standards because they have competitive advantage over the competitors that may be lost in a market standardization with an universal standard or compatibility adaptor (Katz and Shapiro 1985).

In another work this researchers also concluded that "… firms may use product compatibility as a means of reducing competition among themselves … the firms prevent themselves from going through an early phase of extremely intensive competition where each firm tries to build up its network to get ahead of its rival" (Katz and Shapiro 1986a p. 164). That means that in markets with network effects and an already dominant standard the competition based on innovation can diminish or stop because the new entrants will prefer to be compatible with the incumbent standard than the risk and costs of introducing a new standard.

In a market with several competitors using the same standard where the competitors know that creating a new and better standard is a risk strategy and where there is few to none communication between then, there will be inertia in the standard improvement or innovation in the market. That inertia arises even if all companies value the benefits for all with the creation of a new and better standard, but do not value it enough to take the initiative themselves, so they keep waiting for the others to act.

When the companies in the market have different opinions about the advantages of a new standard, even if the global benefits of the switch are bigger than the global costs, there arises a different kind of inertia, the **asymmetric inertia**. In the asymmetric inertia, some companies have positive opinions about a standard switch but do not have the weight to break the inertia of the other companies. They cannot lead the process that could take with them all the other companies in the market in a *bandwagon effect* (Farrell and Saloner 1985).

Katz and Shapiro (1985) studied a company choice process about which standard to offer in the market and the compatibility of this standard with the incumbent standard in the market. To these researchers "… companies with good image and good presence in the market or with a good installed base of customers usually are against compatibilities, even when the global welfare improves when that happens". If competitors can be compatible with a superior incumbent standard in the market, that benefits consumers and suppliers. But "companies with small networks and less reputation usually choose the compatibility of products, even when in some situations the social costs of compatibility where higher than the benefits". That happens when nobody want to offer a new superior standard in a situation where the incumbent standard is outdated. "The total incentives of the compatibility where lower that the social incentives" (Katz and Shapiro 1985).

To these authors the compatibility can be made by:

1. "… conjoint adoption of some standards, where a set of companies get together to make their products compatible with each other";

2. "… by an adaptor design, when a company unilaterally make his product compatible with the market standard".

When it's impossible to make the licensing of an standard because the owner don't license it and the creation of a adaptor is technically impossible or has high costs, the products of some set of companies will only be compatible if all companies profit from that starting with the standard owner that can change its decision of licensing if that benefits him. If the compatibility can be made through an adaptor, the products will be compatible if one of the companies wanted that. If the licensing is possible the companies will make their products compatible by licensing if the costs of this compatibility are lower than the costs of achieving it by making a standard adaptor.

As such, the companies' choices will depend of:

1. Possibility of a company unilaterally to make a decision about compatibility versus the need of a consensus decision of a set of companies in the market;

2. Possibility of licensing.

In both cases government policies have an influence in the market. If the patents and copyrights system is well implemented for instance, the companies will try to build consensus about an industry standard. If not, the companies will try unilaterally to make adaptors because there is less risk of prosecution in an illegal use of a patented technology.

Lin and Kulatilaka (2006) studied the technology licensing in markets with network effects and concluded that when there is network effects the better option for a standard owner is to license it even when it is possible to dominate and become a monopolist in the market. By licensing, the standard owner will allow the market to grow even more because the benefits of a smaller share of a larger market will be higher than the benefits of a larger share or monopoly situation in a smaller market. The optimal licensing mechanism shifts from a royalty regime to a fee regime as the network effect increases.

Katz and Shapiro (1986) while studying and modeling the market dynamics based on the technological evolution and the presence of two incompatible standards influenced by network effects also concluded that network effects have two kinds of influence in the market:

1. The relative attraction of each of two rival standards depend on their sales;
2. The consumer chooses not only taking in account 1, but also based on what they forecast for the future dimension of the network of each of the market standards.

They also concluded that markets without proprietary rights where a company can easily enter will result in a perfect competition market. This equilibrium can have some distortion if "each consumer ignores the network effect it creates on other consumers when he takes his consumption decision" (Katz and Shapiro 1986). In this case the result will be a market without standardization or the adoption of an inferior standard. This happen because some standard have the advantage of first-move and other companies entering the market will prefer to make the less costly adapters, with the result that the market lock-in in a standard that later on can proved that is not the best possible standard.

Katz and Shapiro (1986) also considered that when there are two standards fighting for the market dominance, different situations could arise:

1. The best standard in some date in time can naturally get competitive advantage and dominate the market creating a lock-in with that standard;
2. If one of the standards is sponsored (proprietary, the owner make investments in advertising and competitive price), this standard will have a competitive advantage in

relation to the non-sponsored standard and will be the dominant standard even if inferior;

3. If both standards are sponsor, the winner standard will be the standard that the consumers expect to be more successful in the future.

Liebowitz and Margolis (1996) presented the conditions needed to a new standard win over an incumbent standard. To these researchers if the new standard is technically superior to the incumbent standard is expected that the new standard will win over the incumbent. However, for the new standard more easily overcame the incumbent standard it must have a lower price to allow a market penetration strategy and a strong advertising campaign. To these researchers if the new standard is technically superior he will win over the incumbent standard eventually.

Another factor that influences a company success against an incumbent standard is the heterogeneity of the consumer's preferences developed by Dalle (1997). A company that introduces a new standard in a market with some consumer heterogeneity must try to reach market niches in the first place, to achieve some consumer's critical mass, and after that must try to attract incumbent standard consumers. Witt (1997) concluded that in a market with an incumbent standard and lock-in a new standard can have success if it has the capacity to surpass a "critical mass", a critical number of potential consumers that choose between the incumbent standard and the new standard.

Besen and Farrell (1994) developed the distinction between four different situations in the standard definition in the market:

1. Competition between incompatible standards;

2. Competition over compatibility, when the suppliers made the option of not introducing new standards in the market to compete with the incumbent standard but in alternative introduce compatible products with the incumbent standard by using

"adapters", like the filters that make made OpenOffice or WordPerfect files compatible with MS-Office files;

3. Standards definition by volunteer agreement between market suppliers;
4. Government mandated standards.

In the first and second situations, some standard become the *de facto* standard through market competition without coordination between the suppliers of the market or any external intervention. As examples we have standards created by companies like Microsoft, Autodesk, Adobe or WinZip the actually dominate the markets of "Office" software, CAD software, electronic publishing software and file compression software. In this case, the companies who enter in the market must decide between using the incumbent standard or introduce a new standard against the incumbent standard.

In the last two situations the standard definition, by agreement or Government mandated, create the called *de jure* standard like GSM, 3G, OpenDocument Format or Internet Protocols.

Different situations can happen in the different markets of the ICS industry. In the mobile telecommunications market in Europe, the European weight of the European companies and the influence of European governments allowed the definition of *de jure standards* or the creation of independent organizations to make the standards definition. The market philosophy in the United States of America with almost none Government intervention allowed the creation of multiple standards, some of them non-compatible between them, with losses for the consumers and the market development. In the *software* market, we have seen mainly the creation of *de facto* standards after a competitive process with the implementation of standards of companies like Microsoft, Autodesk, Adobe, Winzip, etc. The Internet was created by the USA government for military reasons with the Government definition of the standards. After that, standardization organizations keep defining *de jure* standards, from information codification standards to the communication protocols ((IPs), while big companies like Microsoft keep trying to implement and get the approval from standardization bodies of *de facto* standards with the objective of achieve strategic and commercial benefits.

In the personal computers segment of the hardware, market the standardization has been a *de facto* standardization, with standards defined by the main hardware companies like IBM, Intel, Creative Labs, etc. after a competition phase in the different equipments and peripherals. The losers of the market had been the group of manufacturers that made the option of not manufacture products compatible with the dominant standard and instead created their own standard, or companies that create their own standard because at the time there was no dominant standard in the industry, as it was before the IBM PC standard. All that companies finished defeated by the strong network effect that was created in this market around the IBM PC standard. Of the manufacturers that for some kind of the above reasons did not follow the market standards, companies like Commodore, Radio Shack, Oric, Acorn, Texas Instruments, Sinclair, Apple, etc., only Apple survived. Apple applied a strong differentiation strategy and received the benefit of the "cult" that their products had but their very small market share show the difficulties of fighting against the dominant standard Intel/Windows.

Lee et al. (2003) research the IS market considering a company option between introducing a new technology compatible with the market dominant standard and creating a new standard, technically superior but incompatible. They made this analysis in the microprocessors market where the main competitors are Intel and AMD with the dominant standard x86 created by Intel, and the RISC microprocessors used mainly in potent graphic workstations. The researchers concluded that a company must create a new standard only if:

1. The majority of his consumers are *power-users* (users with technical skills and that want big computer performance);

2. The market is in the beginning with the incumbent standard still without many consumers and a weak influence of the network effect on the consumer decisions.

When there is a strong market penetration of the incumbent standard, and very few *power-users* in the market, there is a lock-in in the incumbent standard. The lock-in is created by the consumer's inertia regarding the incumbent standard because the actual network give them more benefits (network effect) that the switch to a technically superior standard that has not many practical advantages in the day-to-day use of a consumer that is not a *power-user*. In this case, the company who want to enter in the market must create a compatibility with the incumbent standard adaptor, as AMD did in the microprocessors market, or avoid entering the market because the success probabilities are low.

2.6.2. Consumers decisions and definition of standards

The actual research in the IS market often discuss how the choice of a market standard in influenced mainly by two factors, network effects and switching costs, through complementary products like software and peripherals. With the presence of the switching costs, the first choice of a consumer will influence the attractiveness of future choices, raising the costs of some of them regarding the others.

One of the first additional contributions to the research about standards choice by consumers was made by Shy (1996). He developed Katz and Shapiro work and researched aspects not covered by their work. One of the subjects of research was about how consumer's preferences evaluation about substitutability between technical quality of a standard and the benefits of a standard with a bigger network influence the adoption of new technologies. His work concluded that the success of a standard depends of several factors:

1. Network effect, as a substitute or complement of the standard quality. The bigger the substitutability degree the faster the adoption of new technologies (standards);
2. Compatibility degree of the new standard with the older standard. The bigger the backward compatibility the higher the probability of adoption of the new standard by the consumers;
3. Dimension of the installed base of customers and growth rate of the new standard. The bigger the installed base of the incumbent standard, the bigger the network effect, less probability of standard switch by the incumbent standard customer or the choice of the new standard by a new consumer in the market; the bigger the technological innovation of the new standard, the bigger the probability of adoption of the new standard by new customers arriving on the market and switch by the consumers of the incumbent standard.

In a different perspective, Dalle (1997) research was about the conjoint influence of network effects and consumer's (families and companies) heterogeneity in their standard choice. Dalle considered the first factor (network effects) leads to consumer's decisions coordination and the second effect (consumer's heterogeneity) leads to consumer's decisions diversification. As such, a company that introduces a new standard in a market with some consumer heterogeneity must try to reach market niches in the first place to achieve a number of consumer's critical mass that will allow the creation of some network effects.

Dalle (1997) also introduced a new concept, the concept of local network effect. The traditional network effect, called global network effect, is the effect where the consumer takes in account the actual and/or future number of consumers in some market standard. In local network effect the consumers don't always have information about markets and market shares that allow him to choose between standards while considering the actual or future number of consumers in that standard. As an alternative, the consumer search for information through is contact's network like friends, family, work colleagues, suppliers, customers or competitors. They act as advisers in the choice from a set of products and standards from which the consumer will make the buying decision. Birkea and Swann (2010) considered a similar perspective while studying consumer choices of mobile telecommunications operator, where there is a difference between on-net and off-net calls cost. They concluded that more than the actual network size of each operator, consumers consider the local network like family and friends "advise" to have the same network as them, allowing smaller operators to be chosen by these consumers.

Against the more traditional "economics" perspective that says that there is homogeneity in the consumer's decision process Dalle (1997) also concluded that "the consumers don't necessarily obey to majority rules whatever their relations with the others; there exist many rational reasons for the consumers to have idiosyncratic behaviors". That fact means that sometimes in the markets the coordination between the consumer's decisions does not exist. The existence of global and local network effects and some degree of consumer's heterogeneity can make the creation of a market standard very difficult or impossible. Instead, the coexistence of several market standards or even the existence of several standard market niches of older and outdated standards can happen, as the different weight of each the above factors (global network effects, local network effects and consumer's heterogeneity) influence the consumer decision.

Choi and Thum (1998) concluded, beyond the Katz and Shapiro (1986) model, that the consumer also has the option of choosing the incumbent standard or waiting for a standard with better technology. The research concluded that customers choose less the option of waiting than was expected, choosing instead the incumbent standard, because they usually don't take in consideration that by waiting for the new standard they also will benefit the future consumers of that standard. That way there will be inertia in the switch to a better standard. In contrast with Katz and Shapiro (1986) conclusions, Choi and Thum (1998) concluded that in monopoly situations with the monopoly company choosing a higher price for a new standard it will be even less attractive for the consumer to wait for the new standard.

Kornish (2006) while studying the consumer's choice between the two standards also included the alternative of deferring the decision. This researcher concluded that in any market of some dimension there exist two thresholds. If the number of users of the standard X is below the lower threshold the best alternative is to buy Y, if the number of users of standard X is above the higher threshold, the best alternative is to buy X, and in the middle the best alternative is to wait. That means that in the beginning of a market with still a small number of users, even if standard X has 100% market share but the number of users is below the lower threshold or between the lower and higher threshold, the best choice is to not buy standard X and instead respectively buy alternative Y or wait. But as the dimension of the market gets larger waiting is not the best choice because with a large number of users the standard with the larger market share will probably be the dominant standard in the future. The thresholds values are influenced by the network effect that makes the delay option less attractive as the network effect benefits increase.

2.6.3. Competition between standards

Shapiro and Varian (1999) created an analysis structure for the “competition between standards”. They considered four categories of competition:

1. Evolution, when the new standard is compatible with the incumbent standard;
2. Revolution, when the new standard is incompatible with the incumbent standard;
3. Rival Evolutions when companies in the market introduce standards than are compatible with the incumbent standard but incompatible between them;
4. Revolution versus Evolution if some companies introduce standards compatible with the incumbent standard and other introduce standards incompatible with the incumbent standard.

To these researchers the critical success factors to allow some standard to dominate a market are:

1. Control of the installed base of the network through, for instance, proprietary rights;
2. Innovation capacity;
3. First-move advantage;
4. Production capacity;
5. Existence of complementary products;
6. Image and reputation of the brand.

After studying several cases of competition between standards the researchers also considered further strategic and tactical conditions for a standard success:

1. Allied network between the different market intervenient;
2. Anticipation of the competitor's strategies and actions;
3. Management of consumer's expectations;
4. Not "stopping" the development of products and technologies after dominating the market;
5. To create adapters with the market standard and not implement strategies of low price to try to grab customers but that in the end give a weakness image of the company in the market, if the standard of the company fails in the market.

Farrell and Shapiro (1988) while studying dynamic competition with switching costs concluded that dominant suppliers, with more customers that are lock-in to their standard, sometimes can leave the new consumers to other suppliers in the market. They found that in markets with switching costs and other factors like scale economies, network effects and efficiency advantages, that usually are strong barriers to entry for competitors, in this case can allow their entry even with not so good products or scale disadvantages, because the dominant supplier don't want to serve new consumers because that is less profitable for him and that result in a less optimal equilibrium. Only if the economies of scale are very large the dominant company will want to serve all consumers in the market. Large scale economies and switching cost will form an entry barrier, while switching costs only allow the entry and survival of a new standard to be offered to new consumers

Dranove and Gandal (2004) analyzed the competition between companies and their standards and presented a set of 6 principles that the companies should take in account when involved in a standards competition:

1. "A monopoly in the bush is often worth more than an oligopoly in hand". In some conditions it's better to compete "for a market" then "in a market";

2. The one-way compatibility between standards (a company builds an equipment of his standard also compatible with the competitor standard) usually doesn't work if both standards are in the beginning of their implementation and there is few software or complementary products for them. The manufacturers of complementary products prefer and find less risky to build products compatible with both standards and both audiences;

3. Companies competing in markets with network effects must assure that the early adopters prefer their standard. Otherwise a bandwagon of support for another standard even if inferior can turn in an insurmountable handicap for that companies standard;

4. The companies must insure that they build a value network that includes suppliers, competitors and suppliers of complementary products and services. This value network is critical in markets with network effects;

5. At least one strong standard must survive the initial competition phase. If the manufacturers of complementary products support several different standards, each of them will have difficulty in achieve critical mass and all standards in the market probably will fail with losses for all the market;

6. The Internet communication between consumers plays a major role in the standard competition.

Church, Jeffrey and Gandal, Neil (2004) concluded that in this type of markets, with network effects and other influence factors over consumer decisions, the strategies must influence the expectations of the consumers and/or to create and enlarge the installed base. To do that, there exist several marketing and management "tools" like:

1. Price penetration, to help the rapid success of the standard market penetration;

2. Marketing advertising to influence consumer expectations over the standard dimension and growth of the market;

3. Consumer assurance with prices connected to network dimension or the selling the service and not the software+hardware needed, because if the consumer feels that he will not be lock-in it will be easier for him to choose the standard;

4. Second sourcing and Open Source, that by promoting competition within the standard will make it more attractive to the consumer;

5. Signaling, by showing to the market, even with sunk investments, that there will be continued support to the standard so the consumer can choose it without be afraid that the standard will be terminated soon

6. Product preannouncements, to induce the consumer to wait for new products of the standard instead of switch to other products in other standard (when the announcement is of a product that will never be released because of any reason, it's called vaporware and can be considered illegal if is considered part of an anti-competitive strategy);

7. Investments in complementary software, where a hardware company can influence the complementary software market by investing in it, creating or supporting software companies, restricting the offer of software companies to other standards and with that by increasing the software available that turn the standard network for the consumers.

2.6.4. Standards advantages and disadvantages

Katz and Shapiro (1986) concluded that the creation of a standard have some costs regarding "on one hand, the loss of alternatives ... on other hand because of the technology costs that can be different through time between consumers because of the technological evolution and because the consumption is intercalated in time."

Shapiro and Varian (1999) and Shapiro (2000) identified the benefits and costs resulting from the existence of a standard in the market and from the fact that all the other suppliers choose to create an adaptor to that standard and not competing with a new and better standard. The benefits are:

1. Better realization of the network effect;
2. Consumers protected from choosing the “wrong” standard.

The costs are:

1. Innovation and variety restrictions;
2. Influence on competition because the competition is not between markets/networks but inside a market/network based on the competitors dimension. That can cause a lower degree of competition.

The cost/benefit analysis of the existence of one standard in a market has different results in different markets. The role of the regulation authorities is to allow or disallow the definition of a standard between the competitors in the market by studying the impact of that choice in the market evolution against the market evolution when there is competition between different standards. That analysis may consider that a dominant standard can evaluate to a monopolistic proprietary standard with all the disadvantages for the market.

2.7. Trends in standards definition

Several trends in the standards definition research had appear in the last years regarding different contexts like companies’ organization, public policy or consumer behavior. The ICS markets has standards as the mobile communication standards, the Operating

Systems platforms, the Office Suite file formats or the Internet standards to communicate and present information.

2.7.1. Coopetition against monopoly dangers

With the development of the IS market and in the case of the Operating Systems and critical or common use applications, the market started to understand the "dangers" of the creation of a *de facto* standard owned by an monopolistic company that can use this monopoly power to dominate the market in all aspects and sometimes extend that domination to other markets and benefit from all this in strategic and economic terms, with the negative impact on the competition, market evolution and consumer (Lemley 1996; Saint-Antoine 2011).

Aggarwal and Walden (2003) analyzed the best company strategy in the IS markets that converge to one *de facto* standard and natural monopoly. For these authors these companies must organize between themselves in the development of a market standard to try to limit the problems associated with the market supply by one monopolistic company. By doing it they can benefit of an only standard available to all the companies in the market, supplied through some entity that is created by the coordination between the companies and eliminating the costs associated with a standard defined by a monopolistic company.

According to these authors "... all this will take the markets to a new form of industry organization vanishing the traditional borders and roles of the companies in the markets" with coopetition between companies in many cases.

These authors consider that academic research makes the assumption that the technological standards consumers are millions without any influence power over the standards definition. Very often this is incorrect because the standardization entities are created and receive founds not from individual consumers but from the manufacturing companies in the market. These companies usually are a small group of powerful companies with business knowledge and with the power and incentive to avoid a monopolistic standard supplier or a Government intervention in the standard definition. With this they created a new paradigm in the standards definition.

Following the theory contributions to this research field, that become this research field framing, the evolution of the research has been following two different paths:

1. Focus on theory contributions of the network effects regarding aspects like price, competition, compatibility, path dependence and lock-in, etc. mainly with an "economic theory" background and focus on applied works in different markets where exist network effects;

2. Publications of applied research that explore a theory framework that cannot be considered finished and that still needs more theory development. Nevertheless additional theory research in this field has been published with different focus like the standard choice between consumer's generations, public policy in markets with network effects or consumer choice grounded on the consumer behavior research.

2.7.2. Standards choice and generations

Clements (2004a) investigated the standard choice process when different consumer's generations are considered. Clements concluded that the actual generation when choosing about the adoption of a new standard doesn't consider the costs and benefits of the past and future generations. The actual generation will delay the adoption of a new standard without thinking about future generations and the lock-in of the market in a inferior standard or will rapidly choose the new standard even if don't exist many benefits in the new standard, don't taking in account the negative effect that this change in the market standard can have in the past generations. Clements (2004a) also concluded that if an incumbent standard is proprietary, the incentives of the company owner to induce the consumers to adopting the new standard are usually below the social incentive. This difference happens because the company is afraid of losing customers in the switch if isn't capable of capture all the future benefits of the new standard.

On other hand a company can induce the adoption of the new standard, even when new standard is social inefficient because of the small marginal benefits he offer to the consumer, if is capable of capture the benefits of the new standard that are created by the network effect of more consumers choosing it.

2.7.3. Public Policy

Some research was made about topics like market inefficiencies and opportunity (or not) of Government or regulators intervention. One of the more important working papers about this subject was made by Cabral and Kretschmer (2004), about the factors that must be considered in standard definition public policy. For these researchers two questions are important:

1. What standard to support, if any?
2. When intervene in the market?

To these researchers if the Government authorities are "patient", they will support the more recent standard and give time to the market before any intervention. If they are "impatient", they will support the standard leader of market and immediately intervene in the market. As "patient" or "impatient" are considered government authorities that think on future consequences of intervention and future consumers or that thinks about actual consequences of intervention and actual consumers. The intervention can be, for instance, the adoption of the standard by the government.

2.7.4. Network effects and consumer behavior

Between the recent works who focus on the network effects we can to point out an working paper that demonstrate the impact of that effect in the market evolution, taking also in account the consumer behavior (Clark and Chatterjee, Sangit 1999). This research was not made with an "economic theory" focus, as was almost all the research in the field but with a focus on the behavior research field. These researchers concluded that the consumers create expectations about the future dimension of a standard network and that expectations will strongly influence the consumer choice. The companies can influence the consumer expectations with communication campaigns and branding campaigns, and by doing it they have impact on their own future position in the market.

Barnes, Gartland and Stack (2004) made other research about behavioral lock-in. These authors concluded that beyond the lock-in caused of technological considerations there exist also behavioral lock-in, which develops the Paul David (1985) concept of "irreversibility due to learning and habituation". In behavioral lock-in, the consumer is "locked" in choices less optimal due to habit, organizational learning or culture. This concept can be applied to several fields and while can help to explain some inconsistencies that could happen while studying network-based lock-in, it's mainly used by sociologists and political scientists in other research fields.

2.8. Competition with the incumbent standard: The Open Source case

The Network Economy concepts can be used to define the competition analysis framework between some incumbent standard and an alternative standard, and more specifically between an incumbent proprietary standard and an Open Source Standard in the computer Operating Systems and Applications market, as will be now presented.

2.8.1. What is Open Source Software?

The Open Source Software is software that can be accessed, developed, modified, adapted and integrated in other software without payment by the developers of any royalties to the authors of the software (Raymond 2001). The most common restriction is that any future modifications or derivate software from the original software must also be Open Source (Schiff 2002). The Free Software Foundation introduced the licensing for this kind of software, called General Public License, "aimed to preclude the assertion of copyright or patent rights concerning cooperatively developed software" (Lernel and Tirole 2004) . This license, GNU license, while allowing the modification and distribution of software by software developers, they must in return a) make the source freely available (or at nominal cost) to whomever the program is to distributed and b) insist that other who use the source code agree to do likewise. Behind this all the improvements to code must be licensed in the same terms in what is also called also as "copy left", because the objective is to keep intellectual property free and available to all. So, the Open Source licensing is free. Another Open Source license that was introduced in the 80s was the Berkeley Software Distribution (BSD). Under this license the developers can modify a program, distribute it for a fee but aren't obliged to making the source freely available "as long as they acknowledge the original source" (Lerner and Tirole 2004). Open Source also must not be confused with “shareware”. In “shareware” only the binary files and not the source code are distributed for free or for a trial period only.

The Proprietary Software, on the other hand, is usually distributed in binary code (*Closed Source*) technically difficult to modify and with property rights that don’t allow it. The licensing of Proprietary Software has costs with two main exceptions: software that also have less complete but free versions (AVG Free for instance) to spread the applications in the market with the expectation that the consumer will upgrade to the full and more complete version with license costs; free licensing Proprietary Software that has the strategic objective of make the standard implemented and adopted by market (Internet Explorer, MS Media Player). Microsoft also introduced the concept of Shared Source software. The Shared Source software is presented in open code only to Microsoft’s selected consumers and allows the consumers support of their Windows applications, Windows platform support and internal audits of the Windows platform security. The Shared Source software cannot be used in the development of any commercial product. The code can be read, referenced but not modified. That was the company answer to the large companies and governments that want to have some “control” over the inner works of the dominant closed software and started to see the Open Source as a good alternative for these objectives.

Krishnamurthy (2005) considered several advantages and disadvantages of Open Source Software. To this author the Open Source Software advantages are **Robustness** (security, reliability, availability, survivability) due to the much more number of programmers and testers of different profiles working with an Open Source Software than with Proprietary Software, **Flexibility to User** by the possibility of mix and match different software without the restrictions of being tied with some Proprietary Software supplier. **Support from the Community**, because with Proprietary Software the user has limited free support service or high cost better support service while in Open Source Software it's possible to have high quality support from an Open Source community that is highly motivated to answer questions.

But the author also considered some disadvantages of Open Source Software. One is the **Version Proliferation**, the different versions that can arise like happen with Linux even if there isn't any advantage of "forking" (development of better but incompatible version of some software). Companies like Red Hat are good to solve this problem by selecting some version to support. Other is the **Usability** because of the poor usability of some software because of the resources available or the nature of the audience, people with technical skills.

2.8.2. The Open Source market

The research about Open Source Software started to be published with the development of the Open Source Software market in the end of the XX century. When considering Open Source Software we are talking about developer's communities whose members don't have financial motivations, at least direct financial motivations. This naturally has influence on the Open Source projects innovation capacity and motivation for innovation comparing with full profit motivated companies and developers. With developers offering their work and allowing free licensing software, how can an organization survive if its offer to the market is free? If the Open Source Software offer to the market is really free, why Open Source doesn't dominate the market? Beyond the developer's motivation for innovation in Open Source projects presented above, what is the innovation degree in this type of software projects comparing with Proprietary Software projects? These topics allow the specification of the second and third research questions.

2.8.3. Motivation to develop Open Source Software

Raymond (2001) researched the reasons behind the motivation of open source developer's community. To this researcher the main motivation of this community was the reputation between peers and with that reputation the capacity to attract attention and cooperation from others. In the Open Source community the reputation from the gift of complex "artifacts", the software himself, made this reputation even more important to all. All this "reputation game" also gives benefits for the members of Open Source community who also work for the "real economy" companies in similar areas, opening the possibility of a career climbing based on the reputation achieved.

Lerner and Tirole (2002) asked, "Why should thousands of top-notch programmers contribute freely to the provision of a public good?" Their answer came mainly from the work of Raymond (1999) that they developed. Lerner and Tirole (2002) concluded that the benefits for the Open Source developers are the learning and perfecting of their expertise by developing software, the reputation of contributing to Open Source projects and also the enjoyment of developing software. Also the peer-review by the development community is useful for the developer in his skills improvement.

Lerner and Tirole (2004) further developed this concepts seeing as costs for the Open Source developer that isn't compensated in a monetary way the opportunity cost of time of not being compensated by doing the same in a company or, if working in a company, of not focusing only in the company job. This costs are compensated by the improvement on their performance in work, simply by the pleasure "if choosing a "cool" open source is more fun than a routine task set by an employer" or in the long run because that "may lead to future job offers, shares in commercial open source-based companies, or future access to the venture capital market, and last (but not least) ego gratification from peer recognition.".

Another work in this research field was from Bonaccorsi and Rossi (2003). In their work three key aspects of Open Source were analyzed: Open Source as result of the activity of a community without financial gains motivation; hierarchical coordination without property rights; how Open Source Software spreading in a market dominated by incumbent proprietary standards is possible, that will be presented later in this literature review.

The researchers concluded that three main factors are behind the Open Source programmer's motivation. First, there is "… a form of intellectual gratification with an intrinsic utility similar to that of a scientific discovery, involving elements other than financial remuneration". Secondly, "besides being a form of intellectual work, hackers also regard programming as an *art form*". Third, "programmers frequently rediscover the pleasure of creativity, which is being progressively lost in the commercial world where the nightmare of delivery deadlines is transforming production into an assembly line." These motivations are all non-pecuniary rewards.

(Haruvy, Wu and Chakravarty 2004) in an empirical work from a web survey of 160 open source developers studied aspects like motivation and innovation in Open Source Software. They concluded that the two traditional models of innovation, the private investment model and the collective action model, couldn't explain the Open Source Software success. While motives for developer's contributions to Open Source Software can have several sources of economic, social, and political realms, they classified in only two categories, one of them private, the future monetary rewards and self-fulfillment. But collective aspects, social considerations dominate as drivers of product quality and product development speed, even if monetary considerations continue to remain important.

Riehle (2007) considered in his research two types of Open Source Software, Community Open Source Software, developed by a community of developers he call “committers”, and Commercial Open Source Software, developed by a company that keeps some control in several aspects over the software, including copyright and control of contributions from Open Source developers.

To this author, the “committers” can earn higher wages and have more negotiation power in their work. He based his conclusion also in the empiric work of Hann et al. (2004), where these authors studied the reasons for the developer’s contributions without payment to the Apache Web Server project. Hann et al. (2004) concluded that while contributions to Open Source projects don’t directly imply rising wages, they signal the developers labor market increasing the credibility of the developer and by this way indirectly will offer better. For Hann et al. (2004), “credentials earned through a merit-based ranking system are associated with significantly higher wages. Results suggest that status within an open source meritocracy operate as a credible signal of productive capacity” and with that increase the potential for higher wages.

Riehle (2007) consider that prominent “committers” to Open Source Software can achieve the reputation to choose the companies to work it and receive premium wages. To be considered a “committer”, an Open Source contributor is scrutinized by the following criteria:

1. The developer’s social and technical abilities;
2. Commitment to the Open Source project.

Riehle (2007) see benefits for the "committer" if the number of "committers" is not very large because that would dilute their value in the market. On other hand actual "committers" want to build a working community of "committers", even more if is to develop in new and larger projects. So in the end, too much is changing in the way developers are in the market. To Riehle (2007) "… for software developers, life has become more difficult and exciting at once. Developers face new career prospects and paths, since their formal position in an open source project, in addition to their experience and capabilities, determines their value to an employer. Economically rational developers strive to become committers to high-profile open source projects to further their careers, which in turn generates more recognition, independence, and job security.

2.8.4. The Open Source organization and innovation

Johnson (2001) while studied the Open Source Software development in the market concluded that while the Internet can allow the Open Source community to work with the "combined programming knowledge, creativity and expertise", the lack of profits can allow the free riding and some valuable projects not be developed. Also the Open Source Software is not as efficient as Proprietary Software in the level and distribution of development efforts but the free riding put limits in this inefficiency. In this model of development also the programs are less complete than in Proprietary Software, "it often seems that Proprietary Software is easier to learn, has more features, better documentation, and is more user friendly on the whole". This happen because as the number of components increases the possibility of have the Open Source community develop all the components lowers, because for the Open Source developers the costs for each component are not the same, while the Proprietary Software company will develop all the components that create profits.

Johnson (2001) also confirmed that as the incremental development advantage of Open Source depends on the developers base size, that explain why Open Source Software model is better to develop when a base product is already available that to create a new product, because the developers base is small.

Regarding the organization of Open Source Software, Cusumano (1992) studied the coordination problems in projects similar to Open Source projects. The coordination problems can arise because the relationship between the project and the developers is largely voluntary without formal contract. The researcher concluded that the main problem in this kind of projects is that even if the project initiator is well known by the community, he cannot force participants to continue or increase their efforts in the project. Lakhani and Hippel (2003) developed these concepts and concluded that Open Source developers value the ownership and control they have over their work, something that don't happen in the Proprietary Software projects. That make more difficult the Open Source projects coordination with all the impact in the development of this type of projects.

Bonaccorsi and Rossi (2003) concluded that "hierarchical co-ordination based on the ownership of assets is not a necessary condition for carrying out complex software development tasks. On the contrary, such co-ordination would end up depressing the intellectual, aesthetic and pleasure-based motivation that seems intrinsic to the programming community".

Also studying Open Source Software organization, Healy and Schussman (2003) showed that "activity measures is spectacularly skewed, with only a relatively tiny number of projects showing evidence of the strong collaborative activity which is supposed to characterize Open Source Software". By studying Open Source Software projects present in Sourceforge they found that the typical project has only one developer without any feedback of others or even downloads and usually fails or not go beyond alpha phase. That means that Open Source community as thousands of programmers developing and changing feedback maybe is not accurate, "it simply restates the problem by redefining the scope of the term 'Open Source Software community.'". But for many failed Open Source Software projects we have some who are a success like Apache or Linux Kernel between others. The authors concluded that the success project usually have professional software developers at their cores. They put the hypothesis that "the more successful an Open Source Software project, the more professional its core contributors will be, as measured by length of practical experience, formal qualifications or both." As Cusumano (1992) they also see as critical the role of the project leader due to the voluntary nature of participation in an Open Source Software project. They finally suggest that successful Open Source Software projects have a strong hierarchical component. They cited Hubbard (2000), a leading contributor to the FreeBSD project, comments: "Despite what some free-software advocates may erroneously claim from time to time, centralized development models like the FreeBSD Project's are hardly obsolete or ineffective in the world of free software. A careful examination of the success of reputedly anarchistic or "bazaar" development models often reveals some fairly significant degrees of centralization that are still very much a part of their development process."

So the authors don't see Open Source organization as bazaar organization when considering successful Open Source projects. In this kind of projects usually of big dimension, hierarchical organization, even if not with a formal organization chart, is critical to their success. In the end they see as factors to successful Open Source projects the existence of professionalism, clear leadership and hierarchy, factors usually not very associated with the more “romantic” considerations about Open Source communities.

Researchers also studied the innovation, mainly the innovation motivation in the Open Source community. They grounded their research on previous research about organization science and innovation research even when applied to other fields than Open Source.

Hippel (1998) researched about innovation problems in Open Source Software. One of the problems in software innovation is the difficulty of judging if some software feature is useful for the users and the difficulty that users have in expressing their needs about software features. The consumer needs can only be understood with deep user behavior research but that will raise the global developing costs. Only Proprietary Software companies can recover these costs with the sales profits. Without financial resources to buy consumer research Open Source projects usually only try to reach consumer’s average needs and problems, and that can result in market failure making the developers losing interest in joining some Open Source projects.

Dalle and Jullien (2002) see better development and innovation in Open Source projects because users are developers and can understand the best features to improve and how, so there is more efficiency in the development of software; the improvement in software is continuous and more efficient in Open Source projects because Proprietary Software companies prefer to delay continuous improvements and introduce new versions from time to time for the customer to buy; and more R&D resources are introduced in Open Source projects due to many skilled developers wanting do contribute for free while Proprietary Software companies considerer that investments versus profits and also lower R&D investment when in monopoly or almost monopoly position benefiting from network effects.

Prehn (2007) also consider relevant in his research that in Open Source Software users can be developers and contribute in different ways to the Open Source Software development, through communities or even as a paid "consultant" to Open Source Software companies. In his analysis of the Open Source Software development process Prehn (2007) also concluded that there exist user requirements while the top level projects decisions are made by the core developer team. The developer is a user and his interest in a software project is because as a user he as interest in the software. In bazaar style development users are treated as co-developers supplying valuable feedback such as bug reports and patches or fixes. While in commercial development there exist in Open Source Software communities development there exist a flat hierarchy in order to coordinate the project. The developer role is usually split up into two levels of sub roles: core developers and contributors. The roles as user and developer in Open Source Software are one of the strengths of this development model.

Hippel and Krogh (2003) analyzed the innovation motivation of the Open Source Software as motivated by a combination of private and community-related benefits results from contributions to Open Source Software development projects. To this researchers "the Open Source development is an exemplar of a compound 'private-collective' model of innovation that contains elements of both private investment and collective action models and can offer society the 'best of both worlds' under many conditions".

Haruvy, Wu and Chakravarty (2004) while studying innovation in Open Source Software applied the two traditional models of innovation, the private investment model and the collective action model. They concluded that "there appears to be common ground for private and collective motives", as told by researchers presented like Hippel and Krogh (2003). Their main conclusions were:

1. Social considerations can be as important as monetary prizes to ensure software quality;

2. Self-fulfillment must be an organizational goal because it can affect product innovation. That goal can be achieved through recognition and praise for creative work. Considering innovation and because social considerations play an important role, "it may be necessary to foster a sense of community, emphasize collective behavior, and allow for a wide range of political orientations in order to promote a creative atmosphere."

3. Even if political considerations seem not have impact on development creativity, it has in product quality and development speed. Here it's considered aspects like incentive of collaborative work processes, and avoidance of intense employee competitiveness;

4. The more ideological motivations are stronger usually when the developer decides to join an open source project, but its importance lower as he gathers more open source programming experience.

Ulhøi (2004) concluded that even if Open Source development can be seen as an anomaly in the private property theory, where economists assume that the motivation behind innovation is individual profit and preference for proprietary knowledge, that theory doesn't consider the critical knowledge sharing behind many important innovations. New research must be made in this research field, the innovation in Open Source projects, considering the knowledge sharing as a characteristic of many innovations.

Hippel (2005) considered in his research Open Source Software projects as user innovation networks, run by users to users without manufacturer required. The big advantage of these networks over the traditional is related with the benefits of sharing the innovation with others without need of developing everything. Also there is no need to be dependent only from commercial suppliers that naturally don't have always the best product that fit the user's needs. For this author commercial companies are the more logical organizations to innovate, they have financial incentives of profiting from their innovation and also have the resources to production, distribution, support. But user innovation networks continue to exist and growing, like Apache Server software for instance. For the appearance of these innovation networks of user/self-manufacturers at least some users have incentives to innovate, to voluntarily reveal their innovations and that this innovations diffusion can compete with commercial production and distribution. If only the first two conditions are satisfied there exists a pattern of user innovation and trial and later on commercial production and distribution of the better innovations. Companies like IBM or Red Hat work in the market by doing it, but also by contributing themselves for that innovation networks.

Economides and Katsamakas (2006) studied the innovation incentives in applications and platforms Proprietary and Open Source. They make the assumption that the productivity of investment is the same in Proprietary and Open Source Software even if both sides claim that there productivity is larger. They couldn't find definitive results regarding differences in innovation investment in Proprietary and Open Source Operating Systems but found that the investment is higher in the applications development when the Operating System is Open Source if both Operating Systems are considered similar in quality. In the Operating Systems the level of investment depends on the strength of the reputation effects of developing the Open Source Operating System, the ratio of developers in the Open Source community of users, the level of investment in applications of Open Source OS and Proprietary OS and the cost of implementation of an Open Source Operating System.

Considering the impact of competition between Open Source Software and Proprietary Software on the innovation, we had a word exchange in 2004 at the Linux User and Developer Conference in London between Matt Asay (Novell's director of Linux business office) and Bradley Tipp (Microsoft's national system engineer) that showed that competition has always a positive impact over innovation. Asay (2004) said that “"As things stand, creativity has gone, and that's one reason that Linux on the desktop makes sense. It'll be good for Microsoft, too. They won't like it, but it will force them to innovate.” Tipp (2004) answered in is communication in the following day that “The thing I like is that Microsoft does its best work and is most innovative when it has competition, so bring it on.”

Several authors also researched about quality and security of Open Source Software versus Proprietary Software. Kuan (2001) considered the Open Source has some advantage because customers can adapt the software to their needs and improve the code quality. She considered that “that under certain circumstances, some consumers will prefer the open source option and invest in producing software that is of superior quality to commercial alternatives”.

Johnson (2006) considered that Open Source Software is developed “through a superior process which may avoid pathologies that affect commercial projects”. Referring these “pathologies” Johnson (2006) considered that Proprietary Software developers may collude for not report programming errors of fellow employees to avoid problems to their own reputation and future earnings. When considering Open Source projects, because developers don’t receive wages they have less incentives to that collusion, so there will be more peer-to-peer review and that will allow for better quality software.

Research was also made regarding software security in both models, Open Source Software and Proprietary Software. Here also we don't have consensus between different studies. Some researchers considered that Open Source Software is more visible to all developers so they can readily identify security flaws and other problems, like Raymond (2001) that sees advantage in Open Source because "to many eyes, all bugs are shallow."

Other researchers argued that because in Open Source Software the source code is available for all, malicious hackers can find out its weaknesses. Anderson (2002) argues that the availability of source code in Open Source should have no impact on its security and that in the Proprietary Software close source while hackers will have more difficulties in finding bugs, it will also more difficult to find bugs through "beta" testing (users can use pre-launch software to find problems without having access to code).

The author expect that "open and closed systems will exhibit similar growth in reliability and in security assurance", without any attempt to assess this claim empirically because he consider that a software can be more attacked by hackers not because of being more unsecure but because is more used in the world or they want to indirectly attack also the credibility of the supplier company.

Furthermore Anderson (2005) concluded that in the long run there is no difference between Open Source Software and Proprietary Software: "I have not proved that open and closed systems are always equivalent. They are in an ideal world, but our world is not ideal. The significance of this result is, I hope, to have made a start towards a better understanding of the circumstances in which open systems (or closed systems) are best – and to help us focus on the factors that actually matter".

2.8.5. The Open Source business models

There is little theoretical or empirical research about business models and competition in the software industry grounded on a less theoretical economic modeling perspective. The business models presented below, while giving a general idea of the way business can be done with Open Source Software, were created in a “rule of thumb” or consulting perspective without any scientific testing or confirmation.

Raymond (1999) defined seven business models for Open Source Software, summarized by Schiff (2002) in Table 2.

These different models are a simple description of the kind of the market situations that showed up in the market. For instance, we can put the Open Source solutions of companies like IBM or Oracle between the “Give away the recipe, open a restaurant” and “Free the software, sell the content”.

Krishnamurthy (2005) analyzed the Open Source business models by building several models that tried to represent the several situations that can arise when the software companies work with Open Source Software.

Koenig (2004) also defined seven Open Source Software business models that are presented in Table 3. This seven business models, as the seven business models before, are a description of the market situation without any scientific testing or confirmation. The author also doesn’t analyze what are the best business models for each type of company, putting that judgment in the company managers.

The companies started to work with Open Source Software to achieve two objectives, increase the revenues and decrease the costs (Krishnamurthy, 2005).

Table 2. Schiff OSS business models

Name	Business model	Example
Loss-leader, Market positioner	Use open source software to maintain a market position for a related Proprietary Software product.	Netscape's open source Mozilla web browser and proprietary server software.
Widget frosting.	Sell hardware with open source driver software.	Apple's MacOS X.
Give away the recipe, open a restaurant.	Distribute open source software and sell service and support contracts.	Red Hat.
Accessorizing.	Sell accessories for open source software such as documentation.	O'Reilly and Associates.
Free the future, sell the present	Sell closed source software with a license that makes it Open Source after a time period.	Aladdin's Ghostscript.
Free the software, sell the brand.	Sell other developers a brand that certifies their implementation of your open source technologies is compatible with all others who use the brand.	Sun's StarOffice.
Free the software, sell the content.	Develop an open source product that receives proprietary content that the firm sells.	N/A.

Source: Schiff (2002)

Table 3. Koenig OSS business models

Strategy	Business model	Example
Optimizing (license based)	Optimizing the adjacent software layers, where applications are optimized to achieve greater value to the customer	Oracle
Dual License (license based)	The offer of free use of its software with some limitations including, or alternatively offers for a fee commercial distribution rights and a larger set of features. The free version doesn’t allow code use for commercial applications.	MySQL
Consulting	Removing nearly all licensing costs from a proposed solution and had integration and maintenance consulting fees.	Systems Integrator 10X
Patronage	Need leadership and consistency. Objectives are to drive standards adoption and enter in entrenched markets. It’s expected the success of a de-facto standard and that supporting community will converge around the company contribution. Other objective is to commoditize a particular layer of the software stack, eliminate competitors that are extracting revenue from that layer (Microsoft with Windows for instance)This creates an opportunity to offer above the Open Source Software a value higher up the stack through clustering, availability, provisioning, security, and management software.	IBM
Hosting	Using Open Source Software to keep infrastructure costs low and custom adaptable. “The GPL license allows them to own and keep secret the intellectual property modifications they create, and as long as they don't distribute the software, they don't have to publicly share the modifications” keeping their competitive advantage. Present in service offers like Application Service Provider, Transactions or Advertising.	Salesforce.com Amazon.com Google.com
Subscription	Subscription fees of technical support and maintenance that include configuration support and updates and upgrades to the technology.	Red Hat
Embedded	Using Open Source Software like Linux Operating System in several kinds of systems like TV set-top boxes, cells, servers, etc. and developing software over it that creates the real value for the consumer.	Tivo Netscreen

Source: Koenig (2004)

The companies started to work with Open Source Software to achieve two objectives, increase the revenues and decrease the costs (Krishnamurthy, 2005). The cost reduction happen by the introduction of free Open Source code into the existing code base, like for instance Microsoft recognized with the inclusion of Berkley System Distribution (BSD) code on Windows XP and 2000, or by alliances between the Open Source community of developers and software companies that will use the code developed by that community. In the revenues side we are talking mainly of support services for companies who are more and more using Open Source Software as users.

The community of Open Source products is "typically a diverse group of developers with a shared passion for a product" (Krishnamurthy 2005). They don't distinguish between corporate and individual users and are indifferent to their own profits or the profits that companies can made with their products through service or by using their own software. They want their software adopted by the widest audience as possible and they give also the code to help in that objective (Krishnamurthy 2005). These community objectives presented by Krishnamurthy are similar to the objectives of the other research about Open Source developers motivations showed above.

The way the community control their work is by the license choice, with the original developers always controlling the copyright of intellectual property. They choose between the GPL and non-GPL license. The most important characteristic of the first one is that when a company incorporates GPL source code in his products, it must make available in GPL license the source code of any product that the company will sell in the market.

Krishnamurthy (2005) also considered four business models for the Open Source Software:

1. Distributors.

One of the roles of companies working with Open Source Software is the role of distributor of it. Companies like Red Hat, Mandriva or Novell/Suse are Linux distributors. This kind of companies can earn their revenues by selling the Linux in a CD, usually in a box with some manuals but also by offering support services and upgrade services, mainly to enterprise customers.

2. Software Producers (Non-GPL licenses).

Software producers can integrate some Open Source code in a larger code base and create a new product or they can bundle a complete Open Source product with other products. In both cases the source code of both derived products don't need to be disclosed because the license is non-GPL but the original code can be available. The producer benefits from the lower cost of production and "pay" by allowing the community to see new ways of using the original code, even more if the derived product is a small change from the original product.

3. Software Producers (GPL licenses).

Software producers must release the code of the derived product. This model accelerates the innovation and input but lowers the profit potential of the producer. There are more relationships and loyalty with this model and the producer company can see the code if some user improves the software and put this new version in commercial use. The producer company cannot hide the innovation and development that he builds into the code.

Krishnamurthy (2005) consider that the main difference between GPL and non-GPL licensing is that in the first one the producer company mainly want a user with knowledge to build a two-way relationship while the non-GPL producer want the user to be only a user.

4. Third-Party Service Provider

Their only source of revenues is service so they will offer support service to any software about which they have the know-how and is in use by as many companies as possible. The reason why several companies contract this support services is because of the higher quality and availability than from mailing lists or user groups from the Open Source community.

Besides the model of selling the software product and service or only the service, Krishnamurthy analyzed the success probability of a software producer that sells only software. For this author that probability is low because the software is already provided for free by the Open Source community and trying to add value, like selling a stable version of a product or integrating a suite of products even mixing Open Source and Proprietary Software, will have little impact of offer enough revenue for a company surviving.

To Krishnamurthy (2005) created a two dimensions matrix to analyze the profit potential profits of Open Source Software, presented in Table 4. We have in the x-axis the Customer Applicability of the product, the dimension of the market that the software product can reach. On the y-axis we have the Relative Product Importance for the software users. Taking in account the two axes, the Open Source Software products with more profit potential are in Quadrant II, High Relative Product Importance and High Customer Applicability. They are the Star products, with companies started around them and a large base of developer communities supporting him. They also have the largest direct and indirect marketing support. We talk of product like the Operating System Linux or the browser Firefox.

Table 4. Classification of OSS

High Relative Product Importance (e.g. Operating Systems)	**Low Customer Applicability (e.g., OS/2 desktops)**	**High Customer Applicability (All Desktop and Notebook PCs)**
High Relative Product Importance (e.g. Operating Systems)	Quadrant I High Profile Nichers	Quadrant II Stars
Low Relative Product Importance (e.g. File Management Utilities)	Quadrant III Low Profile Nichers	Quadrant IV Mainstream Utilities

Products in Quadrant III have the lower profit potential, they have low Relative Product Importance and are for a small size customer base, like the 3D modeler program Wings 3D. The developers know they are developing a product of specific relative importance for a niche market, but want to fill that market with a good product.

The products in Quadrant I are for small niches but can have profitable operations because of the High Relative Product Importance. Krishnamurthy (2005) considered as an example SquirrelMail that can be used to run an Internet Service Provider email service. Finally in Quadrant IV we have the Mainstream Utilities that can be used by almost everybody but not many see any specific importance of it, so the profit potential can be low. As examples we have TouchGraph Google Browser or Agnostos (web-based tool to managing to-do lists).

In their research about Open Source Software business models that can allow their long term sustainability, Chang and Mills and Newhouse (2007) considered several business models similar to the above, like Support Contracts (companies like Red Hat), Split Licensing (companies like My SQL), Community (software like Apache); Valuedadded closed source (Linux version XandrOS); Macro R&D Infrastructure (usually R&D Government projects). The authors conclude that the organizations must move from one model to another or to use multiple business models if needed, considering the organizational needs, long-term goals, customer requirements and primary funding sources.

A different approach was made by Hawkings (2004) in his study of the reasons why companies will want to use Open Source Software and why they release for free, in Open Source format, code made internally. This author concluded that the use of Open Source Software is consistent with traditional economic analysis. The consumers (companies) want to buy software with the lower cost and develop internally additional components reducing costs. They release code because that way the code will be maintained free by a large number of developers with less cost than maintaining code internally. With that, they want to try to create *de facto* standards and receive the benefits of this.

Krishnamurthy (2005) also studied this subject and considered that companies use Open Source Software for 3 kinds of reasons:

1. Product performance: Open Source Software is gaining acceptance in the professional market because the users considered that this software has good performance for their needs;

2. Low risk: Users can always download for free Open Source Software, test it in the conditions they find more appropriate and decide after that if they want to implement or not the software in their day-to-day operations;

3. The professional markets evaluate the Total Cost of Ownership (purchasing, installing and maintaining the software) and choose. If Open Source Software has a

growing acceptance is also because the users fond that it has a lower TCO than similar Proprietary software.

Regarding the reason number two, Phipps (2008) introduced a new business model where the software risk will be even lower, the Adoption-Lead model, where users can adopt freely the software from some company and later on, if the software fills their needs, contract with the company the support service for that software. Only at this time, the user will be considered customer of the company that developed the software.

In a competitive environment what factors will influence the profits of an Open Source Software company? Krishnamurthy (2005) considered some key factors that affect profits of Open Source Software companies:

1. Support from Primary Developer Community. The engine of innovation of Open Source is the primary developer community (Tiemann 2002). If the community is focused on innovation the distributors get updated versions of software, the software developers get more code to their projects and users get software with best performance and stability. The success of the community crucially depends on its leadership, provided by one leader or a leadership committee.

2. Presence of Dominant Competitive Open Source Software Products. We have competition in Open Source Software at product category level (Linux versus BSD as OSS Operating Systems) and distributor level (Red Hat versus Novell/Suse as Linux distributions). Like in any market, competition is good to innovation but if excessive can hamper long-term profitability.

3. Presence of Dominant Competitive Closed Source (Proprietary) Software Products. Here we have competition with Proprietary Software like Linux versus Windows, GIMP versus Photoshop, MS-Office versus OpenOffice. Resources like

advertising, sales force, public relations, interactions with the large corporations, mainly from the major Proprietary Software companies, make it very hard to compete with them.

4. Relative Competitive Position. In short, if the software is innovative enough, the chances of winning are bigger. By freeing the software it's hoped that innovation occurs but that only happens if it attracts many developers.

For the success of any Open Source Software business model is crucial an engaged and self-supporting user community that benefits almost every business function of the company like sales, marketing, community support, innovation or support costs. As such, an Open Source Software company must create and sustain this community, a business function frequently non-existent or neglected in traditional software companies (Riehle 2009).

2.8.6. Competition between Open Source and Proprietary Software

Mustonen (2003) studied the competition between a closed source profit monopolist standard and a substitute Open Source standard with the consumer making the evaluation of the different standards characteristics. Mustonen (2003) considered an 'implementation cost' over the licensing price equal for both standards and also assumed a large population of software developers who can choose to work for the monopolist receiving a wage or using its personal free time to developing Open Source projects.

A game theory model was applied. The model analyzed the influence of competition to attract the best developers and competition from a substitute standard that is freely available has on a monopolist strategy. The author concluded that the Open Source

Software have higher success probability the lower the consumers' implementation costs. If the implementation costs are sufficiently low, in equilibrium some consumers will choose the Open Source Software. The monopolist when choosing the price will take this in account and will not be able to apply full monopoly power price in the market.

Bonaccorsi and Rossi (2003) in their research about competition between Open Source and Proprietary Software concluded, in agreement with the existent, literature that in the IS market there are network effects and lock-in but that both this effects can be surpassed. They also consider that if there exist consumer's heterogeneity and local network effect, as showed by Dalle (1997), and the switching costs to a new standard are not very high, it will be possible that the new Open Source standard can win over the incumbent proprietary standard. Bonaccorsi and Rossi (2003) concluded that even if there is a network effect grounded on the number of users that benefits the incumbent standard, the Open Source Software has a kind of "indirect network effect" based on the legal and legitimate access by the Open Source users to a large number and variety of free applications.

Availability of Open Source Software rise with the Open Source developers' number and will be the relation between these two effects, the network effect of the incumbent standard and the "indirect network effect" of the Open Source Software availability that will influence the market in the direction of one or other standard. The market analysis must take also in account that the incumbent standard will react to the competitive pressure by rising Research and Development budget and improving the quality of the incumbent proprietary standard. Considering all this factors, several results can happen in the market, even the possible coexistence of the incumbent proprietary standard and the Open Standard.

Varian (2003) studied different competition environments in different IS market. He compared the software and hardware industry to point out the difference between markets with competition between proprietary standards and competition between open standards and concluded that usually one company dominate the market in the first case and that all companies in the market are more interconnected and interdependent in the second case, with no dominant company in the market.

Lin (2004) analyzed the market evolution when exist competition between an incumbent proprietary standard and an Open Source standard, with consumer’s heterogeneity. Its conclusions go in the same direction of the other research showed above, but with two further conclusions:

1. If there exists shortage of human resources with experience and skills to implement Open Source Software solutions, the cost of the implementation of this free software is high allowing the incumbent proprietary standard to keep high prices and don’t be too much affected in is profitability by some fall of market share, fall that can be attenuated by the network effect that the incumbent standard has;
2. With the rise of human resources with experience and skills to implement Open Source Software solutions, the global cost of these solutions will fall, rising the competitive pressure on the incumbent proprietary standard that will lower the price to keep competitive in the market.

If the company that own the incumbent proprietary standard make price strategic decisions to keep or recover market share while trying to keep the profitability and the network effect of his standard, the Open Source Software will have more difficulties to win over the market and implement his standard as the new market standard. If the only Open Source Software advantage is low price, it will be more difficult to Open Source achieve success in the market. As a result, in markets with network effect and in the long term the Open Source Software will succeed only if it has better relevant features and functionalities to the consumer than the incumbent proprietary standard.

In a research about the user acceptance of Open Source Software, focused Linux, and applying the Technology Acceptance Model (1989), Gallego and Luna and Bueno (2008) concluded that to stimulate the use of OSS, organizations and users would have to select OSS which is useful and easy to use and that they should consider criteria as software quality, systems capability and software flexibility in OSS selection, conclusions that go in the same directions than the conclusions of the above research.

Bessen (2005) while also studying the features of Open Source Software concluded that Open Source Software has advantage on markets with heterogeneous customers, because they can customize it to meet their own particular needs while Proprietary Software only can be commercialized in some pre-defined versions.

Economides and Katsamakas (2006a) while studying the competition in the Information Systems market consider that the competition must be analyzed in both, platform market and applications market, but additionally in the combined interaction across these markets where companies can have a two-sided pricing strategy, for the platform and the application. If the platform is Open Source Software it's assumed that is free for end users and also for the application providers. The application providers can sell their applications or the services around the applications and even subsidize the OSS platform as a way to improve their application sales.

The authors concluded that when the platform is PS, the equilibrium prices for the platform, the applications, and the platform access fee for applications may be below marginal cost because the pricing strategy considers all this components, like also happens in the videogames industry. The proprietary applications sector of an industry based on an OSS platform may be more profitable than the total profits of a PS platform industry. The authors also concluded that if users have a strong preference for application variety, the total profits of the proprietary industry are larger than the total profits of an industry based on an OSS platform but the variety of applications is larger when the platform is OSS.

If a vertically integrated system based on an OSS platform with an independent proprietary application competes with a PS system, the PS system is likely to dominate the OSS platform industry both in terms of market share and profitability. This conclusion maybe explains the dominance of Microsoft in the market for PC operating systems.

Lerner and Tirole (2004) studied the way a commercial company (Proprietary Software supplier) can work and compete with Open Source. They see 3 ways of doing it:

1. By selling complementary products and services of the Open Source Software; they can also encourage their own developers to work in Open Source projects, to learn about the strengths and weaknesses of the Open Source development;
2. By competing directly in the market with Open Source Software;
3. By interface with the Open Source world because "it generates good public relations with programmers and customers."

Dalle and Jullien (2002) considered that Open Source Software can have success if there is a good organization behind it and that is more difficult in Open Source voluntary communities that have more difficult in organize to achieve competitive power. Compatibility issues and customers different profiles also were considered to have strong influence over the success probability of Open Source Software.

Gaudeul (2004) while studying the competition between Proprietary Software and Open Source Software found that each model has his own strengths and weaknesses. Open Source projects can have lack of coordination. In Open Source some kind of software can be developed several times or never, and sometimes the attention to user interface smaller. In Proprietary Software is important to have a good interface but even with coordination the developers choose the features that software can have, or not. Because the Proprietary Software business model is in licensing selling, people or organizations with lower purchase power sometimes cannot have that software.

Riehle (2007) studied the economic motivations of Open Source Software in his competition against Proprietary Software analyzing the point of view of different stakeholders. To this author several stakeholders have economic motivation in choosing Open Source Software and we can consider these motivations as a competitive advantage in the competition of Open Source Software against Proprietary Software:

. System Integrators or Solution Providers gain from using Open Source Software because of the costs cutting and more price flexibility (Riehle 2007). The money that their customers don't spend in licenses can be used in services from the System Integrator when they sell "a stack of hardware, software, and services as one product", so they can define price of the "one product" in a more flexible way.

. For the Software Vendors things work in a different way. For the Proprietary Software vendor the investment (development, marketing, etc.) came from the selling of first copy, and then as further copies are made the profits will rise. In mature markets the software the barriers to entry in Proprietary Software are higher and usually the market has a dominant company that set a price that maximize profits. This price isn't based on the actual cost incurred to develop, maintain, and provide the software, only at least to cover these costs. In Community Open Source on other hand everybody can start a company, enter in the market and start to sell the provision, maintenance and support of the software. Without barriers to entry and near the perfect competition, the price set by these companies is mark-up over cost and this mark-up cannot be very high because of the fierce competition. The costs of developing software are lower because they are divided between all that contribute to the development of the software. The risks of compete against a Proprietary Software leader are also lower so anybody can try it.

Riehle (2007) also considered 2 situations where the CEO of a software company will want to Open Source is software:

1. Proprietary Software not market leader: business will maybe go only to smaller niches of market. The alternative is to open source the software, go to an Open Source business model and receive the benefits of having the software also debugged and improved by the Open Source community, including system integrators, customers, and software vendors;

2. Proprietary Software market leader: When there is fear that competitors will open source their software and/or system integrators will recommend open source software, the proactive answer would be for even the leader to open source is software because even if the profits are larger with Proprietary Software, they can disappear if the leadership is lost.

To this author in any case Open Source Software is sustainable but recognizes that by patents, customer lock-in and similar strategies can the Proprietary Software leader keep is position for long years.

Regarding the several vectors of the competing strategies Campbell-Kellya and Garcia-Swartzb (2010) concluded about the convergence of competitive strategies between OSS and PS companies including production approaches, business models, and strategic interactions. The authors found leading OSS companies investing in R&D (as a contribution to the OSS community and to increase the trust of their costumers showing commitment to their products), making acquisitions (to allow a larger offer by acquiring products and developers to their own company) and mixing in-house development similar to PS companies with code contributions from costumers and consultants. The dual licensing plus price discrimination allow OSS companies to have licensing revenues as the PS companies and the capture of costumers that don't want software with a GPL license. At same time their strategic actions are less based on the OSS versus PS business model but simply as a software company competing in the market.

2.9. Empirical research in the Network Economy

After the fundamental research on Network Economy was presented, with concepts like network effects, path dependence, lock-in, etc., several empirical research papers start to be published, of which we present some of the most cited in Table 5, as an example. The majority of this works focused on the impact of the network effects on the markets development and competitive positioning of the companies on these markets.

The methodology of the works presented in Table 5, similar to the methodologies of the majority of the published research in this field, can be separated in three categories. More than half of the research is grounded on different categories of regression models. The other research is divided between economic theory models and case studies.

The methodology applied in this thesis, as detailed in the following chapters, will be a mix between statistical tools to analyze IS consumer data and Soft Systems methodology to study other subjects of this thesis like business models in the software industry and innovation in Open Source Software versus Proprietary software.

Table 5. Empirical research

Market	Research subject	Methodology	Authors	Year
Spreadsheet	Existence of Network Effects	Regression Models	Gandal, Neil	1994
ATM attractiveness	Existence of Network Effects	Standard Duration model. Weibull results versus Cox partial-likelihood and log-logistic forms estimates.	Saloner, Garth and Shepard, Andrea	1995
Spreadsheet	Existence of Network Effects	Hedonic Regression Models	Brynjolfsson, Erik and Kemerer, Chris F.	1996
US Telecoms market	Network Effects and new technologies adoption	Regression Models	Majumdar, Sumit K. and Venkataraman, S.	1998
Information Technology	Path dependence and lock-in concepts discussion	Case Study	Liebowitz, Stan and Margolis, Stephen E.	1998
Electronic Money	Existence of Network Effects	Economic Theory Models	Van Hove, Leo	1999
Java and Internet	Standardization and Network Effects	Case Study	Menkhoff, Ralf	1999
World-Wide Web	Existence of Network Effects and WWW value	Economic Theory Models	Windrow, Paul and Swann, G. M. Peter	1999
Banking	Existence of Network Effects	Hazard modeling and Weibull modeling, likelihood function	Kaufman, Robert and McAndrews, James and Wang, Yu-Ming	2000

Table 5. (continuation)

Market	Research subject	Methodology	Authors	Year
Microsoft anti-trust	Network Effects influence on anti-trust case	Case Study	Economides, Nicholas	2001
PC buying	Non-detection of Network Effects	Multinomial Logit (MNL),Generalized Extreme Value (GEV) model, Bass Model, Regression Models	Tam, Kar Yan and Hui, Kai Lung	2001
Information Technology	Network Effects influence on competition	Economic Theory Models	Clements, Matthew T.	2002
Web Servers	Existence of Network Effects	Hedonic Regression Model, Factor Analysis	Gallaugher, John M. and Wang, Yu-Ming	2002
Information Technology	Innovation, Network Effects and Lock-In	Economic Theory Models	Lee, Jongseok and Lee, Jeho and Lee, Habin	2003
Videogames	Network Effects and competition	'New empirical industrial organization' regression models	Shankar, Venkatesh and Bayus, Barry L.	2003
DVD players	Strategy with indirect Network Effects	Regression Models	Karaca-Mandic, Pinar	2004
Personal\Digital Assistants (PDA)	Existence of indirect Network Effects	Regression Models	Nair, Harikesh and Chintagunta, Pradeep and Dubé, Jean Pierre	2004
Mobile Telecommunications	Network Effects and regulation	Case Study	Crandall, Robert W. and Sidak, Gregory J.	2004
Telecommunications Industry	Network Effects	Case Study	Church, Jeffrey and Gandal,Neil	2004

Table 5. (continuation)

Market	Research subject	Methodology	Authors	Year
Peer-to-Peer Music	Network Effects	Regression Models	Asvanund, Atip and Clay, Karen and Krishnan, Ramayya and Smith, Michael	2004
Software Piracy	Network effects	Case Study	Katz, Ariel	2005
Word Processing	Network effects	Hedonic Regression Model	Chakravartya, Sujoy and Dogana, Kutsal and Tomlinsonb, Nels	2006
Electronic Inter-organizational Systems (IOS)	Network effects, switching costs, path dependency	Structural Equation Models	Zhu, Kevin and Kraemer, Kenneth L and Gurbaxany, Vijay and Xu, Sen Xin	2006

2.9.1. **The IS market**

Beside the theory fundamentals and the empirical research about specific aspects of the IS market, Bresnahan and Greenstein (1999) and Bresnahan (2000, 2002, 2002a) studied since the late nineties of XX century the global IS market with an epistemological Critical Realism point of view. Considering some difficulties that econometric methods had while testing the theory, they used mainly all the documentation about the development of the market or anti-trust cases like US versus Microsoft to analyze how reality in the IS market was against the theory framework about that market.

Bresnahan concluded that “analysis strikingly similar to the theory, including not only the main implications but also key analytical distinctions, guides business decision making” used in the IS market.

Bresnahan and Greenstein (1999) and Bresnahan (2000, 2002, 2002a) also introduced some new analysis concepts that are very useful for the empiric analysis of the IS market. One of them was “’Divided Technical Leadership’, the supply of key platform components by multiple firms...”. “… Divided technical leadership is inevitable in the current computer industry and divided technical leadership makes entry easier.” Following that they conclude that this has impact over the competition.

With the network effects influence in the market, it can lock-in in some standard benefited from direct and indirect network effects and even superior standards can be locked-out. For the benefited standard is enough to make improvements from time-to-time do avoid a big technological distance from the new standard, to lock-out this new standard from the market.

But in the case of the complements, new innovative complements can gain a large market without needing to fight against existing network effects, so can be disruptive by entering in a way that substitutes cannot because of the network effects. Divided technological leadership is created.

When we analyze complements we must see how the IS market is studied by Bresnahan (2002, 2002a), as market with several layers and even when in some layer there is lock-in, the other layers can be disruptive enough to be a threat to the company that benefit the network effects a certain layer. To this author when studying this market we can consider layers like the presented on the Table 6, considering the recent market situation.

Complements can influence markets ending lock-in positions in four different ways (Bresnahan 2000)

1. Weakening entry barriers given consumer choice where before choice didn't exist;

2. If a complement reaches high distribution because of new technological advances, it can be the beginning of leapfrogging competition leading the market to new and more valuable technological base with new network effects;

3. Competition set off by a complement can take root quickly while direct competition in same layer are more difficult to achieve due the network effects, positive feedback and lock-in;

4. The choices opened by rivalries between partners offer opportunities for consumers to influence the direction of the technological progress, rare if the network effects and lock-in prevails.

As an example, what was the biggest fear of Microsoft in the mid 90's? Not from any direct competitor, a substitute of Windows, because Windows was benefited by strong indirect network effects that locked-in the market. But the browser Netscape Navigator, that reached easily domination of the browsers market plus the new Sun Java language that was multi-platform and adapted for the Internet, was seen by Microsoft not only as complements but also as possible future substitute of Windows, with their network effects benefits in other layer. Microsoft was afraid that developers started to develop mainly for the multi-platform "Navigator plus Java" and users could start using mainly the browser and applications running of the browser, with the traditional Operating System becoming less important in the new technological infrastructure. That was the reason why Microsoft adopted strategies to eliminate Netscape Navigator and Java from the market. Is not in the objective of this thesis to study how these things happened or the anti-trust action that followed, described with detail in papers like Buchanham (2002a). By result of Microsoft strategy, condemned later on in the anti-trust action, Netscape and his browser were put out of market and Java on the client side was also almost completely defeated.

This was a situation of Divided Technological Leadership, in this case Microsoft in the Operating Systems market layer, Netscape in the browsers layer and Sun Java in the languages layer (considering languages best adapted to Internet development). The competition against Microsoft was not from another Operating System but from the union of a browser plus an Internet language, as a possible replacement of an Operating System. This showed that the competition may come not from a direct substitute but from innovative complements.

Against this kind of threat, one of the strategies can be to integrate the layer where the company has a strong dominating locked-in position with the layer from which the threat came, as Microsoft did by integrating the browser in the Windows. With that almost automatically the market share of the Microsoft browser achieved a dominant position that was allowed by the Windows dominant market share.

Table 6. Market layers

Technology	Brand
Processors	Intel, AMD, IBM, Motorola, RISC, …
Computers(desktops, notebooks, servers)	Acer, Apple, Asus, Dell, HP, IBM, Sun, Toshiba, …
Operating Systems	Linux, MacOS, Unix, Solaris, Windows,…
Browsers	Google Chrome, Mozilla Firefox, Microsoft Internet Explorer, Apple Safari, ...
Languages	Basic, C++, Java, Perl, Python, C#, ...
Office Suites	Microsoft Office, OpenOffice, WordPerfect Office,…

In general terms, Divided Technological Leadership improves the global competition in two ways: (1) companies in one layer encouraging entry and epochal change in another layer and (2) rivalry at layer boundaries (Bresnahan 2002). As the first case we have examples like Intel sponsored Compaq entry in 1986 with the 80386 computer, undercutting IBM market power as Intel client. Sometimes companies in one layer try to enter the other by using the leverage provided by the domination of the *origin layer, like Microsoft entry in the word processor market against WordPerfect following the shift from DOS to Windows. This situation can preclude competition when the dominating company in one layer also can dominate the other layer, like happened with Microsoft with Windows and Office Suite.

A company in one layer can also prevent exit of a company that it's not leader in other layer to avoid that the other layer become dominated by the market leader company. Microsoft helped this way AMD against Intel and also keeps supplying MacOS with Mac versions of Internet Explorer and Microsoft Office (MS-Office), critical applications for the MacOS survival. In the last case it was of interest of Microsoft to keep some competition in the Operating Systems Market. If MacOS disappeared, Microsoft could have even more problems with anti-trust authorities because of almost absolute domination of the desktop/notebook Operating System market without competition in sight.

Divided Technological Leadership also helps in the competition between epochs because of the new technical capabilities or "extensions" of complements that are rivals between then with that rivalry extending to other layers. As an example we have the user interfaces of Operating Systems versus applications like word processors and spreadsheets, and more recently browsers.

Without Divided Technological Leadership we have the same company dominating several layers and the slowdown of competition and innovation in the market. With disruptive changes in other layers it's possible to have competitive pressure on layers that were almost completely impermeable to that pressure if coming from inside the layer because of the network effects and positive feedback. The browsers were a more dangerous competitor to Windows than any other Operating System.

Because innovation is one of the critical aspects of the IS market, we see that Divided Technological Leadership (DTL) has advantage over Unified Technical leadership. In the first one we have a better offer of distinct alternatives to consumers, "extension" or epochal shifts that can replace existing dominant products.

We see that by the impact of the browsers in the other layers and also in the near monopolistic Operating System layer, with the more recently Google Chrome. This browser with several other browser applications like Google Docs is a serious threat to Windows application (Blodget 2008). This threat is because "…if Google executes the strategy well, the major remaining advantage of Microsoft Office--rich desktop and device functionality--will eventually disappear, and Windows will become unnecessary. Not good news for Redmond."

In the Unified Technical Leadership (UTL), the some company dominating all the layers, we have slow technical advances while ensuring that new components in different layers work well together, offering limited opportunities of customer choice.

The disadvantage of DTL regarding layers coordination is mitigated by strong network effects that push towards coordination and unification. If DTL allow uncoordinated technical progress that allows different experiences, once consumer choices start to show up the progress is quickly coordinated through communication and coordination mechanisms between companies, especially to take advantage of network effects. So there is no need of direct management of the innovation and coordination because market forces achieve much of the task of coordination.

2.10. Summary

In this second chapter, we presented the literature review considered relevant for the thesis objectives regarding the IS market characteristics and the main influencing factors on the market evolution.

After the introduction, we started with the literature review by presenting the modeling of the network effects in the network economy that is constituted by markets with the called "network products".

The third point was about standards and the different ways in which the standards are created in the IS market, the advantages and disadvantages of the standards existence and their impact in the evolution of the markets.

The fourth point is about influencing factors in the consumer choice of IS standards and factors that inhibit their switch from incumbent to alternative standards. Switching costs are always considered in the consumer choices that can be locked in inferior standards due to a set of circumstances.

The fifth point discusses the concepts of Path Dependence and Positive Feedback and how first and sometimes casual technology choices can later on influence the standards choices and by that way the standard that can win in the market.

The sixth point is about how standards compete in different markets, the factors relevant in that competition and how standard compatibility decisions can influence standards decisions made by the suppliers in the IS market.

The seventh point is about the latest trends in standards definitions including coopetition in the market, how generations influence standard choices, public policy and consumer behavior research focused in this field of research.

In the eight point is introduced the concept of Open Source Software as a new trend in the software markets. Motivation, organization, innovation and business model of Open Source Software are discussed, as are the competition conditions of Open Source Software in markets with an incumbent Proprietary Software.

Point nine make a review of some of the main empirical research that was made after the development of the theoretical bases of this recent research field, including the different forms of analyzing the software market.

III. Research models and hypotheses

3.1. Introduction

The research design of this thesis will include the needed steps to fulfill the thesis objective. The thesis objective is the study how the IS market is created and develop, influenced by factors like network effects and the decision process of consumers and suppliers in the market.

The more objective goals are the analysis of the consumer decision influence factors in these markets but also the analysis of the supplier side of the markets, the way the companies see their degree of innovation but also their surviving prospects considering that the IS market is very competitive.

These objectives will be achieved with two different research methodologies, the Soft Systems Methodology and statistics analysis.

3.2. Research model and hypotheses (supply side of the market)

Towards answering the research questions raised in the literature review some hypotheses will be introduced that are the assumptions from which the research will develop.

When we analyze the Open Source Software and Proprietary Software business models, several aspects must be considered, like human resources availability and attractiveness capacity of that human resources, development model, innovation capacity, viability and survivability of each business model and also the competition capacity and innovation capacity of them.

3.2.1. Development model and innovation

Since software production is based in skilled human resources, when analyzing Open Source Software against Proprietary Software the first question to ask is how Open Source Software communities can attract skilled developers that allow the supply of that kind of software to the market and whose collaboration with OSS companies is crucial for the later (Riehle 2009)?

If Open Source Software "bazaar" philosophy (Raymond 1999) is based on a community of Open Source developers that contribute mainly without monetary rewards to Open Source Software projects, how can they be motivate to keep contributing and by that way allow the maintenance of this software development model?

To several researchers this is possible mainly because Open Source Software developers feel motivated by the reputation between peers. Raymond (1999, 2001) considered this "reputation game" and also the impact of it on "real live" through job offers for Open Source developers with best reputation, for instance. Lerner and Tirole (2002) add the learning and skills obtained through Open Source projects and also the pure enjoyment of participation and developing software. They developed further this concepts by considering that for some developers is "cool" to develop software to Open Source projects and not being a simple employee and also that "…that may lead to future job offers, shares in commercial open source-based companies, or future access to the venture capital market, and last (but not least) ego gratification from peer recognition" Lerner and Tirole (2004). Bonaccorsi and Rossi (2003) saw three main motivation reasons developers considered to work in Open Source projects: intellectual gratification, programming for Open Source projects seen as an "art form", and finally "programmers frequently rediscover the pleasure of creativity, which is being progressively lost in the commercial world where the nightmare of delivery deadlines is transforming production into an assembly line" (Haruvy, Wu and Chakravarty 2004) also saw as main motivators self-fulfillment and future monetary rewards, as researchers like Raymond (1999, 2001) did, but also social considerations as motivation for participation in Open Source projects. Hann et al. (2004) considered that participation in Open Source projects is motivated by long term benefits because "results suggest that status within an open source meritocracy operate as a credible signal of productive capacity" and with that, increase the potential for higher wages. Riehle (2007) developed this concept introducing the definition of "committers" to Open Source Software projects considering that the most prominent of them are in a more advantage position to choose the place to work and ask for higher wages.

So we can have an almost inexhaustible pool of human resources to contribute to Open Source Software communities projects, even as these projects get more professionalized and more founded and also developed on professional companies in the market. But even with this "almost inexhaustible pool of human resources", are they organized in a way that allow the permanent offer of new innovative software with quality to be well received in the market?

The main problem of Open Source Software projects as seen by several researchers is the coordination and cooperation of the developers that contribute to it. Cusumano (1992) saw the problem in the voluntary character of Open Source projects, while Lakhani and Hippel (2003) concluded that because Open Source Software developers value the control over their work, coordination is more difficult. Bonaccorsi and Rossi (2003) considered that coordination is not necessary for the development of complex projects and have a negative impact over the motivations of the Open Source Software community of developers. But a study by Healy and Schussman (2003) showed that the main and more complex Open Source Software projects have more professional contributors at core with strong project leader and a hierarchical coordination not very dissimilar from the Proprietary Software projects. Jordan Hubbard (2000) also concluded that "successful "bazaar" development models often reveal a fairly significant degree of centralization".

From the research presented we can consider that not only Open Source Software communities can attract skilled developers for motivation reasons beyond the monetary reasons, even if indirectly connected to them, but the Open Source Software development model is seen at least as productive as the Proprietary Software model. From these conclusions we can make the first hypothesis.

Hypothesis 1s: Not only the Open Source Software business model is viable considering the capacity of attraction of the needed skilled developers, but also his software project development model is as capable as the software project development model of Proprietary Software, to which the Open Source model approach as the software projects get more complex and professionalized.

Regarding the innovation capacity of Open Source Software and comparing with the Proprietary Software Model, Hippel (1998) saw advantage on Proprietary Software projects due to the availability of financial resources to better make consumer research and find the features consumers want and value in software. Dalle and Jullien (2002) saw advantage in the development and innovation of Open Source projects because of the users are also developers and there exist delays in improvements in Proprietary Software for commercial reasons and because companies lower R&D when in monopolistic positions. Hippel and Krogh (2003) considered the innovation motivation of the Open Source Software as “an exemplar of a compound ‘private-collective’ model of innovation that contains elements of both private investment and collective action models and can offer society the ‘best of both worlds’ under many conditions”. Haruvy, Wu and Chakravarty (2004) concluded the same as Hipper and Krogh (2003) and that self-fulfillment achieve through recognition and praise for creative work and also social considerations play an important role in software innovation. Ulhøi (2004) saw the knowledge sharing as an important factor behind many important innovations, including the innovation in Open Source projects. Hippel (2005) developed his research beyond the results of 1998 (now that many Open Source Software projects have financial support from big IS companies) and considered that these projects are based on user innovation networks with the benefits of sharing the innovation. Maintaining that commercial companies are “the more logical organizations to innovate, they have financial incentives of profiting from their innovation and also have the resources to production, distribution, support”, Hippel (2005) also concluded that innovation also happen in user networks. Economides and Katsamakas (2006) studied the innovation incentives in applications and platforms Proprietary and Open Source not finding definitive results regarding differences in innovation investment in Operating Systems, but a higher investment in the applications development when the Operating System is Open Source, if both Operating Systems are similar in quality.

We can consider that the innovation process, while different in Open Source Software projects (less coordinated, with more knowledge sharing and supported by innovation networks) can be at least as efficient as the more hierarchical, closed and financial founded innovation process in the Proprietary Software projects, even when as the Open Source projects gets more complex, professionalized and also supported by big hybrid companies (Open Source Software and Proprietary Software offer). From this we have a second hypothesis.

Hypothesis 2s: The Open Source innovative process can be at least as productive in creating innovation and introducing it to the market as the Proprietary Software innovation process.

3.2.2. Business model and competition

One of the main differences between Open Source Software business model and Proprietary Software business model is that in the first case the licensing is free; a company cannot make money from selling Open Source licenses, while can make it from selling Proprietary Software licenses, with Microsoft as the best example.

Considering this, can we assume that exist a viable business model that can assure the survival on the market of companies working only with Open Source Software?

Raymond (1999) and Schiff (2002) analyzed several business models that allow the survival in the market of a company developing or just working with Open Source Software. Koenig (2004) also studied seven business models he considered as the more common in the market with companies that worked in different ways with Open Source Software. Krishnamurthy (2005) developed this analysis by considering several ways that companies can work in the market with Open Source Software but also the different kind of software segments that can be reached with different software applications. Krishnamurthy (2005) and Hawkings (2004) concluded that the software suppliers have several advantages in working with Open Source Software in the market and also by

Open Sourcing the software still Proprietary. Phipps (2008) also considered that to lower the risk of adopting Open Source Software by consumers (mainly organizations), an Adoption Lead Business Model, where only after testing the software the user organization will decide if want to make a service contract with the Open Source Software supplier and by that way become their customer, is the best way to attract new customers.

If there are several business models to work with Open Source Software in the market, that allow companies to have financial revenues and survive in the market, even when working with free software licenses, we can make the third hypothesis.

Hypothesis 3s: Even if the Open Source Software licenses are free, Open Source Software has costs at least for some of the consumers that want to use it.

But if several business models were considered as different options for companies working with Open Source Software (and by that way implying that the Open Source Software, while having free licensing, is not really free of costs to many kind of customers), can these companies compete against companies working with Proprietary Software, that enjoy the benefits of monetary reward by selling their licenses?

Several researchers studied the competition between Open Source Software and Proprietary Software (usually the last one seen as the dominant incumbent, as happens when we consider Windows+MS-Office versus Linux+OpenOffice), considering that this markets have the influence of network effects, switching costs, etc. Several factors have influence on the success probability of Open Source Software in the market, like the implementation costs of the software Mustonen (2003) or the degree of market heterogeneity, the level of switching costs and the indirect network effects (access to free Open Source applications) Bonaccorsi and Rossi (2003). While considering that in

Proprietary Software markets usually one company dominate, Varian (2003) don't exclude the possibility of Open Source Software enter in the market and obtain success. Lin (2004) considered that as technical human resources are more available in Open Source Software lowering implementation costs, the competition between Open Source Software and Proprietary Software will be based on the relevant features and functionalities to the consumer.

Bessen (2005) see the customization of Open Source Software as a competitive advantage against Proprietary Software when markets are heterogeneous. On other hand one of advantages of Proprietary Software, if vertically integrated and dominating the market with more applications available and more demand for the Operating System, is the capacity of "coordinate the provision of the platform and its applications through appropriated pricing that internalizes the network effects", as Microsoft does with Windows and Office (Economides and Katsamakas 2006a). In this case is more difficult for Open Source to compete and have gains of market share in that specific software market, even if switching costs to Linux are zero. Dave and Julian (2002) considered that organizational aspects also very influential of the competition in the market, so we can expect more competition as Open Source Software organizations are more and more professionalized and big companies like IBM or Sun embrace Open Source. Also Gaudel (2004) considered the competition between Open Source Software and Proprietary Software possible because each model as his strengths and weaknesses without any of them to have global advantage.

Krishnamurthy (2005) also considered Open Source Software as competitive in the market, with is advantages like robustness, flexibility to user and support from the developers community but also some disadvantages like version proliferation or usability. Riehle (2007) concluded that the economic motivations for the choice of Open

Source Software for several categories of IS solutions in the market are a competitive advantage of Open Source Software in his competition against Proprietary Software. Lerner and Tirole (2004) considered that organizations can compete in the market with Open Source Software by selling solutions around it, developing and selling complements or just by connecting with the Open Source community as beneficial for his offer and also public image in the market.

As we see the different business models assume the capacity of Open Source Software to compete against himself and also against Proprietary Software even when dominant, as happens in markets like Operating Systems or Office Suites for personal computers. Also several researchers, while studying the competition between this two software models, consider that the competition is possible with gains for Open Source Software even if specific advantages of Proprietary Software as dominant incumbent in some markets make the competition more difficult to Open Source Software.

Considering that factors like quality and security are important factors in a competitive environment like the software market, Kuan (2001), Raymond (2001), Anderson (2002 and 2005) or Johnson (2006) concluded that Open Source Software and Proprietary Software are similar in these factors, while other researchers considered that the Open Source Software development model has some advantages.

We can conclude that from the consideration of different factors that influence the competition in the market, that Open Source software is capable of compete against Proprietary Software even when the market position benefits the last one. From this we make the fourth hypothesis.

Hypothesis 4s: Open Source Software can compete in the market against Proprietary Software and even compete and obtain market gains when Proprietary Software is the dominant incumbent.

Research question 2 will be answered through Hypothesis 3s while research question 3 will be researched grounded on the Hypotheses 1s, 2s and 4s.

3.3. Research model and hypotheses (demand side of the market)

As showed in the literature review, the IS market has some different characteristics that were subject of a different kind of research that was globally called later on as the Network Economy research field. From this research we saw that new and different factors have influence on the consumer's choices when they choose products and services in these markets.

It's possible to make several hypotheses from the literature reviews that cover the several factors that have influence on the consumer's choice including direct and indirect network effects (Katz, Shapiro 1985), (Economides 1996); switching costs (Farrel, Saloner 1985, 1986), (Klemperer 1987), (Langlois, Robertson 1992); weak and strong lock-in (Farrel and Saloner 1985, 1986), (Liebowitz and Margolis 1990, 1994, 1995a), (Liebowitz 2000); local network effects (Dalle 1997); the image of the suppliers in the market (Liebowitz and Margolis 1996); the features of alternative choices (Liebowitz and Margolis 1996); the implementation costs of software alternatives (Bonaccorsi and Rossi 2003) or the heterogeneity of the consumers (Dalle 1997).

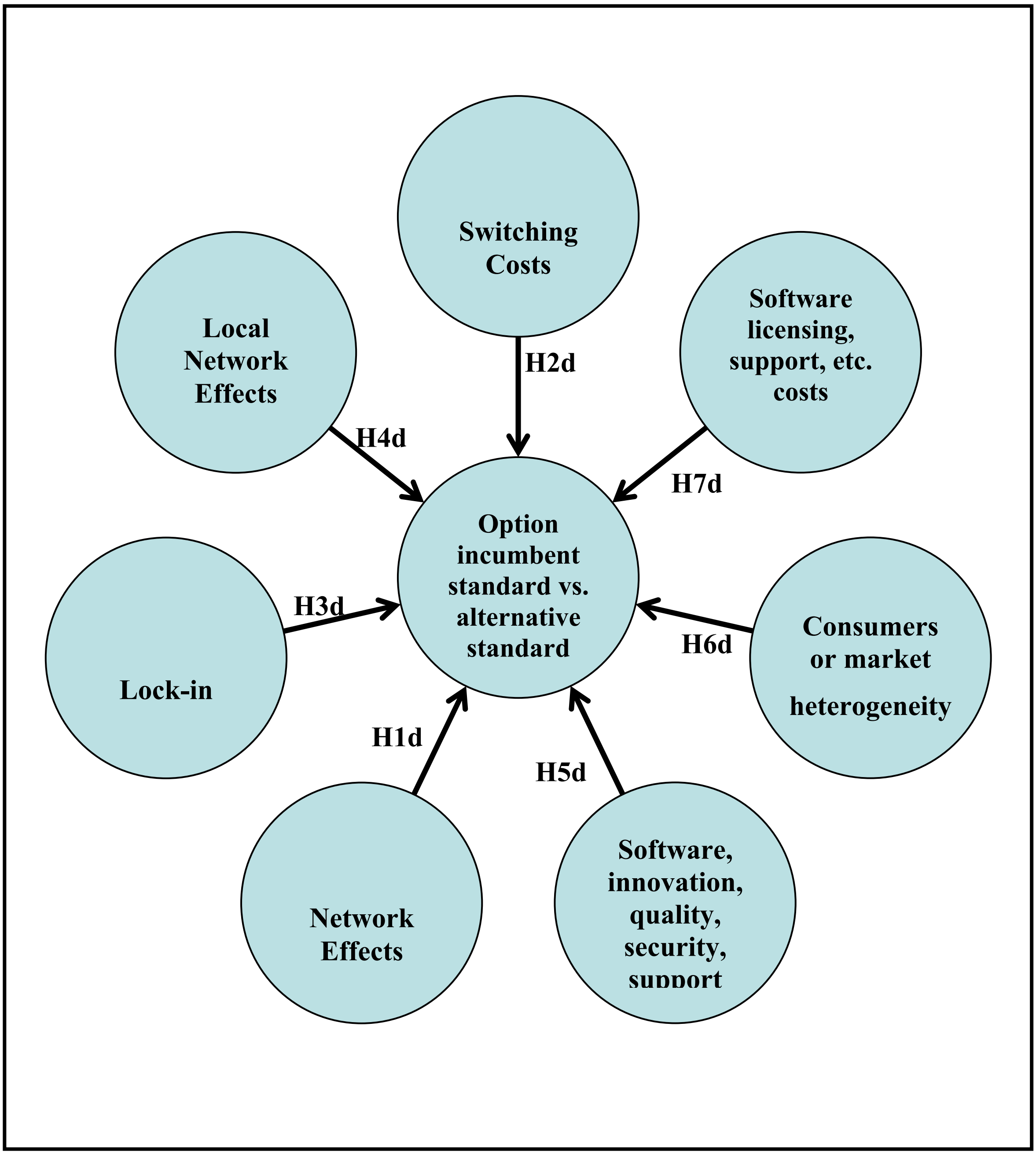
The seven hypotheses showed in Table 7 will allow the research of the factors that influence the consumer decision in this market, as presented in question 1.

Table 7. Demand side hypotheses

H1d	The higher the network effects in the market *(Katz and Shapiro 1985), (Economides 1996), ...*	Lower probability that the consumer will choose the alternative standard against the incumbent standard
H2d	The higher the switching costs in the market *(Farrel, Saloner 1985, 1986), (Klemperer 1987), (Langlois, Robertson 1992), ...*	
H3d	The higher the lock-in weak and strong *(Farrel and Saloner 1985, 1986), (Liebowitz and Margolis 1990, 1994, 1995) (Liebowitz 2000), ...*	
H4d	The higher the local network effect in the market *(Dalle 1997), ...*	
H5d	The better the perception regarding innovation, quality, security, support, etc. of the incumbent standard (*Liebowitz and Margolis 1996*) , ...	
H6d	The higher the heterogeneity of the consumers (the lesser the network effect) *(Dalle 1997), ...*	Higher probability that the consumer will choose the alternative standard against the incumbent standard
H7d	The lesser associated costs to adoption of the alternative standard (licensing, support, training, compatibility, etc.) *(Bonaccorsi and Rossi 2003),* (*Krishnamurthy 2005), ...*	

Based on the hypotheses of Table 7 we modeled in Figure 1 the relationship between the different factors that influence the consumer choice between the incumbent and alternative standard to answer to question 1. A further research development, the development of metrics regarding the consumer choice process studied will be made if the collected data allow that in statistical terms.

Figure 1. Demand side research model



3.4. Summary

In this chapter the supply side and demand side of the software market were analyzed with presentation of hypotheses that cover the main theoretical bases of this research field. The supply side software research model, including software development and innovation and also the business model and competition, comparing Open Source Software and Proprietary Software are the vectors from which the hypothesis about the supply side of the market were made.

On the demand side of the market there is a set of theoretical research that showed different factors that have influence in the software choices of consumers regarding brands, standards, and also between Open Source Software and Proprietary Software, that are software products originated from two different software development philosophies and business models.

IV. Research methodology

4.1. Introduction

We will now study the epistemological philosophies and research methodologies considering the subject of study of this thesis, the IS market from both points of view, supply and demand. Could the research of both sides of the market be analyzed in the same ontological way and use the same epistemological philosophy?

In this chapter we start by discussing the research philosophies that will be considered in the two-side market analysis and the choices made. Then the research questions will be present and detailed the research design and methodological steps to be taken considering both, the research questions and each of the market sides.

4.2. Research philosophy

We begin by considering the ontological aspects of the research, the researcher assumptions about the nature of the subject of the research (Caldeira 2000) and the assumed nature of an Information System (Iivrai, Hirschhein and Klein 1998). When considering the subject of this thesis, IS inside a social science environment, we can consider that it falls in these two ontological forms:

1. Realism, where we have the description of objective facts and human beings subject to causal laws (determinism) that can be measured in an objective way (Iivrai, Hirschhein and Klein 1998) and (Hirschhein 1992);

2. Critical Realism, that try to explain the relationship between human activity and social structures, that act in an independent way from the researcher (like Realism), but cannot be completely perceived in his totality but can be inferred and identified through the observation of their effects (Caldeira 2000), (Iivrai, Hirschhein and Klein 1998) and (Hirschhein 1992).

As a third ontological philosophy we have Relativism where it's considered that the reality is a subjective construction of the researcher (Iivrai, Hirschhein and Klein 1998) and (Hirschhein 1992) and the epistemological Interpretativism that consider that there is no structured reality but different realities that differ with the researcher point of view with the researcher as a part of that reality.

From the first two ontological philosophies we have two epistemological philosophies, positivism in the case of Realism, and a more "openness" in the case of Critical Realism (Caldeira 2000). Critical Realism "… is located between the positivist assumption that "there is a world out there" independent of our interpretations and the interpretative view that the reality is a mental construction" (Caldeira 2000).

We considered that the same epistemological methodology tools could not be used to study both sides of the market because we have different situations. On the supply side we have few representative elements of the population from which we need detailed opinions about their strategies and how they forecast the market evolution. On the demand side we have a large population from which we have a sample of the professional segment (companies) that will answer about their decision process regarding IS choices.

So what epistemological philosophy would we consider in this thesis? If we consider as the main philosophies perspectives in the research in social sciences

Interpretativism, Positivism and Critical Realism (Caldeira 2000, 2002), we have Critical Realism in the supply side of the market research and what we can consider as a Critical Realism approach while using Positivism tools in the demand side of the market research.

In the supply side we have Critical Realism that stays between Positivism and Interpretativism in epistemological terms. As we will see, by using the Soft Systems Methodology to study the supply side of the market, we are using a methodology that is dualistic in his epistemology, anti Positivist while studying social phenomena but also positivist with is role of learning about natural and technical phenomena as well (Iivrai, Hirschhein and Klein 1998).

Positivism says that the scientific investigation is the only way to reach the knowledge. In Positivism the scientist studies the phenomenon without interfering personally (Iivrai, Hirschhein and Klein 1998) and (Hirschheim 1992) and the objective is to study and forecast the social phenomenon and the causal relations between their elements. On the demand side when we collect data from the population sample through closed question questionnaires and make statistical analysis about to test the research hypothesis we are in a Positivism research perspective, even if the reality "cannot be completely perceived in his totality but can be inferred and identified through the observation of their effects", that is characteristic of Critical Realism.

4.3. Research questions

Based in the thesis objectives, literature review hypotheses, this thesis will collect and analyze data using different methodologies to answer the different research questions that are, as present before, the following:

1. Which factors have influence on the buying process decision and the option between Proprietary Software and Open Source Software in the IS market?
2. How likely are Open Source Software solutions to be free to the user?
3. Can the free licensing of software allow the Open Source Software suppliers survival and their innovation in the market?

4.4. First research question

The first research question was addressed considering a sample of companies with activity in Portugal.

4.4.1. Demand side sample definition and collection methodology

The companies sample was collected from several annual rankings of Small and Medium Size Enterprizes and Large Companies published by the main newspapers in database file format. The sample obtained considering the answers to the questionnaire was analyzed regarding the different indicators that characterize each respondent company, like sales volume, activity sector, localization (Portugal administrative regions (Norte, Centro, Lisboa and Vale do Tejo, Alentejo and Algarve)) and others that the empirical work considered relevant to the research, comparing also with the study "*Sobre as PME em Portugal*", IAPMEI (Feb 2008).

A pilot-experience was made to test the questionnaire easiness, using a sample of students of *Escola Superior de Comunicação Social* (ESCS), *Instituto Politécnico de Lisboa*, from graduation students of Advertising & Marketing, Journalism, Public Relations, Audiovisual and Multimedia, their ages mainly in the range of 18 to 22. They received the questionnaire and by filling and having some feedback about the answers we could analyze the "easiness" of comprehension of the questions.

Data collection methodology

From the samples definition defined below we collected the data by using two different methodologies:

. Students: Questionnaires delivered directly to the students at ESCS classes, who fill then and return a week after receiving. The questionnaire was similar to the company questionnaire except in specific aspects like the profile of the respondent.

. Companies: The questionnaire was developed in HTML with php code to send the variables information by email, and made available in *Instituto Superior de Economia e Gestão* (ISEG) website. Since is a questionnaire about choices regarding software purchasing, which could arise some fears regarding the objectives of the questionnaire if there is the perception that is a questionnaire to try to catch situations of software piracy. By making the questionnaire available in a University web site we wanted to give it the academic credibility while avoiding suspicions about the objectives of it.

A database of more 4800 organizations was build from the sources cited above and from databases already made by colleagues in master and PhD graduations. The companies were contacted by email, with a presentation of the objectives of the thesis and an invitation to collaborate in the thesis research by clicking a link to the ISEG site, where the questionnaire was available to be filled. The questionnaire has multiple choice questions and Likert scale questions. The first ones were mainly to collect the data about the organization that answer the questionnaire like companies' characteristics, IS infrastructure, etc., etc. and the second ones to collect data regarding the different thesis hypotheses.

Questionnaire characteristics

The questionnaire (Appendix 27) start with several closed multiple choice questions about the companies' profile. Out of the company profile questions and the last 6 questions about specific software choices, that are all nominal variables, questions 1 to 21 questions have all their items with a 5 point Likert Scale.

The 5 point Likert scale only has labels in the extreme values. By doing it we made easier to have the assumption of distance homogeneity, that could allow to test H_0 regarding the mean or median of the sample.

The questionnaire start with company profile questions about economic-financial aspects and IS infrastructure. From the study of these questions we can also see the heterogeneity degree of the sample, including the IS "culture", important factor on the influence degree of the network effect over the market.

Then we have 24 subjects of question, some with more than one question, that cover the thesis hypothesis while trying to explain the IS buying decision process. The questions are about choices and perceptions of software in general but also about categories of software (Operating System and Office Suite or Open Source Software and Proprietary Software), suppliers, products and choice factors.

The questions 1a and 1b are about applications and files compatibilities with others. In the first case the choice of Operating System is relevant for the availability of the application (for instance, there is no Microsoft Office in Linux version).

The 2^{nd}, 3^{rd} and 4^{rd} questions are about legacy files or applications that can create lock-in in the market. The several questions of the 5^{th} are about the several factors that can influence the choice of software and, as such, cover several thesis hypotheses.

The 6^{th} question is about the knowledge of the main suppliers of software in the market, don't considering specific products or brands present in the market.

Questions 7 to 12 are about innovation, quality and security of different brands of respectively Operating Systems and Office Suites. Questions included in 13 and 14 ask same thing but regarding Open Source Software and Proprietary Software overall.

Question 15 is about software costs. Even knowing that Open Source Software licenses are free, it’s important to know the perception regarding global costs of using that software against using Proprietary Software.

The questions included 16 are about the availability of technical support of Open Source Software and Proprietary Software.

Important factors influencing the dynamics and competition in IS market are the switching costs. Question 17 and 18 are about it, how easy is to switch between different Operating Systems. Question 20 is about the same subject, but regarding Office Suites. The questions included in 19 and 21 are the factors that users consider that can influence each of the decisions.

Finally questions 22, 23 and 24 ask about Operating Systems and Office Suites mainly present in the companies, choices of Operating System and Office Suite if the computers didn’t had yet software installed and choices of software if switching from actual software to other alternative software, Operating System and Office Suite.

So we have in the questionnaire questions about:

1. Software (Operating System and Office Suite) installed in the companies desktop and notebooks;

2. Companies perceptions about image, costs, characteristics, innovation, quality, security, etc. of software suppliers, brands and products and also Proprietary and Open Source Software;

3. Companies’ choice of software brands and products, factors that influence those choices.

4.4.2. Data analysis methodology

We have one or more than one question in the questionnaire to test each of the hypotheses presented in this thesis. The descriptive statistics of each question (variable) were made and we present here the mean, median and standard deviation to help to explain the results obtained. Even if many researchers considered that statistics like mean or standard deviation cannot be used with ordinal variables like Likert Scales (Jamieson 2004), nowadays many researchers (Glass et al. 1972), (Lubke & Muthen 2004), (Carifio, J., Perla, R. 2007), (Dawes 2008), and leading research studies, in management, marketing and other areas consider the use in research of measures such as means and standard deviations from Likert Scales, with leading textbooks also considering this approach.

The choice of the statistical methodology to make the hypothesis tests will depend on the results of Kolgorov-Smirnov tests. The Kolgorov-Smirnov test (H0: Normality of Sample vs Ha: Non-Normality of Sample) will be made and if the null hypothesis of normality of the variables distribution is rejected, the non-parametric Wilcoxon Signed Rank test for the median will be applied. If the null hypothesis is not rejected, we will use the parametric t-test.

While the Central Limit Theorem (CLT) states "... the sum of a sufficiently large number (> 30 items) of independent random variables, each with finite mean and variance, will be approximately normally distributed…" (Rice 1995), even if our sample has more than 30 items we will keep with the more robust non-parametric Wilcoxon Signed Rank Test.

The choice of lower or equal than mean or median versus higher than the mean or median for the hypothesis tests will be made because we only want to consider answers that go “above” the more neutral point of 3, that usually means “neither agree or disagree” when the respondent considered the subject presented in the question, even if 3 could mean “slightly agree” (Lodico, Spaulding and Voegtle 2006).

Construct internal consistency reliability

After statistically analyzing and explaining each question (variable), several constructs will be created from the hypothesis made in this thesis to help to explain the factors behind user’s decisions. The Cronbach's α (1951) test will be applied to test the internal consistency reliability of the unidimensionality of these latent constructs. The α represents the estimated systematic variance or true score of a construct and is based on the correlations among the variables that comprise it, with higher correlations among the variables associated with higher α coefficients (Pedhazur and Schmelkin 1991). The α coefficient can range from 0 to 1, the higher the α the higher the reliability.

Which Cronbach's α threshold will we consider? The 0.70 value is considered by many authors the rule of thumb of Cronbach's α to not reject the hypothesis of internal consistency reliability of a construct. But even if the rule of thumb considers the 0.70 value, Nunnally (1967, 1978) recommended 0.50 to 0.60 for the early stages of research. Van de Venn and Ferry (1980) considered that even $\alpha = 0.40$ can be acceptable for broader defined constructs, with higher values offering greater confidence. Schmitt (1996) considered that Cronbach's α values “depend on test use and interpretation” and that even a value of 0.50 do not seriously invalidate conclusions about internal consistency reliability. Authors like Hair, Anderson, Tatham and Black (1998) or Malhotra, N. K. and Birks, D. F. (2003) discussed Cronbach's α values above 0.60 as acceptable. Leontitsis and Page (2006) also considered that in some situations “$\alpha = 0.50$ not only tells that it is reliable but also the statistical significance of the result is on 0.1 level". Also regarding the values Cronbach's α, Cortina (1993) and Streiner (2003) considered that high values of Cronbach's α by themselves do not guarantee internal consistency or unidimensionality because α is affected by the length of the scale. In this thesis the length of the different scales used are below the situations considered by these authors.

Constructs building

For the latent constructs with internal consistency reliability we must have a methodology to build them from the variables included in their creation. The methodology choice will depend on the characteristics of the sample. We can use confirmatory factorial analysis through structural equations or, if the sample doesn't have the requisites needed, we will use exploratory procedures without exploratory intentions but simply to build the latent variables weighted by the variables scores.

Several options could be considered to build the constructs in the thesis. We start by putting aside the simpler options like construct building from the mean of the several items or by using the percentage weights of the means of the items. On other end we could assume that since we have several hypothesis based on the literature review, we could do it by using Confirmatory Factor Analysis and Structural Equation Models. However, the thesis sample dimension, size less than 100, and the possibility of non-normality of the variables, are against the sample requirements to apply Confirmatory Factor Analysis. Some authors recommend that the sample size, as a rule of thumb, be more than 25 times the number of parameters to be estimated, the minimum being a subject parameter-ratio of 10:1, with the lower bound of total sample size at least 200 (Nachtigall et al. 2003) and (Kline 1998). To Yung and Bentler (1994) we must have a minimum sample size of 2000 to obtain satisfactory results. These authors also considered that in general, "the accuracy and stability of SEM results declines with decreasing sample size as well as with increasing number of variables". Hair et al. (1992 and 1998) recommend a sample size ranging between 100 and 200, with 200 as more secure. Hoelter (1983) argues that 200 is the critical sample size, like Tabachnick and Fidell (2001) that consider the minimum level of 200 for small to medium models. Jöreskog (1990) conclude that limited sample size have a negative impact that will affect the estimation of the asymptotic covariance matrix. Boomsma and Hoogland (2001) also consider problems with sample size less than 200 items, because when researchers "do want to apply structural equation modeling (SEM), there are two persistent estimation problems likely to occur: non-convergence and improper solutions. For both problems there is no really satisfying solution, given that the sample size cannot be increased and the user is stuck with his measurement instruments". Boomsma (1983) considered the same in her research about the robustness of Lisrel (SEM software). Starting with the main assumptions of that the sample size should be large (asymptotic theory) and the observed variables should have a multivariate normal distribution, Boosma (1983) concluded that Lisrel robustness need a sample size larger than 200 and that even for a sample size of 400, Lisrel is not robust with discrete non-normal variables.

The assumption of normality of variables in Confirmatory Factor Analysis is other problem regarding the characteristics of the thesis sample. If the results of Kolgorov-Smirnov test reject the hypothesis that the variables of the sample had a normal distribution, that assumption violation of the sample normality will be a major concern in the estimation of standard errors and the chi-square test statistic for global model fit (Boomsma and Hoogland 2001). MacCallum, Roznowski and Necowitz (1992) also concluded that non-normal data may lead to inflated goodness-of-fit statistics and underestimated standard errors, and by that, can hamper research progress by providing inaccurate findings. Kline (1998) concluded that there is inflation of Type I when the sample is far from meeting the necessary conditions of multivariate normality. Hair et al. (1998) and Wang (1996) consider that with non-normality the sample must be larger than the recommended 200 size, and with at least more than 15 respondents for each parameter. Also Browne (1984) and Hu, Bentler and Kano (1992) consider the same problems in their research about non-normality impact on the Confirmatory Factor Analysis (CFA) robustness.

While our data sample doesn't follow the assumptions to make Confirmatory Factor Analysis or Structural Equation Modeling, we can consider the use of Exploratory Factor Analysis (EFA) because while there exists some scientific research about consumer choice of IS purchases, most of it is fragmented and from markets and realities outside Portugal. In conceptual terms, we consider the inability to employ SEM in the context of this thesis reflected in the conclusion of Hair et al. (1992) that "it is necessary to use structural equation modeling only in confirmatory mode, leaving exploratory analysis to other multivariate techniques". Nevertheless, we cannot consider this research as a pure exploratory analysis as cited by Hair et al. (1992), because we are considering several theoretical hypothesis, even if from literature review of a reality outside Portugal.

Construct building methodology

In the end, to build the constructs we will use exploratory procedures without the pure exploratory intention (Hair et al. 1992), but in similar way to the methodological approach presented of Sanjay and Devaraj (2003) from the working paper of (Schwab 1998):

1. The unidimensionality is assessed through factor analysis conducted on each construct scale. The construct validity is evaluated by the extent to which items in a single scale all measure the same construct (Flynn et al. 1991). It will be employed factor analysis, with principal component method used on the items in each scale, to determine whether they loaded on a single scale (the construct that underlies the scale). The significance criterion of a factor will be an eigen value of at least one. If items fail to load on a single factor, this result is analyzed by comparison with factor analysis forcing a single factor.
2. Scale reliability for each construct, considered regarding the literature review and hypothesis made, is examined using Cronbach's α;
3. The construct is build through the factor scores obtained from the factor analysis.
4. Hypothesis testing will be made over the several constructs.

The building of the constructs as present in point 3, without using of Confirmatory Factor Analysis, was also considered by Saris (2008, 2008a). Preacher and MacCallum (2003) concluded that "... many modern applications of EFA, such as those focusing on scale development, assume theory already exists and use it as a basis for interpreting factor solutions.". While considering that Structural Equation Models can be used, "...thus eliminating the need to obtain factor scores...", Preacher and MacCallum (2003) also concluded that Exploratory Factor Analysis (EFA) can be used to compute factor scores to represent individual differences in a latent variable, and then to use those factor scores in subsequent analyses. Suhr (2006) also see EFA as helping to determine what the factor structure looks like when confirmatory analysis fails, considering exploratory factor analysis as essential to determine underlying constructs for a set of measured variables. Newson (2008) considered exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) as two statistical approaches to examine the internal reliability of a measure and to investigate the theoretical constructs, or factors, that might be represented by a set of items, also considering that both can be used for exploratory or confirmatory purposes. Brannick (2009) also considered “Exploratory analysis is to my mind generally preferable to confirmatory analysis, but my view is somewhat controversial”. The author considered that when in scale development the confirmatory analysis showed that the hypothesized model does not fit very well and statistical tests will virtually always reject the very model in need to be confirmed, the confirmatory programs will offer little help in producing a better representation of the data. Exploratory analysis objective on other hand exists to help to make sense of the data, and this is typically what is needed in scale development. While confirmatory techniques work best when there exist measures that have been carefully developed and have been subjected to (and survived) prior exploratory analyses, in scale development, we need to worry about difficulty factors emerging in your data.

Bollen (2002) accepted that the latent variables from exploratory factor analysis, where the factors are *a posteriori* latent variables, are usually considered as hypothetical rather than real latent variables. Nevertheless, he considered that this does not imply that a CFA *a priori* latent variable can be regarded as real. For this author there is no right or wrong definition of latent variables. It is more a question of finding the definition that is most useful and that corresponds to a common understanding of what should be considered latent variables. Hecht (2001) while also referring a Ransdell, Hawkins, and Adams (2001) paper, considered that "... the exploratory factor analysis methodology used by Ransdell and her colleagues provides important initial evidence regarding the validity of a best-fitting theoretical model.” when emphasized that to empirically support a theoretical model, both exploratory and confirmatory research methods can provide the important necessary evidence.

Considering this, our acceptance of a value larger than 0.50 for Cronbach's α (instead of the 0.70 rule of thumb threshold) depends also on the factor analysis to obtain the variables weights of the construct, that must extract only one factor based on the eigenvalue with the factor extracted accounting for at least 60% of the variance (Malhotra 2003). The factor analysis to obtain factor scores will not "force" the existence of a unique factor, to help the creation of more reliable constructs.

Factor analysis tests will be made like the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, an index used to examine the appropriateness of factor analysis, with values between 0.5 and 1.0 indicating that the factor analysis is appropriate while values below 0.5 imply that factor analysis may not be appropriate (Kaiser 1974). Other test will be Bartlett's test of sphericity (Bartlett 1937, 1938) with the null hypothesis that the variables are uncorrelated in the population with the correlation matrix an identity matrix. If this hypothesis cannot be rejected, then the appropriateness of factor analysis should be questioned, so we want the test to be significant (a significance level less than 0.05).

This methodology will be the same for all the constructs, with the results tables in Appendix.

4.5. Second and third research questions

The second and third research questions about the real cost of Open Source software for the user and about software companies' business models and innovation will be researched using the Soft Systems methodology.

4.5.1. Market modeling with the Soft Systems Methodology

One of the objectives is this thesis will be to describe the main characteristics of the IS market also from the supplier's point of view, the Proprietary Software suppliers and Open Source Software suppliers as background to the hypothesis and research questions regarding these market. To have a better knowledge of the IS market from the point of view of the market suppliers we applied a research methodology based on the variables of Soft Systems Methodology (SSM) developed by Peter Checkland (1981, 1999 and 2006). The Checkland model has a structure to describe a real situation and in this case will be applied to describe the way IS companies see the market evolution, competition and business models.

The different components of the Soft Systems Methodology allow the analysis of the different components of the market like owners (organizations), actors (that play an important role in the IS market as software developers) and even the transformation process (the way different software philosophies like Proprietary Software and Open Source Software work).

In this methodology is also considered the fact that the way people see the reality, their world view, is not the same for every person. So it's expected some differences between answers of managers of different companies, as their world views are different even for the same factual reality.

The Soft Systems Methodology starts with the ‘Root Definition’, the definition of the situation studied by the methodology, which in this thesis is “Software Supplier’s innovation and surviving”. The system CATWOE that will be applied includes the different factors analyzed by this methodology: **C**ustomers (those who will benefit from the activity), **A**ctors (those who make the activity), **T**ransformation Process (how the activity is performed), **W**orldview (how the person interviewed see the system), **O**wners (the owners of the process, stockholders for instance) and **E**nvironmental Constraints (influence on activity of the global environment), as present in Figure 2.

In “Software Supplier’s innovation and surviving” we can describe the model as including:

1. **C**ustomers, receive the results of the **T**ransformation process. In Open Source Software the **C**ustomers are in some cases also **A**ctors, that in this market we consider to be the software developers;

2. **A**ctors, that in this market are the managers and software developers;

3. **T**ransformation process, mainly software developing philosophy and supporting business model, considering the **W**orldview for both;

4. **O**wners, mainly the shareholder structure of each company that control and can change or stop the **T**ransformation process;

5. **W**orldview, point of view of the respondents. Each person can have a different **W**orldview of the same reality;

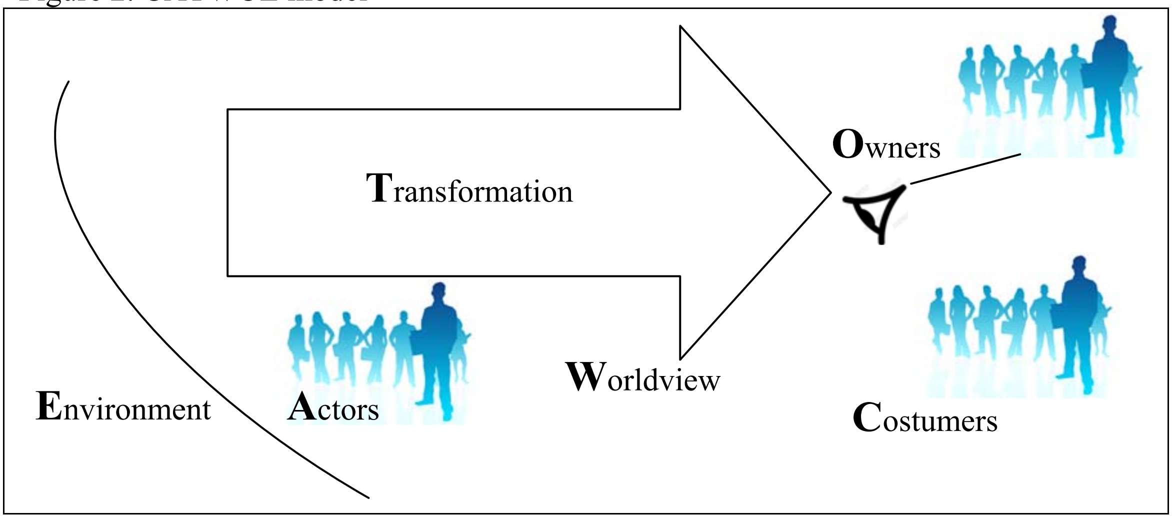
6. **E**nvironmental constraints, the different factors like economy, technology, social aspects, competition, customers, Government, regulation, etc. that influence the **T**ransformation process.

The objective of the CATWOE study is to have some background analysis of the IS market where the consumer decision process is made. The content analysis of the

CATWOE will allow the answer of research questions regarding supplier's innovation and surviving in the market considering the suppliers worldview.

The aspects related with monitoring the system, the called three E's, (Efficacy, Efficiency and Effectiveness) and the Activity Model, also part of the Soft Systems Methodology, will not be covered because their objectives aren't part of the thesis objectives.

Figure 2. CATWOE model



The choice of this methodology was due to the fact that Soft Systems Methodology (SSM) "was specifically designed to assist in the resolution of ill-structured problems. It was also designed as an interpretative approach, allowing insights to be gained about this form of problem situation" (Bennets, Peter D.C. and Wood-Harper, A. Trevor and Mills, Stella 2000).

Green and Simister (1999) considered that the Soft Systems Methodology is important as way of study and modeling the business process of an organization through a strategic briefing. They see Soft Systems Methodology as better for this kind of work then the more Taylorist Business Process Re-engineering, even in the improved social constructivist interpretation where business processes are seeing as socially constructed and not as objective entities as before. That's because Soft Systems Methodology "not only possesses a successful track record of implementation, but also it is theoretically well developed" (Green and Simister 1999).

Criticism about the way Checkland "simplify" the WorldView (Weltanschauung) while suggesting, "that is enough to try and tease out the underlying rationality of why a person sees it meaningful to carry out a certain activity or transformation" was made by Bergvall-Kareborn (2002). Even if Bergvall-Kareborn (2002) consider the SSM use of the Worldview as the most helpful for analysis (and we consider it enough for this thesis objectives), it also considered that the Worldview does not show the diversity found in different perceptions. He introduced an alternative concept, originated from what it is called "Dooyeweerd's Philosophy", a qualifying function as a function of 15 aspects that characterizes a particular activity and could improve the Worldview analysis of CATWOE.

When criticizing the problems that can arise in the interpretation of the different elements of the CATWOE in the SSM model, authors like Basden and Wood-Harper (2006) don't considered the replacement of the CATWOE or adding some new elements but just in enrich the interpretation of CATWOE, including the consideration of the Dooyeweerd's (1955) multi-aspectual philosophy of interpretation.

Mathiassen and Nielsen (2000) on other hand considered the introduction of "Interaction" as a way of have a better application of Soft Systems Methodology in the IS development reality besides the "Transformation" process. To these authors, while the "Transformation" is "a mapping from one domain (input) to another domain (output), "Interaction" is "a domain with states and state transitions". Mathiassen and

Nielsen (2000) considered as examples of Transformation Systems organizational intervention and change, development of computer-based IS, any kind of design or invention effort, and construction of physical or abstract artifacts. Management systems, IS and administration systems are examples of Interaction Systems. To Mathiassen and Nielsen (2000) “a system with the purpose of providing information about resources and personnel in an organizational unit is hence a good example of an interaction system”.

While Mathiassen and Nielsen (2000) work is a development of the traditional CATWOE framework and can be applied in future developments of the research of this thesis, we considered it need more development and empirical work before their application in the research like this thesis. The CATWOE framework is a good way of describing a reality of a market without consideration of the deeper interactions that can happen at the organizational level, that are beyond the thesis objectives.

Soft Systems Methodology limitations, presented by authors like Jackson (1992, 2003), Flood and Jackson (1991), Mingers (1984), and Lane and Oliva (1994), amongst others, argued mainly that “because of the interpretive underpinning, SSM is not a ‘problem-solving methodology’ and that can cause concern and uneasiness amongst practitioners”. Since problem solving is not an objective of using the SSM methodology in this thesis, these concerns are not considered.

4.5.2. Supply side sample definition and data collection methodology

To study the market from the supplier’s side by using the Soft Systems methodology, several companies were contacted to answer an open question questionnaire. The sample include main IS organizations of Proprietary Open Source business models like Microsoft, IBM, Sun, RedHat, Mandriva, OpenOffice.org, MySQL, including at least the top Open Source Software and Proprietary Software suppliers in the Portuguese IS market (Table 8).

Table 8. Supply side interviewed companies

Company	Main software	Type of license
Caixa Mágica	Operating Systems	Open Source Software
IBM	Operating Systems, Office Suites	Open Source and Proprietary Software
Mandriva	Operating Systems	Open Source Software
Microsoft	Operating Systems, Office Suite	Proprietary Software
Novell/Suse	Operating Systems, Office Suite	Open Source and Proprietary Software
OpenOffice (through ESOP (Associação de Empresas de Software Open Source Portuguesas)	Office Suite	Open Source Software
Red Hat	Operating Systems	Open Source Software
SUN (including MySQL)	Operating Systems, Office Suite	Open Source and Proprietary Software

Apple, Corel, E-Press, and KDE were not available to answer the interviews. It’s from the answers to these interviews that the components of the Soft Systems model regarding the software market will be explained.

Data collection methodology

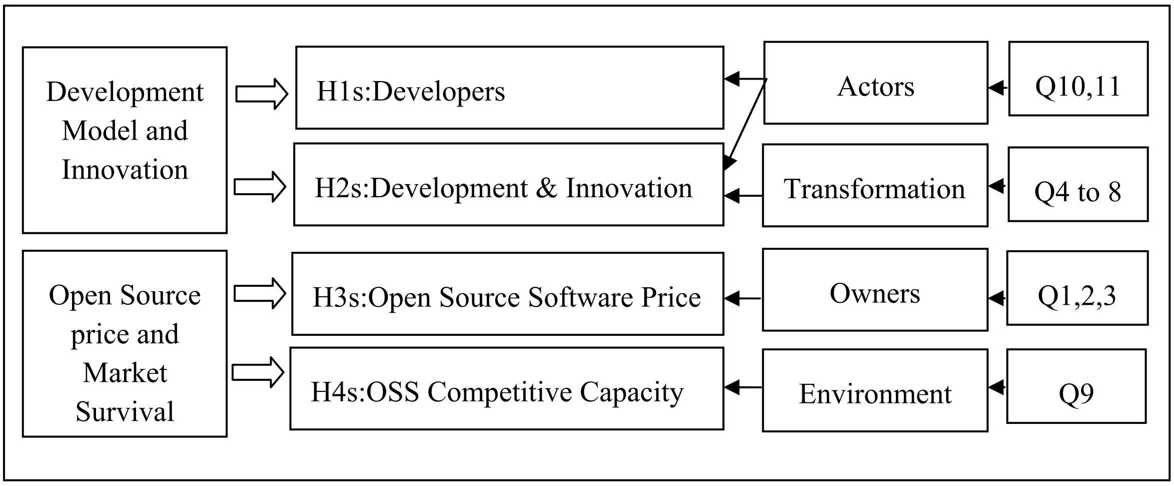
The data collection was made with semi structured face or email interviews using a questionnaire that were send beforehand by email. The questionnaire (Appendix 28) include questions related with Open Source and Proprietary software business models and revenues sources, innovation and evolution of the market, environment conditions and also specific questions about the organization, remuneration plans, R&D investments, etc.

4.5.3. Data analysis methodology

The objective of the questionnaire data is to analyze the ATWOE of the Soft Systems methodology (Checkland 1981) presented in Fig 2, leaving the **C**ostumers to other analysis methodology on the demand side.

The questionnaire has 11 questions associated with the thesis hypotheses. The first three questions are about the income sources and economic survivability of the software companies, mainly of the Open Source companies whose software licenses are free. The following 5 questions are about innovation in the global software market and innovation differences between Open Source Software and Proprietary Software companies. The 9th question is about the environment of the market and how that environment has influence over it. The last two are about the Actors, how the developers are organized, rewarded and motivated in the different software development organizations. The Worldview is considering that one manager of each organization is interviewed for this thesis. The relationships between the different research questions, hypothesis, SSM CATOWE and (Q)uestions are present in Fig 3.

Figure 3. Supply side model



4.6. Summary

In this chapter the different philosophical research perspectives were discussed and since this thesis makes a market analysis from both sides, demand and supply, two different epistemological options were made considering the different realities and data of each of the market sides. We will adopt the Critical Realism to study the supply side of the market and a Critical Realism with also positivist methodologies while studying the demand side of the market.

The supply side of the market will be studied through the Soft Systems Methodology (Checkland 1981, 1999 and 2006) while the demand side will be studied through statistical analysis of the several variables and constructs related with the different thesis hypothesis, with priority to the explanation of the global market and all the variables and constructs that influence it.

V. Research results

5.1. Introduction

In this chapter, we will discuss the research results considering both supply side and demand side of the IS market. The research methodologies, discussed in the previous chapter, are different for each side of the market. The supplier side will apply the Soft Systems model while the demand side will be research by using statistical analysis for the different variables and constructs that have influence on the consumer choices.

5.2. Supplier Side Enquiry Results

We now analyze the several elements of the CATWOE model of the Soft Systems methodology Checkland, P.B. (1981), based on the inputs received from the interviews with managers of software companies. We refer their answers as the company "answer". After that conclusions about thesis hypothesis and research questions will be presented.

5.2.1. Customers

The customers, users of personal computer Operating Systems and Office Suites, are the first element of the CATWOE model and will be analyzed through a questionnaire to be answered by organizations that buy and use the IS infrastructure. The results of this analysis, on the demand side, are available ahead on the thesis.

5.2.2. Actors

The actors are the developers working in the Transformation process of the software market. They can work in three main categories of organization:

1. Private or public companies. These companies can develop Proprietary Software and/or Open Source Software;
2. Users/Developers Communities;
3. Individual User/Developer.

Even if there are many individuals working in the transformation process beyond the developers, the subjects of this research are the software developers. The double role as users and developers it's an important characteristic of the Open Source Software development model (Dalle and Jullien 2002; Prehn 2007).

The software developers work for monetary rewards or non-monetary rewards, sometimes both kinds of rewards. Their reward and motivation are more associated with the category of organization to which they work for than with the type of software (Open Source or Proprietary) they develop. For instance, as Open Source projects get larger or started to being developed, adapted or improved in companies even with inputs from the Open Source community, more and more Open Source developers while working inside that companies or for that companies as freelancers, start to be motivated also with wages, bonus, stock options like the developers of Proprietary Software companies. Their motivation is the success of the company that will reflect in monetary prizes but also recognition by the global software market. So there is no big difference if they are working in Open Source Software companies or Proprietary Software companies, the rewards are almost the same type and motivations are also similar.

But for some individuals working in Open Source Software projects, the contribution of their work to the Open Source community and the world can be more rewarding. They don’t have monetary rewards when they work in individual Open Source projects or Open Source Community projects. Their rewards, their motivation, came from peer-to-peer recognition, the felling of contribute to the community or the world by offering their code and also the possibility that their recognition translates later on in career improvement (Raymond 2001). They also may want to learn and perfect their expertise by developing software, have reputation of contributing to Open Source projects and enjoy developing software and receive the peer-review by the development community, useful for the developer in his skills improvement (Lerner and Tirole 2002). Developers can also work for intellectual gratification, see programming as an art form, don’t wanting the restrictions of the enterprise world (Bonnacorsi and Rossi 2003). They contribute usually for the Open Source community, even if sometimes they also work simultaneously as professionals to Proprietary Software or Open Source companies, being careful to avoid interest’s conflicts with their jobs. It’s their choice of contributing to the society like others work in charity or similar projects.

Considering all this aspects of developer’s roles and their monetary and non-monetary rewards, how are developers rewarded in the main software suppliers?

Enquiry results

Caixa Mágica has is in-house developers and also freelance developers. The first ones receive salary plus bonus and monetary compensation is agreed with freelancer developers. **Caixa Mágica** also includes code from the Open Source community. The developers of Open Source code have the non-monetary reward like the peer-to-peer recognition that also can bring with it recognition and a potential invitation to work in a software house.

IBM refused to answer to this question but it's expected to have compensation schemes similar to companies like Sun, Novell or Microsoft.

Mandriva just considered that "developers need to eat". Developers working in Open Source or Proprietary Software companies or Open Source developers working in their own or community projects, must receive some form of payment in their lives. The first ones receive the more traditional salary plus several kind of bonus and the second ones see their code contributions as a hobby with their monetary rewards coming from other activities that can be also software development.

Microsoft compensates his developers with wages and stock options but also perceives peer-to-peer recognition as compensation with increasing importance due to the evolution of values in our society.

Novell see the compensation as more "traditional" in companies working with Open Source or Proprietary Software while. In Open Source communities the developers don't receive monetary compensation but participate in the community, develop their knowledge by that participation and receive recognition from peers when having is name associated to a good software project. **Novell** think that with more and more companies picking up Open Source Software to earn money by supporting it or adding its version, is unfair to those developers who contributed with Open Source Software code for free, even if these developers did it as a personal choice.

OpenOffice.org considered that methodologies for compensation of developers in Open Source Software are wages plus peer-to-peer recognition when working in organizations and peer-to-peer recognition when working by themselves in individual projects or even contributing to bigger projects.

At **Red Hat** the in-house developers have traditional remuneration similar to Open Source and Proprietary Software companies, including salary base, results based money prizes, stock options, etc. External developers are never paid "but strong community developers increase their chances of being noticed and hired by the organization, which is a strong motive for many, like happens in the Fedora community."

Sun consider that while in companies (Proprietary Software or Open Source) there exist "traditional" ways of compensation, like salary plus bonus and/or stock option, in "pure" Open Source individual or community projects is the appreciation from all the developers community, the peer-to-peer recognition or prizes like "Google Summer of Code™" that are the compensation.

Summary

We see almost a consensus between these different software companies, working with Proprietary software and/or Open Source Software, about how the main actors in this business, the developers, are rewarded.

The big evolution in the market is the "professionalization" of Open Source Software, adopted by software companies. When that happen the Open Source developers that work in that companies or as freelancers for that companies have monetary compensations like the Proprietary Software developers and not only the peer-to-peer recognition.

Actually we have developers that can have several “roles”, making development developing in different situations (companies, community, individually), and sometimes in simultaneous situations with different motivations received from each situation. They go through different roles in their personal and professional life.

5.2.3. Transformation Process

When we talk about the transformation process in our analysis we talk about the way the software development is made. That includes how developers are organized in the development of software and how innovation in software projects can happen. Questions regarding programming methodologies, languages or technologies are out of the scope of this thesis.

Software development organization

The way developers are organized is to assure several objectives: software quality, software projects organization and scheduling and also to foster innovation. Innovation is the way to develop of the market, to keep the demand rising, to win over other competitors with the rewards, monetary and/or non-monetary that everybody working in the projects wishes for their software and themselves.

Regarding the development organization we can also consider the same three “categories” of organizations: private or public companies that develop Proprietary Software and/or Open Source Software, users/developers Communities and Individual User/Developer.

These three categories of organizations have different ways of organizing the software projects. One of the factors influencing that is the dimension of the software project. As the dimension of the project increase, the formalization of the hierarchical relations also increase because there is the need of adjust schedules, choose the number of developers, choose ways of integrated all the inputs in one piece of software, etc. In that case we have more hierarchical levels with project managers and other managers working just to manage and coordinate the developers included in the project.

In this sense, the first two type of organizations (private or public companies and communities) work in the same way with formality increasing with the project dimension, with more formality in the first case due to the added responsibilities regarding the survival of the company, with the relevant double role of users/developers in Open Source Software development (Dalle and Jullien 2002; Prehn 2007). The third “category” of organization, the individual developers, usually has small projects on their own or cooperates in bigger projects, usually Open Source community projects. When developing small software project, the creator is the responsible for it, adding the contributions coming from several Open Source developers, usually in an informal way without the restrictions of bigger projects like strict schedules for instance. When we talk of bigger software projects, where there is a community of developers behind the project because of its size, a more strict software quality and scheduling control is needed because of its popularity (many contributors) and influence in the software market (responsibility). The individual developer that contributes is restrained by the more formal organization of these kinds of projects. As examples we have Mozilla or Linux Foundation.

In larger Open Source Software community projects some difficulties can happen, like the need of the project leader to be a prestigious developer in the community or the difficulty of coordination if the main code input arrives in a voluntary way Cusumano (1992). Also Open Source developers working for the community value the fact that they "own" their work and can control it, so the coordination is more difficult. Even if Bonaccorsi and Rossi (2003) don't consider the hierarchical coordination as essential to complex Open Source Software projects and concluded that the coordination is a barrier to creativity and motivation of programming as a pleasure, a characteristic of the Open Source community, as Open Source get more "professionalized" and more companies start to include Open Source code in the internal development of software, acquire Open Source projects or release their version of Open Source applications or Operating Systems, these companies also implement a more hierarchical coordination structure to avoid any coordination problems like the cited by Cusumano (1992). They employ Open Source developers rewarding them like the Proprietary software developers, and implement the schedules, deadlines, roadmaps, quality control, project leaders, etc. that are characteristic of the Proprietary software development organization.

Healy and Schussman (2003) concluded that as Open Source Software projects get more complex and with bigger dimension, professionalism, clear leadership and hierarchy are critical factors for their success.

Enquiry results

Caixa Mágica organizes software projects in a hybrid model between the "bazaar" and the "cathedral" as in the Raymond (2001) definition. They have a Release Manager instead of Project Manager, with similar functions. The core work has a hierarchy organization with targets, roadmaps, release analysis, etc. and own developers, more like the "cathedral". Then there exists a network of freelance developers or companies that contribute to software projects while receiving a monetary payment and are coordinated by messenger, email, etc. in a style more like the “bazaar”.

IBM refused to answer to this question but it’s expected that they have a formal software project organization similar to companies like Sun, Novell or Microsoft.

Mandriva considered their organization as a controlled collaborative development environment, using tools and practices that already allow it.

In **Microsoft** the developers are organized in a coordinated structure to allow development efficiency and quality. The software projects always start with a pilot stage with intensive customer feedback and starting of the coding, the alpha stage. This stage in Microsoft usually is considerable more deep than in other kind of organizations, including Open Source Software.

Novell, even when working with Open Source projects, is organized with formal hierarchies and schedules, following the company strategy. They consider that in Open Source community the developer is freer to decide what to develop, when, and what kind of contribution to community he wants to make. If he contributes to bigger projects, where exist the need of project coordination to filter the contributions and decide what to include in the release, while the developer that contribute in a free way still don’t have any mandatory commitment, the project administrators also don’t have any commitment to include the contributions that these developers make.

Novell allows some creativity and free thinking to their own developers, their individual innovation, but has a strategic orientation that define what ideas to use or leave, what projects to prosecute and how to allocate human and financial resources to the projects to prosecute.

To **OpenOffice.org** the way how Open Source projects are organized can evolve in two ways. By natural "Darwinism" where accepted leaders appear to coordinate that projects. Usually that happens in the smaller to medium projects. In larger projects usually there are organizations that make the coordination and also support the projects by themselves or by collecting support from different sources. Also there exist thousands of individual Open Source Software projects, usually small and without coordination problems, where only scheduling problems can arise.

In **Red Hat** most of their developers also work within the bounds of pre-existing Open Source communities. That allows **Red Hat** to influence the direction of projects, while also being able to take advantage of the work that non-**Red Hat** developers contribute. Developers in **Red Hat** R&D are encouraged to create Open Source Software projects so that **Red Hat** can be the upstream manager of more projects.

Sun considered that in Open Source the small projects can be developed in a more independent way with small to none coordination. In bigger projects the needed discipline and method can be imposed by a company while in a cooperative community, like Open Source community, the coordination can be more difficult with more resources wasting. But even with coordination, companies must give to developers some freedom to allow their creativity. If not, probably the best will leave the company. Actually there exist similar work methods, coordination, objectives, schedules in Open Source and Proprietary Software projects, but Open Source projects can have contributions in a more free way, even if without the same efficiency that is imposed by the marketing or top management regarding strict schedules to introduction of new products or new versions or updates. In Open Source Software projects usually the pressure is lower and the contributions will be added if ready or added later if not, without the same pressure than in Proprietary Software projects.

Sun also referred that even if the biggest part of Open Source Software projects are not professionalized, larger projects are more and more created inside companies, even if with external contributions. In these projects the freelance developers also receive wages and bonus as any other developer and have a more professional and responsibly way of work. Developers now also work in both Open Source projects and Proprietary Software projects while changing from company to company or even in the same company. **Sun** considered also that Proprietary Software companies consideration that their work methodology is better than in Open Source projects, because they have intellectual property, better coordination, etc. is just marketing slogans because the actual difference between the work methodologies of this two types of software projects are smaller than never.

Software innovation

Innovation is the growth engine of the IS market. But can we tell that innovation process is different when we talk about Open Source innovation or Proprietary Software innovation? It's expected more innovation in one or another of these different forms of software development and commercialization? In this thesis we will analyze the differences between how innovation develop in each of the two types of software business models, Open Source Software and Proprietary Software and the opinion that

Open Source Software companies and Proprietary Software companies have about the best conditions to achieve innovation.

Hippel (1998) considered innovation more difficult in Open Source Software, because Open Source companies didn't have resources to make detailed consumer studies that would reveal the consumer preferences, needs and opinions about software in the market. Today this advantage is no longer considered because those kinds of studies are more available, customer feedback is easy to get through forums, blogs and because behind Open Source Software projects we now have big companies like IBM or Sun, with enough resources to buy detailed market studies.

Economides and Katsamaras (2006) didn't saw important differences in innovation investment between Open Source Software and Proprietary Software, but only some more investment in application development when the Operating System is Open Source. They studied more specifically the investment in Open Source Operating Systems development. They concluded that the investment depends on software project contributor's reputation, ratio of Open Source developers, application investment in Open Source versus Proprietary Software and implementation cost of Open Source Operating System.

Hippel (2005) researched about sources from which we can expect more innovation. If Open Source Software has the advantage of having an innovation network of developers and users/developers, with knowledge and innovation sharing with no dependence regarding commercial standard software in a more open environment, the more focused Proprietary Software companies seem the more logic form of innovation. They have financial incentives of profiting from their innovation and also have the resources to production, distribution and support. But since innovation networks have more incentive to reveal their innovations, sharing the knowledge, spread the innovation, they can compete against the "commercial" innovation and distribution of Proprietary Software.

The study of the innovation process itself is beyond this thesis, but the opinion of the main IS suppliers about innovation in the market, to complement the aspects presented in the literature review, were vital to answer the third research question about the survival and innovation of the Open Source Software suppliers.

Enquiry results

Caixa Mágica considers that more investment in R&D doesn't directly imply innovation, but without investment there is no innovation. The innovation foster also depends on the innovation culture of the organization. The main factors that influence the innovation degree are: competition and need of differentiation against the competitors, fast evolution of the market and users habits that have a strong influence on the need of a faster pace of the innovation.

Regarding the factors that influence innovation in **Caixa Mágica**, they think they are the same. The need to be in front of innovation and knowledge, not only at a national level but at world level, also raised the need of partnerships with organizations like Mandriva or OpenOffice.org, to help to create a global vision that a national company, even more a small company like **Caixa Mágica**, can't have. The European level of innovation and the creation of innovation networks allow more innovating products, best practice and knowledge exchange and also better forecast of future trends.

Caixa Mágica considers that innovation happens in Open Source and Proprietary Software, but in Open Source projects with fewer barriers to entry due to the open code and possibility of transforming and improving it, the probability of new innovation raises. Also in Europe, because don't exist software patents, software innovation can happen in an easier way. Because usually software innovation in happens in small steps, if the software is not protected by patents the improvements and incremental innovations can be made by all. Open Source Software has that advantage, because his openness allows the creation of networks of innovation that develop in a more free way around it.

Caixa Mágica also consider that in Open Source and Proprietary Software innovation is based mainly on the quality of the human resources, the developers, researchers, analysts, designers, etc. and because of that the human resources qualification is very important. While the user is very important because of his feedback about the software they use, human resources of the companies are even more critical for innovation.

IBM thinks of innovation as a process to help customers to innovate and the R&D investment as a way develop new product and services, but also to establish collaborative and co-creation relationships with freelance developers, other companies and other institutions including customers, creating networks of innovation.

IBM also consider that by transforming themselves in a globally integrated company, by globally integrating its own business process and functions eliminating redundancies and overhead structures, they improve the capacity of innovation by providing greater clarity of key priorities around shared goals.

They don't see Proprietary Software as having any advantage over Open Source Software regarding innovation. They see the broad adoption of open standards as "essential to the computing model for an on-demand business and as a significant driver of collaborative innovation across all industries" and that broad-based acceptance of open standards — rather than closed, proprietary architectures — being more easily for the users of the computing infrastructure to absorb and benefit from new technical innovations, while allowing more innovation to thrive.

The innovation in **IBM** is based in the organization own engineers and developers, customers feedback, market research and also world developers considering the Open Source projects.

Mandriva see the innovative side of their products as result of innovation made through cooperative R&D projects that are partially founded by EU and French Government. **Mandriva** didn't develop any answer regarding the factors influencing innovation in the markets, while considering that their innovation is fruit of "our strategic vision and need to remain competitive".

Mandriva see advantages in the Open Source innovation process because is "through bottom up innovation and openness". They see it as mainly technology driven in Open Source Software and more as engineering/developing process in Proprietary software companies.

Microsoft don't think that exist a direct connection between R&D investment and innovation that are adopted with success by the market, even if the first one (R&D investment) has a positive influence over the later (innovation adopted by the market). They consider that the main innovation sources for the market and company are users (Microsoft customers or not) feedback, R&D and also the Open Source community.

Microsoft sees innovation in Proprietary Software organizations as part of their core business and survivability and not based on voluntarism like Open Source. Because of that, even if innovation can happen in Proprietary Software companies or Open Source communities, the search for it is more consistent in Proprietary Software companies, with R&D investments stronger than in Open Source projects without support from major organizations, as a more consistent way of achieving innovation and introducing in the market the products and services that innovation allows.

Microsoft doesn't see beside that too much difference between innovation creation in Open Source Software and Proprietary Software models, with the innovation sources coming in both cases from consumer's feedback and needs and also from competition pressure.

Novell don't think that exists a direct relationship between investment in R&D and innovation but consider that as software projects get more complex and the difference between Open Source Software and Proprietary Software start to blur, more and more investment must be made in both kind of software to increase the possibility of new innovations to rise. The innovation degree in the market, and also in the company, is influenced by the user's needs and competition. As examples, security and confidentiality are more and more requested in software, it's the market asking for it, demanding it, so more and better innovative solutions are needed to service the customer and to differentiate from the competitors. On other hand the different competitors must also cooperate in an open way to offer innovative solutions to the user that actually wants open standards and solutions.

Novell also consider that because in Open Source individuals develop in a more free way and also participate and share information and know-how, without the restrictions of Proprietary Software development, Open Source is a better environment to innovation happen. But innovation can happen in all sides, in Open Source or Proprietary Software because innovation came from individuals, from their thinking and that can happen everywhere. And nowadays, because many developers that work with Proprietary Software also work with Open Source code allowing Proprietary Software companies to invest in Open Source, and also develop as hobbyists, the information flows more freely and innovation can happen in all sides.

In the end **Novell** conclude that in both kinds of organizations the market needs are the main drive of innovation. The suppliers, Open Source Software or Proprietary Software companies, are oriented to the market and try to satisfy the market needs and try to find new solutions for that needs. The larger non-software companies also can innovate in-house to solve their proper specific needs.

OpenOffice.org doesn't agree that by investing more on R&D we have necessarily more innovation but consider that the knowledge network, the free exchange of knowledge like happen in Open Source community, can do more for innovation that simply investing more in R&D, even if the effect of that investment is positive. They see the main factors that influence the innovation as being the clients in the first place and competition in second.

They expect innovation to happen more in Open Source Software simply because the number of developers in Open Source community is much larger than the number of developers in any Proprietary Software company, even considering larger companies like Microsoft, and innovation came from individuals and not from the organizations.

OpenOffice.org considers Proprietary Software innovation as based mainly in customer feedback and own engineer and developers, while Open Source innovation as based main on Open Source community and also customer's feedback.

Red Hat sees innovation in Open Source Software as having a big advantage over Proprietary Software innovation because the entire world of Open Source developers (some of them hobbyists who also work in Proprietary Software companies) can be seen as sources of innovation to companies that work with Open Source Software.

The factors that influence innovation inside **Red Hat** are "clear customer demand" and situations where the "Open Source community may not have knowledge or ability to drive innovation" showing as a perfect example of this their S(ecurity)E(nhanced)Linux. The innovation in **Red Hat** is based in "a mix of customer feedback and user-driven innovation. We frequently make R&D work from the ideas of some of our largest customers."

Red Hat also considers that innovation is more expected in Open Source projects where "(a) small modular tools can add up to big changes and (b) the typical user can participate in the ongoing development of the project". They see as examples the success of projects like Apache and Drupal, where people who build web technologies have a high incentive to build modular web infrastructure tools.

Sun see as the main innovation source the human resources and also patents that allow the development of improvements, because fracturing developments are rare and are more common improvements of existing software code. In the market there exist product improvements made by competitors that stimulate innovation and requests from customers by suggesting improvements or asking for improvements they saw in competitor's products. Usually the main innovation in the market is a "better way of doing something", gradual improvements, better algorithms. Sometimes fracture innovation happen by a new "impulse" idea that is taken by somebody and developed later on but that is not as common.

Sun considers the main source of influence on own innovation their customers and competitors. Both influence also the degree and pace of innovation like happen on Sun projects like “Looking Glass 3D”, where through the new graphic possibilities of computers they develop 3D interfaces like game interfaces to the business world, or project “Sun Wonderland, 3D for Enterprise” where innovation based on technologies applied in videogames is adapted to the business reality.

When questioned if innovation is easier to happen in Open Source Software or in Proprietary software, **Sun** see it happen in both worlds. As examples they considered that the later Internet Explorer (Proprietary Software) versions copies developments in Mozilla Firefox (Open Source) and vice-versa, xml documents exist in OpenOffice since 2000 and now is in Microsoft Office, etc. Usually Proprietary Software when achieve market domination has lower incentives to keep the degree of innovation because is more concerned with costs and profits. That happened with Windows and Internet Explorer. Microsoft for instance, halted new versions of Internet Explorer for a few years, with version 6, and had no intention to introducing a new version except when integrated with Windows Vista. They changed their minds with the success of Mozilla Firefox and introduced Internet Explorer 7 before the launch of Windows Vista. Windows also started to be developed in a bigger pace after competitive pressure from Linux. In both cases Open Source innovation were adapted or used by Microsoft. Even in early days of personal computers, Windows was a copy from Macintosh that was a copy from a concept never commercialized by Xerox.

To **Sun,** independently of the development model, there are exchange of ideas between both concepts and collective learning of developments in each of the concepts. They don’t see any reason to say that innovation can happen more in Open Source then in Proprietary Software or vice-versa. In Open Source Software, since there is less constraint regarding company objectives, financing, etc., some innovations have big chance of thrive because there are less restrictions in inventing, fantasizing, there exists more development freedom. In Proprietary Software the development investment has more strict financial objectives.

Sun consider that Proprietary Software advantages like deep market studies, better knowledge of the consumers are lower and lower because feedback and input from customers to Open Source Software are more and more common and usually Open Source Software has a better capacity of integrate that feedback and input on their software because of bigger flexibility. Even if Proprietary Software is improving in this matter, life cycles of software are shorter in Open Source with Linux has upgrades each 6 months or less. In complete new versions time between product introductions is larger, usually years but getting shorter because competition is getting stronger for Open Source Software and Proprietary Software.

As an example, **Sun** referred OpenOffice as too integrated to allow new versions in short time, so is being changed in the last years to a more modular system that allow input from customers and faster upgrades. Also extension (add-ins) for specific needs will be allowed like Alfresco (Enterprise Content Management (ECM) software). **Sun** see as the biggest disadvantage for Open Source Software their lower marketing communication, less known products and less brand awareness.

Open Source Software organizations sustainability in the market

From the software market analysis one further specific question arises. If companies that develop Proprietary Software can sell the licenses as the main source of revenues, behind the support services they also can offer, how can Open Source Software companies survive and have financial resources to innovate, if the licensing is free and not a source of income? As showed in the different business models for Open Source Software presented by Raymond (1999), Schiff (2002), Koenig (2004), Krishnamurthy (2005), Open Source Software companies usually have support services as main source of revenues even if OSS and PS companies' strategies and revenues sources are converging in recent years (Campbell-Kellya and Garcia-Swartzb 2010). Is that enough for the survival in the market?

Enquiry results

Caixa Mágica considered that its business model, based mainly on support services even if they also sell Caixa Mágica Linux (package with CD, manuals, some support, etc.), is strong enough to allow the survival on the long term. The company has profits that show the viability of their business model. They think that a similar business model will allow the survival of similar companies but that may not work with all of them. Being an Open Source company or Proprietary Software company is not a guarantee of survival. The company financial structure, their differentiation and software quality, the targeted market segments, all that factors have influence over the survival of any kind of software company.

Mandriva presented as main source of revenues e-commerce sales of Mandriva Linux boxes (package with CD, manuals, some support, etc.) and electronic downloads of Linux "packs" that include services, OEM agreements in emerging markets and services like consulting, training, support and maintenance to corporate customers. They believe in their surviving because they expect to reach break-even in 2008, but don't guarantee that other Open Source companies can survive in same way, because of "many other influential factors". **Mandriva** considered also that beside the Open Source business models, many factors have influence over the surviving of the companies like in many other markets. Quality of the software and services offered, for instance, are critical for the surviving of any software supplier.

Microsoft has all kind of revenues source, including license selling, support services and consulting services. They see their business model as going gradually from mainly license selling to license plus services selling in an integrated form and even other kind of business models like providing software for free in Internet and having ad revenues. Microsoft sees his model as allowing their survival and also the survival of companies with similar models.

But **Microsoft** also see the Open Source model of revenues source only from Support Services and Consulting Services as allowing the survival of Open Source Software companies in the market. In the end, if the software is appealing to the customers and the company structure is competitive for their business model, any kind of software company can survive in the market using one or other business model.

Novell see his own survival as possible with the sales resources that came from licensing (non-Open Source) and services and even want to increase the licensing sales with or without additional support. **Novell** also start to adopt their Proprietary Software license model to market developments. For instance, they change from selling licenses without support, which was sold as a service separated from the license, to sell a package including licensing and one year of support.

Considering Open Source Software companies in the market, **Novell** expect that only companies that can offer good support services will succeed. They don’t believe in “best effort”, a company only selling Open Source Software (package with CD, manuals, some support, etc.), because customers will only buy Open Source Software if they have technical resources on their own to implement that solutions or if their software supplier has good technical resources to offer support. If the two situations don't happen the customer will prefer Proprietary Software. To **Novell** an Open Source Software supplier with strong technical human resources and capability of offer quality support services will have success. The future of the market will be that kind of business model.

OpenOffice.org considered that their own survival is achieved by receiving support and donations from several organizations, mainly Sun that consider the strategic importance of having an Office Suite to compete with Microsoft Office Suite. But they also consider that the model of support services plus consulting services that usually Open Source Software organizations have as revenues source, as a way of market survival without licensing revenues.

Red Hat has as main source of revenue the subscription of Red Hat Enterprise Linux that the company considers to be enough to guarantee their long term survival. They presented the growth of these revenues as a survival guarantee but also, as a publicly traded company, their permanent search of new revenue opportunities.

When considering if similar companies can also survive in the market the answer was simply "it's possible": "**Red Hat** is the incumbent with the strongest brand and the only pure Open Source company that's making a lot of money" they told. So even without the same success they believe that other companies can survive with the same business model.

Sun has a business model based on the selling of hardware and software licenses, with support and consulting services also having a strong component, as a guarantee of survival. They have services and consulting in Open Source projects and also contribute to several Open Source organizations like OpenOffice.org.

Sun also consider that Open Source companies can survive in market with support and consulting services. They referred MySQL (bought by Sun) as an example and quote MySQL president as saying, regarding Open Source Software business model: "There are 2 kinds of persons (organizations), the first ones with time but without money and the second ones with money but without time. The first ones have time to test and install Open Source Software, don't buy it but give it more notoriety. The second ones don't have time but have money. They buy Open Source solutions that include support and consulting services. The second ones are the consumer target that allows the survival of Open Source companies as a viable business model, like happened with MySQL that survived and grow even before bought by Sun."

This survival hasn't the same profitability that happens when a company dominates a market and sells software licenses, but with the software commoditization, more and more the consulting and services will gain importance as source revenues in the market. **Sun** added that for that survival to be assured the market share of Open Source Software must rise and that's difficult because the dominant company, Microsoft, has a model of consumers lock-in with help of network effects on both hardware suppliers and also consumers. Even if companies recognize the enormous cost of Proprietary Software solutions, they are afraid of change, they consider the risks of going to Open Source Software (switching costs) as high. **Sun** showed as an example that until recently almost 100% of desktops and notebooks were sold with Windows installed. For almost all the user and even more in notebook computers, the switch to Linux was difficult to make. Only recently notebooks started to allow choice between Windows and Linux.

Sun also referred that on the Office Suite market, even with all versions of it starting to using open files formats allowing the use of the files in any version of Office, Proprietary or Open Source, Microsoft is trying to lock professional consumers with SharePoint, a document management application included in the Microsoft Office License Agreement that is installed with MS-Office and that only work with Microsoft products like MS-Office, Internet Server and Exchange. Blankenhorn and Rooney (2007) studied this new kind of lock-in that appeared in the market, created by applications integration and not file formats. They concluded that there is more freedom with open file formats of Office Suites but less with applications like SharePoint that don't allow, for instance, the replacement of the Microsoft Office or Exchange with other Proprietary Software or Open Source equivalent applications. Even if Open Source has all the same components of software to allow a similar solution they still don't have the same degree of integration. Microsoft knows this and offer SharePoint to install with Office. With all the Microsoft components installed and integrated, is almost impossible to change some of the components with an Open Source version.

This kind of situation turns the competition of Open Source more difficult because of the technical aspects of connection and integration of the Proprietary Software (Microsoft in this case) components and the survival of companies that want to offer similar solutions more difficult.

Other problem considered by **Sun**, mainly with the younger users between ages around 12 to 24, is the mystification that Windows or MS-Office is "free". That happens because Windows is by default the Operating Systems of notebooks (the computer category with the biggest slice of sales in this market segment) and also because everybody find a way of having a pirate copy that software. The same happen with Microsoft Office so the Open Source OpenOffice advantage of free price is lost because everybody sees Microsoft Office also as a “free” product.

Regarding the Operating System for instance, to **Sun** the Open Source Software Operating System must be more attractive the young segment and also better known by that segment. As an example they referred 3D files, possible with Windows Vista Aero but also with the last versions of Linux, without that feature known by many users. That’s a marketing communication problem of Open Source when comparing with the marketing communication resources that companies like Microsoft or Apple invest.

Summary

In summary, as in the case of the Actors, there exists some consensus between software suppliers about the way the Transformation Process, software projects in this case, are defined and organized.

If in companies developing Open Source Software or Proprietary Software there exist a hierarchical coordination and all the organization around it is similar, in Open Source community it’s expected a “bazaar” (Raymond 1999, 2001) software development organization. But with the rise of the Open Source Software projects dimension, we also start to have a more hierarchical organization with coordinators, schedules and timelines to releases introduction, even if developers are free to offer their inputs without obeying them because their inputs go through quality filters and are introduced in the releases if they arrive in time. That’s happen with the Linux core for instance.

All the companies interviewed also considered that innovation can happen both in Open Source Software and Proprietary Software projects, while also considering some aspects that can have some positive or negative impact over it, like the more free and open to know-how share of Open Source Software or the more focused development process of Proprietary Software but without recognizing any of this as a surmountable advantage.

There was a consensus that we don't have necessarily a direct connection between amounts of investment in R&D and innovation creation, even considering that R&D investment is important. When talking about factors that influence the innovation degree in software suppliers and markets, usually no distinction was made between both situations and between Open Source Software and Proprietary Software. The main influential factors considered by the software companies interviewed were customers and competitors, with Caixa Mágica considering only the relevance of the feedback role of the customers and Sun and Caixa Mágica also considering as important the human resources.

As an illustrative example of R&D situation we present in Table 9 the R&D investments of some important software companies in absolute values and as sales percentage. We have different situations, not influenced by the fact that companies work with Open Source Software or Proprietary Software (table 9). But as concluded before, even if investment in R&D innovation is important, it's not a guarantee of innovation.

Table 9. Sales and R&D of IS companies (millions US$)

Company	Sales 2006	R&D 2006	%	Sales 2007	R&D 2007	%
Apple	19,315.0	712	3.7%	24,006.0	782.0	3.3%
Corel	177.2	25.9	14.6%	250.5	44.7	17.8%
IBM	91,424.0	6,107.0	6.7%	98,786.0	6,153.0	6.2%
Mandriva (1)	5.7	2.0	35,0%	4.3	1.5	35.0%
Microsoft	44,282.0	7,650.0	17,3%	51,122.0	10,693.0	20.9%
Novell/Suse	919.3	180.4	19,6%	932.5	208.4	22.3%
Red Hat	278.3	40.9	14,7%	400.6	71.0	17.7%
Sun	13,068.0	2,046.0	15,7%	13,873.0	2,008.0	14.5%

Source : Financial statements of companies (1) Euros. R & D with financial support from EU and French government funds

Regarding survival on the market of Open Source Software companies, all the companies interviewed considered the services business model of Open Source Software as allowing the survival of the companies working with that model. The software company success in the market will depend on factors like software quality, service quality, market segment targeted, company structure, the kind of factors that influence the success of companies in all IS market, either in the Proprietary Software or Open Source Software business models. Actually we have in the market the following kinds of business models:

1. Companies like IBM, Novell and Sun that even if investing in Open Source projects and offering to the market Open Source Software solutions, have also other sources of income and are not completely dependable of income from services connected with Open Source Software, so their survival and resources to make investments in Open Source projects are big. IBM for instance, is present in all market segments and has different revenue sources like license selling, support services, consulting services and also hardware, business process services and outsourcing

services. 37% of IBM revenue sources are from different kind of services including services associated with support to Open Source Software projects. Sun, working mainly with large companies, government and education markets, also has a revenue structure that makes it not dependable of Open Source Software revenues to survival and allow this company to put resources on Open Source projects, including projects like OpenOffice.org that have as source of revenues donations from different organizations and users.

2. Proprietary Software companies that also use Open Source Software code even if trying to avoid any GPL licensing code, like Microsoft for instance. Microsoft, the biggest software company in the world with monopoly power in markets like personal computer Operating Systems and Office Suites, covering all the market segments, has a business model mainly based on licensing selling.

In the last years due to changes in the software market, with the introduction of the business model of software giveaway with revenues from ads, dominated by Google, or the Open Source Software model of offering software and receiving revenues from services connected with that software (SAAS – Software As A Service), Proprietary Software companies like Microsoft started to upgrade gradually its business model by also entering in the ad revenue and also the SAAS business models, the last case with their own Software plus Services model (Ballmer 2007).

3. “Pure” Open Source Software companies like Caixa Mágica, Mandriva or Red Hat have their main financial resources from the selling of services and consulting and see that business model as allowing their survival, since they consider that they have a good company structure with all the resources needed to satisfy the consumer needs with a quality offer.

4. Foundations like Mozilla that created the Firefox browser or OpenOffice.org, that are in the market with large projects with lots of contributors and a more professional structure, and are dependable of donations, mainly from the biggest Microsoft competitors that want to indirectly to compete against it, in this case in the browser and "Office Suite" markets.

When we consider "pure" Open Source Software companies and their business models, we saw by the feedback from the companies interviewed that we have more frequently business models like "Give away the recipe, open a restaurant", that is the distribution of Open Source Software with the selling of support and consulting contracts (Schiff 2002), similar to the "subscription" described by Koening (2004). They also have dual licensing offers, with one of the licenses free but the software limited in some instance and not allowed to be used in commercial applications, and a licensed version with all the services and features associated (Koenig 2004). When we analyze the market using Krishnamurthy (2005) methodology we see that the main category of Open Source companies are the "Distributors" like Red Hat or Caixa Mágica and "Third-Party Service Providers", whose only source of revenues is support service so they will offer it to any Open Source Software (Operating System or application) that has enough dimension in the market to allow their profitability and survivability. The reason why companies contract these support services is because they don't have technical resources inside and prefer to pay for higher quality and availability of support services than from informal mailing lists or user groups of the Open Source community. Krishnamurthy (2005) analyzed also the profit potential of Open Source companies in the market and concluded that the profit potential is higher when the software has a higher importance for their clients like the case of Operating Systems or specific applications used in the core business of the clients, where we have respectively "Star" companies selling the same software, of critical importance to users, to the majority of the market and "High Profiler Nichers", servicing specific market niches that need specific versions of software or services. We can consider the companies interviewed for this thesis as "Stars" in the market, with higher profit potential.

All companies interviewed, even Proprietary Software companies, considered that with the Open Source business models considered above an Open Source company can survive in the market, considering the usual influencing factors for survivability in the market like company structure, quality of service and consulting, the characteristics of the market segment target and company offer.

As the literature review about the competition between Open Source Software and Proprietary Software also concluded, Open Source Software as whole can succeed if some conditions are satisfied: the lowering of implementation costs (Mustonen 2003); the rising of "indirect network effect" based on the legal and legitimate access by the Open Source users to a large number and variety of free applications", that can at least lower the network effects barrier (Bonaccorsi and Rossi 2003); the rise of human resources with Open Source knowledge that will lower implementation costs (Lin 2004). But Lin (2004) also considered that behind all this, in the medium to long term the Open Source will also have price pressure from Proprietary Software competition and will only succeed if it also "has better relevant features and functionalities to the consumer than the incumbent proprietary standard".

When considering the Open Source profit potential, two of the key factors presented by Krishnamurthy (2005), the support of Open Source community and the presence of a dominant Proprietary Software, were considered in the interviews answers about survivability of Open Source Software companies. Proprietary Software companies don't see for now that competition with Open Source companies can impact their profitability, considering the innovation as a differentiator factor that could rise the market position and profitability of innovative software companies.

Adding to this consideration we have the research results presented by Campbell-Kellya and D. Garcia-Swartzb (2010) showing the strategies convergence between OSS and PS companies including in R&D investments, acquisitions, and revenues sources with dual licensing by the OSS companies, etc.

In the end, and consistent with the literary review, we have a consensus in the market about the strong probability of success of software companies whose offer to the market is mainly support and consulting to Open Source Software. All considered that the critical factors for the survivability in the market has been general market and competition factors not specific of any kind of business model (Proprietary Software or Open Source Software) but common for all the business models and companies present in these and other markets.

5.2.4. Worldview

In this thesis the Worldview as considered by Checkland (1981), is presented by considering in the thesis the different point of view of the managers of the different companies (Table 10), while trying to give a global vision of their organization and the IS market as viewed by themselves as company managers.

Table 10. SSM Worldview

Company	Contact	Functions
Caixa Mágica	Paulo Trezentos	Chief Executive Officer (CEO)
IBM	Manuel Sá da Costa	University Relations IBM Portugal
Mandriva	François Bancilhon	Chief Executive Officer (CEO)
Novell/Suse	João Baptista	Novell-Portugal (CEO)
Microsoft	Carlos Lacerda	Europe Information Worker Division Manager
OpenOffice (through ESOP (Associação de Empresas de Software Open Source Portuguesas)	Rui Ribeiro	Sybase Professional Services Manager
Red Hat	Greg DeKoenigsberg	Community Development Manager
SUN (including MySQL)	Paulo Vilela	Systems Architecture Manager

This Worldview is complemented by the results of the questionnaires presented to customers about factors like image of quality and innovation of the IS suppliers.

5.2.5. Owners

Several kinds of owners (persons or groups who have control over the system Checkland (1981)) are present in the software market when we consider both, Proprietary Software and Open Source Software.

When we talk about Open Source Software and even more the GPL license, we don’t really talk about owners because the software is free and the code available for all, even if the name of the code developer is always recognized. The software can be developed by individual users, user’s communities, private or public capital companies but there is no ownership because the source code is available for all to use it, integrate it in other software, adapt it to specific needs or improve it. This adaptations or improvements are also available for all free of charge.

The Proprietary Software on other hand belongs to the company that develops it. The company has legal rights over it including patents and usually the source code is not available outside the company. The Proprietary Software companies can integrate Open Source Software in their Proprietary Software, improving it or not, but all the source code of the derived product (if the Open Source has GPL license) must be available for all. Only if the Open Source code has a non-GPL license the Proprietary Software company is not obliged to make freely available the source code of the derived product, not even of the improvements made to the Open Source code when integrated with the Proprietary code.

The owners at a higher level are the stockholders of the public or private companies that develop Open Source Software and/or Proprietary software, with the first ones owning the transformation process that offer revenues mainly through training and support services and the second ones owning the transformation process that offer revenues mainly through licensing of the software but also through training and support.

In the users communities that develop Open Source Software the "owners" in a more broad sense are the developers, but also all other individuals that contribute to these communities simply because they believe in the Open Source concept projects or have any other personal reason that make them want to belong to some community.

Summary

In the end, directly or indirectly the "owners" define the "business model", how software will be supplied to the market and the "price" of it (whatever is that we can consider “price”), taking in consideration that the main objective is the survival in the market and/or profitability.

5.2.6. Environment

What is the influence of the environment and their various constraints (Checkland 1981), on the IS market? What kind of factors, like economics, competition, customers, regulation, Government, etc. have more influence on the actual situation and future development of the market?

Enquiry Results

Caixa Mágica considers that costumers are the biggest market influencers. Costumers by expressing their needs are the main drives of the market development. Competitors also have strong influence because they fight for the market with **Caixa Mágica** and try to offer the best and more differentiate product to satisfy customer needs. Government has little impact over the market and their purchase power only influences the suppliers to offer more competitive products. Crisis like the actual economic and financial crises don’t have too much impact because Information and Communication Systems are the infrastructure of the actual world and even if some impact happens and customers try to find cheaper solutions, Open Source Software has advantage over Proprietary Software.

IBM considered more general environment factors like globalization, dislocation and emerging markets as having strong influence over the way the IS market is developing regarding hardware, software, services and human resources working for it.

They considered that countries like the called BRIC (Brazil, Russia, India and China) group, with around 40% of the world population and where the IS market is still developing, will have strong influence over future standard choices, future dominating software license systems (Open Source versus Proprietary software) and many more aspects of the market. For instance, Brooke Crothers (2008) presented in a blog the new processor Godson-3 developed by the Chinese Academy of Sciences, compatible with the world standard x86 architecture, has the objective of give microprocessor independence of China and allow a cheaper package of computer with Linux and OpenOffice for the large millions of Chinese students and other citizens. This kind of developments will have a very strong influence how the world will choose its standards in the near future.

Mandriva consider customers and competitors well above all the other factors and in this order, as the main influential factors on the evolution of the market and companies working on the market.

Microsoft sees technology adoption by customers and competition has the main influential environment factors in the market. The competition is more and more based only on quality and product value for the customer because the standards are becoming more open and interoperability demanded from customers these days. **Microsoft** considers that “actual competition is not mainly between different standards as before, because standards are more and more open, but between product quality and value for a customer that in his choices has now more influence over the market.”

Novell was pessimistic about the economic influence over the IS market. While also considering that customers and competitors are the main influencers of the market, they see adverse economic situation (like the 2008 financial crisis) also having a strong negative impact in the short term. Adverse economic conditions had negative influence on the investment capacity of customers but also of suppliers, that in that situation only invest in the core business and less in projects that only create benefits in the medium to long term. **Novell** considered that in this kind of situation government help is critical.

Novell don't think that IS companies can avoid the impact of financial crisis but that in this kind of situation they always try new solutions to survive. The new offer of subnotebooks by hardware suppliers, at around half the price of the cheapest notebooks, was mainly to attract customers that are cutting in IS investments in difficult financial times.

OpenOffice.org considered as the main environment factors with influence on the markets the competition and also the larger customers. These customers, with their own professional IS infrastructures that know what their needs are, want that needs satisfied by the software suppliers (Open Source Software and/or Proprietary Software) and by their demanding they can influence all the market evolution.

Sun while thinking in similar way about customers and competition influence over the market also considered specific aspects of how competition can be influenced "… some tenders by big organizations are not very open because they already have some conditions for the software to be bought…", for instance, Microsoft Windows or Microsoft Office completely compatible. To **Sun,** tenders to completely new projects, like the Portuguese ID citizen card (special card with chip to keep the numbers of citizen, health care, voter, tax, etc.), are more open to all kind of software and formats. **Sun** considered that government influence (regulation or anti-trust actions) usually as "too little, too late".

Red Hat also considered customers and competitors as the main influential factors on the market and all the others as few relevant in the medium and long term.

Summary

Regarding the Environment Influence over the market, all the companies considered customers and competition as the most important influential factors of the market evolution. All the companies interviewed considered the needs and choices of the different market segments as a strong influence on the IS market, with each market segment having more influence on the specific IS solutions they use in their activities. Competitors by their competitive strategies also have natural influence in market evolution. About this **Sun** also considered aspects that can have negative influence over the competition and market evolution, like some software project restrictive tenders or software solutions to lock-in the customer. While **Caixa Mágica** also cited factors like economic situation without giving it much importance, **Novell**, maybe because is a company more exposed to that kind of impacts, considered the economic crisis and also the need of Government financial help in this situation, as important environment factors that could influence the market in the short term. None company considered the government regulation influence as important.

5.3. Main results of the research – Supply Side

Four hypotheses were made regarding the supply side of the software market and studied with the Soft Systems methodology. The results obtained confirmed the four hypotheses.

Hypothesis 1s: Not only the Open Source Software model is viable considering the capacity of attraction of the needed skilled developers, but also its software project development model is as capable as the software project development model of Proprietary Software, to which the Open Source model approaches as the software projects get more complex and professionalized.

It's expected that Open Source Software will continue to attract from the worldwide developer's pool the needed number of developers for this model viability, even if the motivations and rewards (no-monetary and monetary) can change during the life cycle of the developer and also the life cycle of the market. There is consensus that both developing models, more hierarchal centralized in the case of Proprietary Software and decentralized and sometimes with lower coordination in Open Source Software, allow the supply of quality software. There was also recognized that, as the Open Source Software projects get more complex and/or controlled by professional commercial organizations, the Open Source Software development model approaches the more hierarchical centralized model of Proprietary Software.

Considering all this, Hypothesis 1s is confirmed.

Hypothesis 2s: The Open Source innovative process can be at least as productive in creating innovation and introducing it to the market as the Proprietary Software innovation process.

Even if in the literature review we concluded that there was no consensus about possible innovation advantages of Open Source Software or Proprietary Software development models, there was consensus between the market suppliers that since innovation is a human creation, innovation can happen everywhere where there is a developer. They didn't recognize an insurmountable advantage of one development model over the other in the innovation process, considering each of them with their strength points and also their weaknesses.

As we see, Hypothesis 2s was also confirmed.

Hypothesis 3s: Even if the Open Source Software licenses are free, Open Source Software has costs at least for some of the consumers that want to use it.

This hypothesis that Open Source Software monetary costs exist for some costumers even with free licensing, was answered in an indirect way. Open Source Software users, even if not all of them, pay by the use of Open Source Software, even if not for the licenses themselves. The recognition of economic viability of different business models for Open Source Software, the existence of monetary revenues even for companies that work only with Open Source Software and also the confirmation of Hypothesis 4s (analyzed below) that also implied the survival of organizations that work with Open Source Software, confirm Hypothesis 3s.

As Sun manager cited, paraphrasing MySQL's CEO Marten Mickos, “There's a difference between organizations that have more time than money and organizations that have more money than time; the first ones have time to test and install Open Source Software, don’t buy it but give it more notoriety. The second ones don’t have time but have money. They buy Open Source that includes support and consulting services. The second ones are the consumer target that allows the survival of Open Source companies, a viable business model.”

Hypothesis 4s: Open Source Software can compete in the market against Proprietary Software and even compete and obtain market gains when Proprietary Software is the dominant incumbent.

There is also consensus in the research theory, confirmed from the answers of the software suppliers that Open Source Software can compete against Proprietary Software. This consensus happen even considering that the first is characterized by the openness of his code and the free licensing and that in many specific categories of software the market is dominated by Proprietary Software, which is almost monopolistic in some cases, with all the benefits that, for instance, network effects give to that position in the market. The suppliers also agree that is their own inner organization (management and development), the features and quality of the software they offer, and also the quality and relation price/quality of his service, support and maintenance, besides market factors like network effects, that will be the main factors of competition and not the “advantage” of Open Source Software as having free licensing in the market. This confirms Hypothesis 4.

Summary

We concluded that the market perception is that Open Source Software and his business and development model is in the market to stay, being competitive and innovative enough to compete against the Proprietary Software, which in many cases is the dominant in the market. The financial survival of Open Source Software companies is as possible as Proprietary Software companies survival, even if the business models are different without revenues from licensing in Open Source Software business models. This answer research question 2.

We also concluded that the "price" of Open Source Software isn't zero for all customers. Even if licenses are free and costumers that only want the software will not pay for it, there will be always costumers that will opt for paying of a "package" that includes support and training and that prefer to pay to assure responsibility from third parties for their installed Open Source Software. While not covered on this thesis, we can consider that as the software gets more complex and critical for the costumers (Server Operating Systems for instance), the option for the payment of Open Source Software solutions will be higher, even if licenses are free. This answer research question 3.

5.4. Demand side

We are going to analyze the different variables and constructs that have influence in the consumer choices of personal computer Operating System and Office Suite, through the data collected with the questionnaire. After that conclusions about thesis hypothesis and research questions of the market demand side will be presented.

5.4.1. Companies' sample

To collect data on the demand side of the market, companies that are users of IS, a questionnaire was placed in ISEG site http://student.iseg.utl.pt/joaorosario/index.htm. The divulgation of this research was made with a link to the enquiry that appeared in the site of IDC (Appendix 29). An email was also sent to a database of 4800 companies present in the Portuguese market. From the 4800 we had 1661 returned email errors, and 3139 emails arrived the destination, from which we don't know the percentage of email that were lost in spam filters. In the end we had 95 questionnaires returned, a small response rate (around 3%) but that can be considered as a good response rate considering: the large number of emails that were send, where in many cases for companies without IS department and it was impossible to have the absolute assurance that the receiver of the email was the best person to answer it (even if the email introduction asked for it to be forwarded to the capable person for answering it); spam filters that always topped the emails in several situations; and the subject of the questionnaire, that could be considered by many companies as a sensible subject, because of the questions about the number of computers in the company, brands of Operating Systems and Office Suites installed, etc. That could be seen as a way of a company to reveal if his software licensing is legal or not, in a country with a large percentage of software piracy, near 50%.

Of these 95 questionnaires we cancelled one of them because of a mismatch in a validation question, so we ended with 94 questionnaires.

5.4.2. Demand side statistical results

We will now present the results of the questionnaire answered by the organizations (‘companies’, ‘users’), starting by showing the profile of the companies included in the sample. Several variables to classify each company where included in the questionnaire like the “CAE-Código de Actividade Económica” (Economic Activity Code), their legal structure, number of workers, sales volume, district localization, if the company has an IS department, number of computers, percentage of notebooks, operating systems of the computers.

Companies’ Economic Activity (CAE)

As presented in Table 11 the sample has 44% of companies in the Transformation and Construction activities (secondary sector), versus 28.2% in an IAPMEI study (2008), and only 3% in the primary sector. Several services activities (tertiary sector) represent 54% of companies in the sample.

Table 11. Companies’ economic activity

Sector	Nr. of companies	%
C-Transformation Industries	31	33%
G-Wholesale and retail trade	16	17%
F-Construction	10	11%
S-Other service activities	9	10%
H-Transports and storage	6	7%
M-Consulting, scientific, techniques and similar activities	5	5%
A-Agriculture, animal production, hunting, forest and fishing	2	2%
D-Electricity, gas, steam, hot and cold water, cold air	2	2%

Table 11. (continuation)

Sector	Nr. of companies	%
E-Captation, treatment and distribution of water; sanitation, waste management and depollution	2	2%
I-Accommodation, Food & Beverage and similar	2	2%
J-Information and communication activities	2	2%
K-Finance and Insurance activities	2	2%
N-Administrative activities and support services	2	2%
L-Real estate activities	1	1%
O-Public and defense administration; Mandatory social security	1	1%
Z-No answer	1	1%

Companies' legal structure

While keeping the Portuguese legal names because the direct translation sometimes is not correct because of differences between legal structures in different countries, we can see that the "Sociedade Anónima" (Corporation) represents the large majority of the sample with 78%. The "Sociedade por Quotas" (Limited Liability Partnership) represent 15%. All other legal structures together represent only 7% (Table 12).

Table 12. Companies' legal structure

Legal structure	Nr. of companies	%
F-Sociedade Anónima	73	78
E-Sociedade por Quotas	14	15
C-Sociedade Unipessoal por Quotas	3	3
D-Sociedade Civil sob Forma Comercial	1	1
H-Sociedade em Nome Colectivo	1	1
I-Cooperativas	1	1
X-Governo	1	1

The sample Legal Structure distribution is not the same as the Legal Structure distribution of the Portuguese companies and other organizations, where the largest majority is Small and Medium Size Enterprizes of which the large majority is not “Sociedade Anónima” (Corporations). We can try to explain this result for two kinds of reasons. First, the Micro, Small and Medium Size Enterprizes don’t have staff and/or knowledge to answer to this kind of questionnaires due to limitations of IS knowledge. Second, the same companies, mainly the micro and small companies, are more suspicious of this kind of questionnaires about their inner works than the largest companies that usually are more comfortable to share information that they don’t see as confidential. The software piracy situation also has influence, because is common in the smaller companies that for that reason don’t want to answer to this kind of enquiry about computers and software they own.

Companies’ number of workers

For reasons similar to the above, while in Portugal 99.6% of the companies are micro (less than 10 workers), small (less than 50 workers) and medium (less than 250 workers) companies (IAPMEI 2008), they represent only 62% in our sample, 38% are the considered large companies.

Table 13. Companies' number of workers

Number of Workers	Nr. of companies	%
100 to 249	27	29%
50 to 99	18	19%
250 to 499	16	17%
500 to 999	11	12%
10 to 49	9	10%
1000 to 4999	7	7%
1 to 9	4	4%
More than 4999	2	2%

Company sales volume

Considering sales volume the companies classification is: micro (sales volume lower than 2 million Euros), small (sales volume lower than 10 million Euros) and medium (sales volume lower than 50 million Euros) companies (IAPMEI 2008); all the others are considered large companies. This second variable of classification means that is considered after the number of workers that is the first classification variable. Regarding sales volume we have Small and Medium companies representing around 55% of our sample for the same reasons cited above.

Table 14. Companies' sales volume

Sales Volume	Nr.of companies	%
More than 9 million and less than 43 million Euros	43	46%
More than 43 million and less than 100 million Euros	20	21%
More than 1 million and less than 9 million Euros	15	16%
More than 100 million Euros	10	11%
Less than 1 million Euros	3	3%
No Answer	3	3%

Company geographic distribution (district)

The geographical distribution (district) of the location of the headquarters of the companies in the sample follows the main economic activity locations in Portugal, namely the west coast districts of Lisboa and Porto, largest Portuguese districts, representing 63% of the companies. If we add the other west coast districts (from north to south), Viana, Braga, Aveiro, Leiria, and Setúbal, all together represent 88% of the company locations in the sample.

Twelve of the eighteen Portugal districts are present in the sample and also Açores archipelago. By observing the Table 15 we can see the main differences between the companies sample geographic and the companies' population geographical distribution. This is only an approximate image of the reality because many of districts belong to more than one administrative region. We considered here the district included in the administrative region where the district capital is located.

We see that Lisboa and Vale do Tejo companies are over represented in sample, 42% versus 33% while Madeira or Alentejo are underrepresented with values of 0% against 2% and 2% versus 5%.

Table 15. Company geographic distribution (district)

District	Nr. of companies	%	Administrative Region	Companies %
Beja	1	1%	Alentejo	5%
Évora	1	1%		
Faro	2	2%	Algarve	5%
Açores	3	3%	Açores	1%
Aveiro	11	12%		
Leiria	4	4%	Centro	21%
Viseu	3	3%		
Lisboa	37	39%		
Santarém	2	2%	Lisboa e Vale do Tejo	33%
Setúbal	1	1%		
Madeira	0	0%	Madeira	2%
Porto	22	24%		
Braga	6	7%	Norte	33%
Viana	1	1%		

Companies' IS profile

The questionnaire has an IS profile of the companies presented in the sample, namely if they have IS department, their "dimension" considering the number of computers, the weight of the notebooks in the total number of computers and the Operating Systems installed in the computers.

IS department

Regarding the presence of an IS department in the company structure, 86% of the companies in the sample have IS department. This result was expected since the smaller companies, usually without an IS, are underrepresented in this sample. Another reason for that underrepresentation could be that companies without IS department, that outsourced the IS of the company or without IS complexity, seem to be less attracted to answer a questionnaire about a subject they consider that don't having enough knowledge to answer.

Table 16. Companies' IS Department

Question	Yes	No
Company has IS Department	86%	14%

Number of computers

The distribution of number of computers between the companies in the sample shows that the large majority of the companies, 86%, have less than 250 computers while only 62% of the companies have less than 250 workers. This bias can be also considered to be caused by the largest weight of the Transformation Industries and even Wholesale and Retail Trade activities of the companies in the sample, sectors where is expected that the number of computers per worker is lower than in other economic activity sectors like Consulting.

Table 17. Number of computers per company

Number of computers per company	Nr. of companies	%
100 to 249	27	29%
50 to 99	26	28%
10 to 49	23	24%
250 to 499	5	5%
1000 to 499	5	5%
1 to 9	4	5%
500 to 999	2	2%
More than 4999	2	2%

Percentage of notebooks

While the number of notebooks sold in Portugal increased in number and the percentage of notebook sales in Portugal is larger than the percentage of desktop sales (IDC 2009), the desktops still dominate the number of computers in the companies, with more than 40% of the companies in the sample with a percentage of less than 10% of notebooks (Table 18). With the notebook sales larger than desktop sales over the last years we expect that that the numbers of notebooks present in the companies will slowly raise as installed desktops are turn obsolete and are retired.

Installed Operating Systems

The results about the Operating Systems installed in the notebooks and desktops of the sample just showed what was expected; the dominance of Microsoft Windows with 49% of the companies having only Microsoft Windows and 89% of the companies with Microsoft Windows installed in more than 90% of the computers.

Table 18. Percentage of notebooks in the companies

Percentage of notebooks	Nr. of companies	%
10% or less	38	40%
11% to 20%	20	21%
31% to 40%	9	10%
21% to 30 %	8	9%
41% to 50 %	8	9%
51% to 60 %	5	5%
61% to 70 %	2	2%
81% to 90 %	2	2%
0%	1	1%
71% to 80 %	1	1%
More than 90%	0	0%

MacOS has a very low penetration in the companies presented in the sample, with 83% of them without MacOS and only 16% with less than 10% of the computers with MacOS. We can consider MacOS reality in Portugal as a niche product, present mainly in design and advertising activities.

Linux is installed in more computers of the sample companies than MacOS, with 38% of the companies having 10% or less of the computers with Linux.

In 84% of the computers we have one of the following, Microsoft Windows, Linux or MacOS. From the results we could consider that in some companies there exist computers with legacy applications (maybe with older Operating Systems like MS-DOS) or with other Operating Systems like Sun Solaris (Unix based) for workstations or some specific Operating System needed in the some activity sectors.

Table 19. Percentage of computers with each Operating System

Percentage of companies' personal computers with Windows	Nr. of companies	%
100%	45	48%
More than 90%	39	41%
81 to 90%	6	7%
61 to 70 %	3	3%
71 to 80 %	1	1%
Percentage of companies' personal computers with Apple MacOS	**Nr. of companies**	**%**
0%	78	83%
Less than 10%	15	16%
11 to 20%	1	1%
Percentage of companies' personal computers with Linux	**Nr. of companies**	**%**
0%	56	60%
Less than 10%	36	38%
11 to 20%	2	2%
Percentage of companies' personal computers with Other Operating System	**Nr. of companies**	**%**
0%	79	84%
Less than 10%	13	14%
11 to 20%	2	2%

Installed Office Suites

The results about the Office Suite present in the notebooks and desktops of the sample companies showed a large dominance of Microsoft Office. Microsoft Office is installed in the majority of the computers in 96% of the sample companies, while only 4% have the Open Source OpenOffice Suite installed in the majority of the computers.

Table 20. Percentage of computers with each Office Suite

Percentage of companies' PC with...	Nr. of companies	%
Microsoft Office	90	96%
OpenOffice.org OpenOffice	4	4%

Summary

Regarding the company profiles of the sample, we can see that while there is some heterogeneity regarding economic-financial aspects, there is a high homogeneity in the IS environment with a very dominant position of Microsoft Windows and Microsoft Office.

Can this have influence over the companies' choices regarding IS?

Dalle (1997) considered that the degree of heterogeneity has influence over the degree of the network effect. The lower the heterogeneity, like happen in the companies sample considering the Operating System and Office Suite installed in the computers, the higher the network effect influence on consumer choices as exposed in Hypothesis 6d, and the lesser the probability that alternative software options will be considered.

H6d	The higher the heterogeneity of the consumers (the lesser the network effect) *(Dalle 2003), ...*	Higher probability that the consumer will choose the alternative standard against the incumbent standard

<u>5.4.3. Operating System, Office Suite and switching to other alternatives</u>

In the end of the questionnaire we had 6 questions, about the Operating System and Office Suite used in the majority of the computers, that would also check the figures above about Operating Systems of the IS profile, and also questions about Operating Systems and Office Suites alternatives choices if considered. The results confirmed the domination of Microsoft Windows and also of Microsoft Office, as also showed above (Tables 21 and 22).

Table 21. Operating System actual situation and choices

Operating System in majority of Computers	Installed in computers	Choice for new computers	Choice if “mandatory” switch from installed
Apple MacOS	0%	4%	11%
Caixa Mágica Linux	0%	2%	4%
Mandriva Linux	0%	0%	4%
Microsoft Windows	100%	80%	66%
Novell/Suse Linux	0%	4%	5%
Red Hat Linux	0%	10%	10%

When asked what Operating System and Office Suite the company would choose if a brand new computer came without any software, still the majority preferred Microsoft Windows plus Microsoft Office with percentages of 80% and 69%, but with 27% of the sample companies choosing the Open Source OpenOffice.

Finally, when asked to which Operating System they will switch from their actual computers with software already installed, while the Microsoft domination continues, it’s less strong because we asked “but if you switch… ”. Even with this “restriction” 66% would prefer to keep Microsoft Windows, not considering switching in any situation, while 11% would go to MacOS and 10% to Red Hat Linux. In the case of

Office Suite, 50% would still prefer to keep with Microsoft Office while 31% would choose OpenOffice.

Table 22. Office Suite actual situation and choices

Office Suite in majority of Computers	Installed in computer	Choice for new computer	Choice if "mandatory" switch from installed
Apple iWork	0%	1%	9%
IBM Lotus SmartSuite	0%	1%	2%
KDE Office	0%	0%	1%
Microsoft Office	96%	69%	50%
OpenOffice	4%	27%	31%
Sun StarOffice	0%	2%	7%

In summary and considering the actual installed software and the options available for a brand new computer without software or for a computer where the software was to be switched, respectively 79% and 70% of the companies would not switch their Operating System (market dominated by Microsoft Windows) and respectively 63% and 49% of the companies would not switch their Office Suite (market dominated by Microsoft Office).

Are these results consistent with the theoretical background present in this thesis and with the others answers that the companies gave in the questionnaire?

From the company profile we concluded that the low heterogeneity in the IS (IS) environment, that has influence over the network effect (Dalle 2003), can be one of the reasons why the majority of the companies don't want to switch from the actual incumbent software.

But, can the switch option be in minority simply because the users think that the alternative is worse than the incumbent supplier, more expensive, or with lowers quality?

Supplier knowledge by IS users

We will study the companies' knowledge of the software suppliers companies, their perceptions about Operating System and Office Suite brands regarding innovation, quality and security of products, their perceptions regarding innovation, quality, security, cost and technical support of Proprietary Software and Open Source Software, and IS choices. We will see if they are consistent with the answers regarding software choices, that showed a strong preference for Proprietary Software in general and mainly for Microsoft software, Microsoft Windows and Microsoft Office.

We start the research by studying the degree of knowledge that users have about the IS suppliers in global terms. This will give an idea of the awareness problems that some IS suppliers can have.

As presented by Hypothesis 5d, several aspects of the software supplier brand image have influence over consumer choices. If the supplier is less known by the consumer, while that can be "good" if the supplier offer is weak with bad quality, it isn't if the supplier has a good offer to the market that the potential user don't know about. It's expected also that companies with worst results here will also potentially have lower product evaluation answers or more non-answers.

H5d	The better the perception of the incumbent IS supplier against the alternative suppliers (*Liebowitz and Margolis 1996*) , ...	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Supplier Company Knowledge quest6a, … quest6l

The questions 6a to 6l “about my knowledge of the software suppliers” and all the others presented from now on have a 5 point Likert scale with extremes “Completely Unknown” and “Completely Known”. Statistical tests were made to study the statistical significance of the answers.

The hypothesis made where the null hypothesis, that the respondent doesn’t consider the subject presented in the question while making IS choices versus the alternative hypothesis, that the respondent takes the subject present in the question in consideration when making that choices, H0:Median<=3 versus Ha:Median>3. The statistical test is the non-parametric Wilcoxon Signed Rank Test because of the non-normality of the questions data.

From the results showed in Table 23 we conclude that the sample companies have small knowledge about Caixa Mágica, E-Press Corp, KDE and Mandriva, (H0 not rejected) and also Red Hat (H0 also not rejected but could be considered inconclusive because result in the range between 0.05 and 0.95). By studying the descriptive statistics we see that this lack of knowledge is stronger with E-Press Corp and KDE.

Table 23. Supplier's knowledge statistics and statistical tests

Company	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Apple	4.15	4	1.08	2.66	0.00	6.59	0.00
Caixa Mágica	2.74	3	1.44	1.79	0.00	-1.95	0.98
Corel	3.59	4	1.33	1.91	0.00	3.77	0.00
E-Press Corp	1.65	1	1.00	3.58	0.00	-7.59	1.00
IBM	4.34	5	1.08	3.46	0.00	7.17	0.00
KDE	2.26	2	1.43	2.70	0.00	-4.71	1.00
Mandriva	2.69	3	1.38	1.61	0.01	-2.21	0.99
Microsoft	4.86	5	0.41	4.98	0.00	9.15	0.00
Novell/Suse	3.67	4	1.35	2.03	0.00	4.01	0.00
OpenOffice.org	3.97	4	1.20	2.58	0.00	5.62	0.00
Red Hat	3.17	4	1.58	2.14	0.00	0.68	0.25
Sun	3.68	4	1.31	1.98	0.00	4.31	0.00

5.4.4. Perceptions about software brands

If the main software suppliers are globally well known by the companies, what can we say about the perceptions they have of their software products regarding innovation, quality and security, as presented in hypothesis 5d?

For each of the software products we have questions (7 to 12) regarding the perceptions about innovation (new innovative products), quality (software without bugs, less crashing) and security (against virus, hackers, etc.) of the different brands present in the market.

Since we observed before that the dominant software environment of Operating System plus Office Suite is Microsoft Windows plus Microsoft Office, and that the majority of the companies don't want to switch from these options, we will analyze if the reason for that choice is because they consider Microsoft software superior in innovation, quality and security comparing with other brands in the market.

H5d	The better the perception regarding innovation, quality, security support, etc. of the incumbent standard	The lower the probability that the consumer will choose the alternative standard against the incumbent standard	Innovation, Quality and Security for each of the Operating System and Office Suite brands Quest7a, 8a, 9a to 7h, 8h,9h and quest10a, 11a, 12a to 10h,11h, 12h

Perceptions about Operating Systems brands

We start by analyzing the statistics and making the hypothesis tests to each of the perceptions considered, Innovation, Quality and Security of Operating Systems. The statistical methodology will be the same as above.

As we can see in Table 24, Apple MacOS and Microsoft Windows are perceived as innovative (H0 rejected). Even if the H0 is non-rejected for other Operating Systems, the descriptive statistics showed that at least Novell/Suse Linux and Red Hat Linux could be considered inconclusive, "near" the "neither agree or disagree" or even "slightly agree" answers.

Table 24. Operating systems perceptions statistics and statistical tests

Brand	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
			Innovation				
Apple Mac OS	4.10	4	0.92	2.29	0.00	6.88	0.00
Caixa Mágica Linux	2.96	3	1.07	2.88	0.00	-0.84	0.81
Mandriva Linux	2.90	3	1.07	2.39	0.00	-1.06	0.86
Microsoft Windows	3.98	4	0.67	2.69	0.00	7.66	0.00
Novell/Suse Linux	3.10	3	0.89	2.74	0.00	0.81	0.22
Red Hat Linux	3.11	3	1.06	2.29	0.00	0.64	0.26
			Quality				
Apple Mac OS	4.15	4	0.79	2.44	0.00	7.39	0.00
Caixa Mágica Linux	3.22	3	0.99	2.23	0.00	1.86	0.03
Mandriva Linux	3.23	3	1.04	2.14	0.00	1.85	0.03
Microsoft Windows	3.46	4	0.98	2.36	0.00	4.09	0.00
Novell/Suse Linux	3.56	3	0.84	2.64	0.00	5.02	0.00
Red Hat Linux	3.54	3	1.06	2.24	0.00	3.91	0.00
			Security				
Apple Mac OS	4.13	4	0.89	2.35	0.00	7.05	0.00
Caixa Mágica Linux	3.49	3	1.06	1.89	0.00	3.55	0.00
Mandriva Linux	3.45	3	1.14	1.75	0.00	3.11	0.00
Microsoft Windows	2.97	3	1.13	1.66	0.00	-0.28	0.62
Novell/Suse Linux	3.76	4	0.95	2.37	0.00	5.53	0.00
Red Hat Linux	3.71	4	1.07	2.25	0.00	4.79	0.00

All Operating Systems are perceived as having quality, working well without bugs, crashes or other problems (H0 rejected), but when analyzing the mean we see that Apple Mac OS is evaluated as the best Operating System in Quality terms and Microsoft Windows one of the worst, having behind it only Caixa Mágica Linux and Mandriva Linux, these two Operating Systems from software suppliers that were also the less known of all.

The consumer's perceptions about security, the problems associated with virus and hackers, show that only the Microsoft Windows has a negative perception. All the Operating Systems are seen as being secure (H0 rejected) with the exception of Microsoft Windows that is perceived by the users as an Operating System not secure. Apple MacOS is evaluated as the best Operating System in Security terms and Microsoft Windows the worst.

Summary

We can conclude that considering all aspect of the Operating Systems perception, only Apple MacOS is considered by the users as the best Operating System regarding Innovation, Quality and Security. Of the six Operating Systems present in the questionnaire two of them, Linux versions of Caixa Mágica and Mandriva have a worst global perception, maybe because they are less known software suppliers as we concluded with the statistical tests of question 6. Microsoft Windows has a better innovation perception than Novell/Suse Linux or Red Hat Linux but a worst perception regarding Quality and the worst perception of all in Security terms, with the null hypothesis of median less or equal to 3 not rejected.

5.4.5. Construct building

We will now start to build the first construct following the methodologies presented in Chapter IV, with application of the Cronbach α test to test the construct internal consistency reliability and factor analysis to obtain factor scores that will be the weights of the construct variables. Factor analysis tests will be made like the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Bartlett 1937, 1938).

Construct "Global perception of an Operating System"

Operating Systems aspects like innovation, quality and security that together can create a construct, the "Global perception of an Operating System", were analyzed. For each Operating System considered, the Cronbach's α (1951) test was made to test the internal consistency reliability of this latent construct to be build from Innovation, Quality and Security perceptions.

All the Cronbach α have values larger than 0.70 with the factor analysis tests and results in agreement with the expected results as considered above (Appendix 1 and Appendix 2). For the constructs build we made the statistics analysis including descriptive statistics and statistical tests.

As we can see from the statistics and statistical tests (t-test if normal variables and Wilcoxon Ranked if non-normal variables) in Table 25, while there is a positive global image of all Operating Systems (H0 rejected), Apple Mac OS and the Linux versions of Novell/Suse and Red Hat have the best global image.

We test the significance of the difference between these evaluations against the incumbent Microsoft Windows with the Operating System paired sample test. While the perception mean for Microsoft Windows was lower except against Caixa Mágica Linux and Mandriva Linux, the related-samples t-test and Wilcoxon Z showed significance beyond the 0.05 level only for the pair Microsoft Windows-Apple MacOS, rejecting the null hypothesis of equal means only for this pair of Operating Systems (Table 26).

Table 25. Operating Systems global perception statistics and statistical tests

	Operating System global perception						
Brand	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test(a) or Wilcoxon Z(b)	Asymp. Sig. (1-tail)
Apple Mac OS	4.13	4.32	0.76	1.38	0.05	7,35(b)	0.00
Caixa Mágica Linux	3.26	3.32	0.93	1.59	0.01	2.50(b)	0.01
Mandriva Linux	3.24	3.02	0.99	1.57	0.01	2.12(b)	0.02
Microsoft Windows	3.43	3.58	0.81	0.84	0.48	5.38(a)	0.00
Novell/Suse Linux	3.50	3.69	0.75	1.53	0.02	5.25(b)	0.00
Red Hat Linux	3.49	3.68	0.98	1.27	0.08	4.54(a)	0.00

The effect size d (Cohen 1988), that tests the significance of the difference between means, is calculate by subtracting the means and dividing by the standard deviation of the pair. For Cohen's d an effect size of 0.2 to 0.3 might be a "small" effect, around 0.5 a "medium" effect and 0.8 to infinity, a "large" effect (Cohen 1988). Facing doubts about what was “small” or “medium” or “large”, Cohen gave his justification for these definitions. “The terms 'small,' 'medium,' and 'large' are relative, not only to each other, but to the area of behavioral science or even more particularly to the specific content and research method being employed in any given investigation. In the face of this relativity, there is a certain risk inherent in offering conventional operational definitions for these terms, for use in power analysis in as diverse a field of questionnaire as behavioral science. This risk is nevertheless accepted in the belief that more is to be gained than lost by supplying a common conventional frame of reference which is recommended for use only when no better basis for estimating the Effect Size index is available" (Cohen 1988). In the case of Microsoft Windows-Apple MacOS, we have a Cohen d value of 0.58 that means a medium effect size.

We can conclude that there is no statistically significant difference of perceptions between the incumbent Microsoft Windows and the several Linux brands, even if Microsoft Windows has a mean perception worse for two of them and best for other two of them. Apple MacOS has a better perception than Microsoft Windows (a larger mean) and the statistical test for this pair rejected the null hypothesis of equal means.

Table 26. Operating Systems means difference statistical tests

Operating System paired sample t-test or Wilcoxon test					
Microsoft Windows -	Mean	Std. Deviation	Std. Error Mean	t-test(a) or Wilcoxon Z(b)	Sig. (2-tail)
Apple MacOS	-0.70	1.20	0.13	-5.39(a)	0.00
Caixa MágicaLinux	0.24	1.31	0.15	-1.41(b)	0.16
Mandriva Linux	0.27	1.38	0.16	-1.15(b)	0.13
Novell/Suse Linux	-0.02	1.13	0.13	-0.72(b)	0.47
RedHat Linux	-0.04	1.39	0.15	-0.25(a)	0.80

Perceptions about Office Suite brands

By using the same methodology applied in the case of Operating Systems perceptions we will now analyze the Office Suite, first the perceptions regarding innovation, quality and security presented in Table 27.

Microsoft Office, OpenOffice.org and Apple iWork, are seeing as innovative Office Suites (H0 rejected). Sun StarOffice, that is similar to OpenOffice sharing most of the code, has a Wilcoxon test that showed that the population median is not significantly greater than the test median at the 0.05 level, maybe because there are marketing inefficiencies in the communication with the market for this application. IBM Lotus SmartSuite and Corel Word Perfect are in the inconclusive range.

Almost all the Office Suites are perceived as having quality, working well without system stops or other problems (H0 rejected), with Microsoft Office, Apple iWork and OpenOffice having a better perception. The exceptions are E-Press Corp One Office and KDE KOffice. As we saw that these two companies are the less known by the users, can we consider these lower results as result of lack of knowledge of the companies and their Office Suites?

The consumer's perceptions about security, the problems associated with virus and hackers that attack the IS infrastructure show that only the E-Press Corp One Office has a negative perception. As we can see, all the other Office Suites are seen as being secure (H0 rejected). However, the Microsoft Office security mean is near the bottom, with Apple iWork evaluated as the best Office Suite in Security terms, followed by IBM Lotus SmartSuite.

Table 27. Office Suite perceptions statistics and statistical tests

Brand	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
			Innovation				
Apple iWork	3.46	3	0.90	2.26	0.00	4.03	0.00
Corel Word Perfect	3.12	3	0.82	2.68	0.00	1.12	0.14
E-Press Corp One Office	2.77	3	0.86	3.20	0.00	-2.25	0.99
IBM Lotus SmartSuite	3.13	3	0.88	2.70	0.00	1.11	0.13
KDE KOffice	2.75	3	0.80	2.90	0.00	-2.66	1.00
Microsoft Office	4.17	4	0.78	2.18	0.00	7.49	0.00
OpenOffice.org OpenOffice	3.48	4	1.00	1.99	0.00	3.87	0.00
Sun StarOffice	3.18	3	0.94	2.50	0.00	1.45	0.08
			Quality				
Apple iWork	3.65	4	0.82	2.09	0.00	5.35	0.00
Corel Word Perfect	3.29	3	0.88	2.28	0.00	2.57	0.00
E-Press Corp One Office	2.97	3	0.83	2.90	0.00	-0.44	0.67
IBM Lotus SmartSuite	3.44	3	0.75	2.23	0.00	4.36	0.00
KDE KOffice	2.97	3	0.83	2.90	0.00	-0.44	0.67
Microsoft Office	3.80	4	0.81	3.07	0.00	6.62	0.00
OpenOffice.org OpenOffice	3.54	4	0.86	2.07	0.00	4.59	0.00
Sun StarOffice	3.22	3	0.85	2.62	0.00	1.90	0.03

Table 27. (continuation)

Brand	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
				Security			
Apple iWork	3.78	4	0.87	1.91	0.00	5.72	0.00
Corel Word Perfect	3.33	3	0.89	2.37	0.00	2.80	0.00
E-Press Corp One Office	3.15	3	0.87	2.67	0.00	1.25	0.10
IBM Lotus SmartSuite	3.52	3	0.78	2.47	0.00	4.72	0.00
KDE KOffice	3.21	3	0.88	2.67	0.00	1.68	0.04
Microsoft Office	3.30	3	0.94	1.98	0.00	2.80	0.00
OpenOffice.org OpenOffice	3.49	3	0.86	1.98	0.00	4.24	0.00
Sun StarOffice	3.36	3	0.84	2.48	0.00	3.10	0.00

We can conclude that there are some similarities in the evaluation levels of Apple iWork, Microsoft Office and OpenOffice in Innovation and Quality. Only in security terms Microsoft Office has a lower perception than Apple iWork and OpenOffice, maybe a perception influenced by the perception of Microsoft Windows.

Construct "Office Suite global perception"

The Office Suites perceptions of innovation, quality and security together create a construct, the "Office Suite global perception", with the Cronbach's α (1951) test and factor analysis in accepted values (Appendix 3 and Appendix 4).

Considering the global perception of the Office Suites (Table 28), Apple iWork, Microsoft Office and OpenOffice seem the best evaluated. Sun StarOffice, which is code similar to OpenOffice, has a global image even worse than IBM Lotus SmartSuite, maybe due to a marketing communication problem of the Office Suite and also the "Sun" brand. Only KOffice and E-press Office have a less positive perception as showed by the rejection of the null hypothesis but are also the less known suppliers.

Table 28. Office Suite global perception statistics and statistical tests

Brand	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test(a) or Wilcoxon Z(b)	Asymp. Sig. (1-tail)
Apple iWork	3.66	3.70	0.75	1.17	0.13	7.75(a)	0.00
Corel WordPerfect Office	3.26	3.00	0.78	2.23	0.00	2.84(b)	0.58
E-Press Corp One Office	2.95	3.00	0.78	2.34	0.00	-0.20(b)	0.00
IBM Lotus SmartSuite	3.38	3.30	0.66	1.86	0.00	4.79(b)	0.35
KDE KOffice	2.99	3.00	0.77	2.08	0.00	0.39(b)	0.00
Microsoft Office	3.78	3.70	0.67	1.13	0.16	10.82(a)	0.00
OpenOffice.org OpenOffice	3.52	3.70	0.78	1.32	0.06	5.81(a)	0.00
Sun StarOffice	3.26	3.00	0.81	2.14	0.00	2.96(b)	0.00

Could we say that there is a difference between means of the incumbent Microsoft Office and the other Office Suites with similar means like Apple iWork or OpenOffice or even other Office Suites? We will confirm it with the parametric and non-parametric paired sample mean t-test and Wilcoxon test in Table 29.

Table 29. Office Suite means difference statistical tests

	Office Suite paired sample t-test or Wilcoxon test				
Microsoft Office -	Mean	Std. Deviation	Std. Error Mean	t-test(a) or Wilcoxon Z(b)	Sig. (2-tailed)
Apple iWork	0.15	0.91	0.11	1.43(a)	0.16
Corel WordPerfectOffice	0.57	0.97	0.11	-4.46(b)	0.00
E-press OneOffice	0.88	1.03	0.13	-5.49(b)	0.00
IBM LotusSmartSuite	0.42	0.88	0.10	-3.72(b)	0.00
KDE KOffice	0.85	1.05	0.13	-5.48(b)	0.00
OpenOffice.org OpenOffice	0.29	0.95	0.11	2.68(a)	0.01
Sun StarOffice	0.56	1.04	0.12	-4.29(b)	0.00

In all cases, the perception mean for Microsoft Office was higher than the mean for the paired Office Suite. The related-samples t-test and Wilcoxon Z showed significance above the 0.05 level only for the pair Microsoft Windows-Apple iWork, not rejecting the null hypothesis of equal means only for these pair of Office Suites.

The effect size d (Cohen 1988) in the case of Microsoft Office pair with other Office Suites beside Apple iWork, has d values of respectively 0.59, 0.85, 0.48, 0.81, 0.31 and 0.54. We can conclude that we have a “small” effect size of Microsoft Office versus OpenOffice, a “medium” effect size of Microsoft Office versus Corel WordPerfectOffice, IBM Lotus SmartSuite and Sun StarOffice and a “large” effect size of Microsoft Office versus E-press OneOffice and KDE KOffice

As with Operating Systems, we also must consider in this conclusions that E-Press and KDE had the null hypothesis of median less or equal to three not rejected. That reflects in the percentage of no-answers about E-Press Corp One Office and KDE KOffice of respectively 40% and 34%. Only Microsoft Office with 11% of missing answers, OpenOffice.org (OpenOffice) with 22% of missing answers and Apple iWork with 24% missing answers have less than 25% of missing answers. Corel WordPerfect Office, IBM Lotus SmartSuite and Sun StarOffice, have 29%, 25% and 29% of missing answers, showing how difficult is for Office Suites beside the dominant suite, Microsoft Office, to have success in market if an important percentage of users are unaware of them or of their features.

Software perceptions versus choices options

Considering the actual software installed in the organizations and the options available, and the proposed situation where the organization buy new computers without software, 79% of the companies would not switch their Operating System (the majority being Microsoft Windows) and 63% would not switch their Office Suite (the majority being Microsoft Office).

But on other hand, we concluded that Microsoft Windows and in a less degree Microsoft Office aren't the products with best global perceptions or even best Innovation, Quality and Security perceptions, with Microsoft Windows with a bad positioning in the last two variables. Strangely enough and considering that Microsoft Office has a better perception than Microsoft Windows, it seems that more organizations could choose to switch from Microsoft Office to other Office Suite than from Microsoft Windows to other Operating System.

From these results we can conclude, as showed in the literature review and presented in the thesis hypothesis, that other factors have influence on the software choices beside the perception that users have of the software. We now will study that possible influential factors and if they are considered by the organizations or not. Several questions were made for that and we will start by explaining each of the questions, the thesis hypothesis associated and testing if the question and associated thesis hypothesis is considered by the organization in their software choice considerations.

5.4.6. Software characteristics influencing factors

Beside the perceptions of specific brands of software present in the market, what are the other influencing factors that the users consider when choosing software?

Brands Reputation

After analyzing the results of the different Operating Systems and Office Suites brand perceptions and also the user's software supplier's knowledge, we will start by studying if brand reputation (image, quality and security) influence software choices, testing hypothesis 5d.

H5d	The better the perception regarding innovation, quality, security support, etc. of the incumbent standard (Liebowitz and Margolis 1996) , ...	The lower the probability that the consumer will choose the alternative standard against the incumbent standard	Supplier Reputation Image, Quality Security quest5f, g, h

While all the user perceptions about the image of the software supplier have influence over the software choice (H0 not rejected), we see that reputation of quality and security of the software supplier has more influence in that choice than the brand image (Table 30).

Table 30. Supplier's reputation relevance statistics and statistical tests

Variable	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
5f – Software supplier brand image in the market	3.47	4	0.90	2.90	0.00	4.37	0.00
5g – Software supplier reputation regarding software quality (without bugs and crashes)	4.15	4	0.89	2.86	0.00	7.33	0.00
5h – Software supplier reputation regarding software security (without virus and hackers vulnerabilities)	4.09	4	0.92	2.64	0.00	7.06	0.00

Construct "Suppliers global reputation relevance"

From the questions above we create a construct, the "Suppliers global reputation relevance" (Appendix 5 and Appendix 6). While Kaiser-Meyer-Olkin (KMO) has a value of 0.48, not reaching the 0.50 proposed by Kaiser (1974), the Bartlett's test of sphericity (Bartlett 1937, 1938) rejected the null hypothesis of inappropriateness of this factor analysis and the cumulative percentage of variance extracted by the factors reached an accepted level of 66.57% of variance explained so we keep with the construct.

As we see in Table 31, considering a mean of 3.95 and media of 4.00 with the Wilcoxon test rejecting the null hypothesis of median less or equal to 3, the supplier's global reputation is a relevant consideration in software choices.

Table 31. Supplier's global reputation relevance statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Suppliers global reputation relevance	3.95	4.00	0.75	1.60	0.01	7.32	0.00

Software Costs

As we saw, the majority of users don't want to switch from the dominant Microsoft Windows to other Operating Systems, even if they regard as better some alternatives. But more users consider switching from the dominant MS-Office to the Open Source OpenOffice, even if MS-Office is in relatively better position regarding the competitors than Microsoft Windows.

We will now research the influence of the monetary software costs in these decisions, considering three kinds of software costs. The Hypothesis 8d showed that the alternative standard has more probabilities of be chosen as associated software costs are lower.

H7d	The lesser associated costs to adoption of the alternative standard (licensing, support, training, compatibility, etc.) *(Bonaccorsi and Rossi 2003), …*	Higher probability that the consumer will choose the alternative standard against the incumbent standard	Software Costs Licensing, Installation, Training quest5c, 5d, 5e Global Cost of software OSS vs. PS quest15

Questions 5c, 5d and 5e question about the importance in software choice of the following costs: licensing, installation and implementation, and training, that directly or indirectly have always monetary costs.

In Table 32 we can see that the different kinds of software costs are relevant in the choice of software. The null hypothesis of median lower or equal to 3 is rejected.

Table 32. Software cost statistics and statistical tests

Variable	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
5c – Software Cost (licensing)	4.09	4	0.83	2.18	0.00	7.42	0.00
5d – Software Cost (installation and implementation)	3.96	4	0.90	2.45	0.00	6.83	0.00
5e- Software Cost (training)	3.67	4	1.00	2.08	0.00	5.30	0.00

Construct "Software Global Cost"

From the questions above we create a construct, the Software Global Cost. The internal consistency reliability was confirmed and the factorial analysis made with the cumulative percentage of variance extracted by the factors of 75.53% of variance explained (Appendix 7 and Appendix 8). The statistics and the Wilcoxon test in Table 33, shows that the software global cost is relevant in software choices.

Table 33. Software global cost statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Software global cost	3.90	4.00	0.80	1.77	0.00	7.14	0.00

Considering software costs relevant in the software purchasing decisions, we will now study the perceived costs of Open Source Software and Proprietary Software.

Question 15 of the questionnaire was about this perception and the results are present in Table 34. We see that users have the perception that Open Source Software is cheaper than Proprietary Software, with statistical tests rejecting the null hypothesis of median less or equal to 3.

Table 34. OSS and PS cost statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
15. Open Source Software is cheaper that Proprietary Software use (includes licensing, training and maintenance).	3.77	4	1.06	2.30	0.00	5.49	0.00

Open Source Software and Proprietary Software perceptions (Innovation, Quality and Security).

After analyzing the different software products, where we have Apple MacOS, Microsoft Windows, Apple iWork, Corel WordPerfect, E-Press One Office, IBM Lotus SmartSuite, Microsoft Office and Sun StarOffice as Proprietary Software brands and all the others as Open Source Software brands and also how users consider the costs in their decisions, including Open Source Software versus Proprietary Software categories, we will now study how users perceive these two kinds of software considering innovation, quality and security, as present in hypothesis 5d.

H5d	The better the perception regarding innovation, quality, security support, etc. of the incumbent standard (Liebowitz and Margolis 1996)	The lower the probability that the consumer will choose the alternative standard against the incumbent standard	Innovation, Quality and Security of Open Source Software and Proprietary Software quest13a, quest13b, quest13c quest14a, quest14b, quest14c Support Availability quest16a, quest16b

Questions 13a, 13b and 13c are about innovation, security and quality of Open Source Software and questions 14a, 14b and 14c about Proprietary Software are presented in Table 35.

While users have positive perception about innovation, security and quality of Open Source Software and Proprietary Software (H0 not rejected), we can see that there is a better perception of Proprietary Software when considering software innovation and quality and a marginal better perception of Open Source Software security, not very different from the perceptions regarding Open Source Software and Proprietary Software brands.

Table 35. OSS and PS perceptions statistics and statistical tests

Variable	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
13a. OSS Innovation	3.59	4	0.88	2.11	0.00	5.16	0.00
13b. OSS Security	3.36	3	0.83	2.18	0.00	3.71	0.00
13c. OSS Quality	3.35	3	0.84	2.29	0.00	3.55	0.00
14a. PS Innovation	3.84	4	0.65	3.07	0.00	7.53	0.00
14b. PS Security	3.35	3	0.86	2.39	0.00	3.67	0.00
14c. PS Quality	3.43	3	0.71	2.52	0.00	4.99	0.00

Constructs “OSS global image” and “PS global image”

From the questions above we create two constructs, the “Open Source Software global image” and the “Proprietary Software global image”, both respecting the statistical thresholds so we can accept them in the thesis (Appendix 9 and Appendix 10).

Following this we made the statistics analysis of the new constructs, descriptive statistics and statistical tests. As we see in Table 36, statistics and Wilcoxon test for the Proprietary Software global image and t-test for the Open Source Software global image, while both have a positive image globally Proprietary Software it seems to be perceived as having a better global image than Open Source Software.

Table 36. OSS and PS global image statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test(a) or Wilcoxon Z(b)	Asymp. Sig. (1-tail)
Open Source Software global image	343	3.35	0.73	1.10	0.13	5.45(a)	0.00
Proprietary Software global image	3.53	3.63	0.62	2.67	0.00	6.32(b)	0.00

We will now test if there is a significant difference between means of Open Source Software Global Image and Proprietary Software Global Image even if the mean of the first one is lower than the mean of the second one. We will test with the non-parametric paired sample Wilcoxon test (Table 37).

The related-samples Wilcoxon Z showed significance above the 0.05 level for the pair Open Source Software global image versus Proprietary Software global image, not rejecting the null hypothesis of equal means for this pair. We can consider that the users do not see a significant difference between the global image of Open Source Software and Proprietary Software.

Table 37. Software global image means difference statistical tests

	Software global image paired sample Wilcoxon test				
Open Source Software Global Image -	Mean	Std. Deviation	Std. Error Mean	Wilcoxon Z	Sig. (2-tail)
Proprietary Software Global Image	-0.10	0.79	0.08	-0.72	0.47

Construct "OSS better global image than PS"

From the differences of the variables (innovation, security and quality) perception evaluation between Open Source Software and Proprietary Software, we build a new construct, a comparison construct considering the difference of that perceptions, "OSS better global image than PS", with the Cronbach α near 0.70 (Appendix 11).

From the statistics and the t-test for the Open Source Software better global image than Proprietary Software construct (Table 38), we cannot conclude that Open Source Software has a different or better global image than Proprietary Software, as was also confirmed in the means test in Table 37.

Table 38. OSS better global image than PS statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test	Asymp. Sig. (1-tail)
Open Source Software better global image than Proprietary Software	2.96	3.00	0.61	1.22	0.10	-0.64	0.74

OSS and PS technical support availability perception

Beside the costs and innovation, security and quality perceptions of Open Source Software and Proprietary Software, other important consideration in IS choices is the availability of quality technical support. Considering this we make the statistics and statistical tests for the two questions concerning the technical support availability (Table 39). While agreeing that there is quality technical support for Proprietary Software (null hypothesis rejected), users don't agree that there is the same offer of quality technical support for Open Source Software (null hypothesis not rejected).

Table 39. OSS and PS technical support statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
16a. OSS Technical Support	2.98	3	0.89	2.33	0.00	-0.18	0.56
16b. PS Technical Support	4.01	4	0.75	2.51	0.00	7.40	0.00

We will now test if there is a significant difference between means of Open Source Software Technical Support and Proprietary Software Technical Support. We will test with the non-parametric paired sample Wilcoxon test (Table 40).

The related-samples Wilcoxon Z showed significance below the 0.05 level for the pair Open Source Software Technical Support and Proprietary Software Technical Support, rejecting the null hypothesis of equal means for this pair. We can consider that the users perceive a significant difference between the availability of technical support of Open Source Software and Proprietary Software. The effect size d (Cohen 1988) value is above one, showing a "large" effect size. The perception of technical support is significantly different considering Open Source Software or Proprietary Software, with advantage to Proprietary Software.

Table 40. OSS and PS technical support means difference statistical tests

	Software Technical Support Paired Sample Wilcoxon test				
Open Source Software Technical Support -	Mean	Std. Deviation	Std. Error Mean	Wilcoxon Z	Sig. (2-tail)
Proprietary Software Technical Support	-1.04	0.98	0.10	-7.36	0.00

Construct "OSS better technical support than PS"

From the difference of the variables of technical support perception between Open Source Software and Proprietary Software, we build a new construct, a comparison construct considering the difference of that perceptions, "OSS better technical support than PS".

As we see by the statistics and the t-test for the Open Source Software better technical support than Proprietary Software construct (Table 41), we don't reject the hypothesis of median less or equal to three. Since we statistically confirmed that the means are not equal, we can conclude that there is the perception that Open Source Software technical support is worse than Proprietary Software technical support.

Table 41. OSS better technical support PS statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
OSS Software Better Technical Support than PS	2.29	2.00	0.59	3.33	0.00	-7.24	1.00

Summary

Costs are considered by users as an influential factor in their choices about software purchase and when considering the perceptions of both, Proprietary Software and Open Source Software costs, Open Source Software is perceived as cheaper than Proprietary Software. On other hand, when considering the global image perception users have a better perception of Proprietary Software (even if Microsoft Windows, dominant Proprietary Software is perceived as the worst Operating System in quality and security), while this perception is not statistically significant. When considering technical support availability users have the perception of an advantage of Proprietary Software against Open Source Software, with this perception statistically significant.

5.4.7. <u>Other software choice influencing factors</u>

Besides factors regarding specific aspects of software products, brands, or even business model (Open Source Software versus Proprietary Software), several other factors can influence the software purchase decision. They will be studied now considering the same methodologies as before.

1. Network Effect

The network effect, Hypothesis 1d(emand) of the thesis, represent the compatibility with other by the possibility of using the same applications and/or exchange of files (direct network effect) and also the availability of applications and peripherals (indirect network effect) for that standard. The questions 1a and 1b were made to confirm about the existence of network effects in the market.

H1d	The higher the network effects in the market *(Katz, Shapiro 1985), (Economides 1996), …*	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Use same applications than partners and exchange files with partners quest1a, quest1b

From the statistics and statistical tests (Table 42) we can conclude that users consider relevant in their software choices the file compatibility with their business partners (H0 rejected) while choosing applications, while not considering as relevant the possibility of purchasing the same applications that their business partners have (H0 not rejected) while choosing Operating Systems. The Operating System choice is not influenced by need of using the same applications of business partners. We have only a direct network effect through files compatibility with business partners.

Table 42. Network effect statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
1a. Capability of use the same applications of business partners (OS choice).	3.17	3	1.38	1.99	0.00	0.94	0.17
1b. Capability of exchange files with business partners (Application choice).	3.74	4	1.28	2.28	0.00	4.43	0.00

2. Weak lock-in

One of the factors that influence the choice of switching to alternative software is the weak lock-in, the compatibility of a user with their own. One of the influencers of this effect is the legacy applications and software, sometimes older versions of already inexistent software but the organization still use (as an example some old MS-DOS or early Windows version of an application without recent versions).

H3d	The higher the lock-in weak and strong *(Farrel, Saloner 1985, 1986), (Liebowitz, Margolis 1990, 1994, 1995) (Liebowitz 2000), ...*	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Using older applications and files quest2, quest3 Using new versions of old software quest4

Questions 2, 3 are about the older applications and older files still in use by the organization creating a lock-in caused by that legacy. Question 4 is about the use of applications introduced years ago in the market but always updated with the last versions (like last versions of Operating Systems or Office Suites keeping the same supplier) in the sense of path dependence concept introduced by Paul David (1985) and W. Brian Arthur (1989).

As we see in Table 43, legacy (old) applications and files seem to not have influence in the weak lock-in (H0 not rejected), while applications that keep having updated versions, like applications from incumbent dominant companies as Microsoft Windows and Microsoft Office, can have influence on that kind of lock-in (H0 rejected). The weak lock-in is caused by the applications updated with new versions in a path dependence way.

Table 43. Weak lock-in statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
2. Use of old versions of applications or applications out of market	2.28	2	1.35	2.40	0.00	-4.71	1.00
3. Use old files of old applications	2.32	2	1.26	2.37	0.00	-4.37	1.00
4. Recent versions of applications introduced several years ago in the market	3.89	4	1.15	2.52	0.00	5.73	0.00

3. Local Network Effect

One of the factors that influence the choice of IS products and also many products and services in other markets is the formal or informal advice by third parties. When there is a larger lack of knowledge by the potential buyer, this kind of advice rise in is influence over the purchase decision process. Questions 5i to 5q are about the several sources of advice and their influence on the decision process. We consider two categories of advice, from inside the organization including business partners (5i to 5l) and from outside the organization (5m to 5q).

H4d	The higher the local network effect in the market *(Dalle 1997)*	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Local Network Effect - Internal Advice quest5i, quest5j, quest5k, quest5l Local Network Effect - External Advice quest5m, quest5n, quest5o, quest5p, quest5q

We can see by analyzing the questions statistics and the statistics test (Table 44) that the advice is accepted only from IS staff, internal and external (including IS suppliers), the null hypothesis (median less or equal to 3) in questions 5l and 5m is rejected. The local network effect does not come from heterogeneous sources but from these two sources. This IS advice can be toward the incumbent Operating System and Office Suite since the prevalent IS culture (where the IS staff belong) in Portugal is strongly influenced by this incumbent products or, due to more technical knowledge, to other alternative solutions that can be advised by these professionals.

Table 44. Local network effect statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
5i. Organization workers	3.07	3	0.95	2.11	0.00	0.68	0.26
5j. Organization clients	2.67	3	1.05	2.23	0.00	-3.00	1.00
5k.Organization suppliers (not IS suppliers)	2.45	2	1.04	1.86	0.00	-4.47	1.00
5l. Organization IS staff	4.11	4	0.95	2.62	0.00	7.03	0.00
5m. External IS staff (including IS suppliers)	3.80	4	0.92	2.70	0.00	6.16	0.00
5n. Family or friends	2.00	2	1.04	2.61	0.00	-6.47	1.00
5o. Computer shop staff	1.93	2	0.95	2.52	0.00	-7.09	1.00
5p. IS magazines	2.51	3	1.02	2.50	0.00	-4.31	1.00
5q. Internet sites about IS technologies	2.85	3	0.98	2.44	0.00	-1.59	0.94

Construct "Local network IS staff"

From the questions 5l and 5m where the null hypothesis of median less or equal to 3 was rejected we create a construct, the "Local network effect IS staff" (Appendix 12 and Appendix 13). While the Cronbach α has a value lower than the 0.70 threshold and the Kaiser-Meyer-Olkin (KMO) has a value of 0.50, the Bartlett's test of sphericity rejected the null hypothesis of inappropriateness of the factor analysis and the cumulative percentage of variance extracted by the factors had a level of 68.16% of variance explained. With these results we decided to keep the construct.

Following this we made the statistics analysis of the new construct, descriptive statistics and statistical tests. Table 45 statistics and Wilcoxon test showed that the Local Network trough advice of IS staff is relevant in influencing software choices.

Table 45. Local network effect IS staff statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Local network effect IS staff	3.95	4.00	0.77	2.08	0.00	7.37	0.00

4. Software features requirements

Now we analyze how organizations take in consideration their actual IS needs and their actual and potential future needs.

H5d	The better the perception regarding innovation, quality, security support, etc. of the incumbent standard *(Liebowitz and Margolis 1996)*	The lower the probability that the consumer will choose the alternative standard against the incumbent standard	Actual and potential future software requirements quest5a, quest5b

Table 46 shows that organizations give a strong importance to the software features that can solve their actual needs, and even more to satisfy potential future needs (H0 rejected in both cases). When users consider relevant the satisfaction of their future potential needs, we can consider that they evaluate the innovation capacity of the suppliers to introduce new software in the market, the capacity to satisfy the consumers potential future needs and the supplier capacity to survive in the market to be present in that future.

Table 46. Software features requirements statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
5a. Software features that satisfy the actual needs of organization	4.51	5	0.70	3.49	0.00	8.33	0.00
5b. Software features that satisfy the actual and the potential future needs of organization.	4.58	5	0.60	3.80	0.00	8.50	0.00

Construct "Software features requirements"

From the questions above we wanted to create a construct, the "Software feature requirements". With the Cronbach's α (1951) test value of 0.39 (Appendix 14) we concluded that while both questions go in the same direction regarding software needs, the latent construct doesn't have internal consistency reliability so the construct will not be build. The users perceive actual needs one on hand and actual and future potential needs on other hand, as different situations that can influence in different ways their purchasing choices.

5. Switching costs

One of the factors that go against any standard change is the switching costs.

H2d	The higher the switching costs in the market *(Farrel, Saloner 1985, 1986), (Klemperer 1987), (Langlois, Robertson 1992)*	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Switching from Proprietary OS to Open Source OS and vice-versa quest17, quest18 Switching from Proprietary Office Suite to Open Source Office Suite and vice-versa quest20

Did the users have a perception of having switching costs while switching between standards to a standard that they consider a good alternative in some way? Switching costs consider the perception of “how easy” is to switch between software if we want to do it. Questions 17 and 18 are about Operating System switch cost while Question 20 is about Office Suite switch cost.

We can see in Table 47 that the users consider that there exist switching costs between Operating Systems and also between Office Suites (H0 not rejected). They consider easier switching from an Open Source Software Operating System to a Proprietary Software Operating System than vice-versa. The switch between Office Suites is considered easier than the switch between Office Suites. Anyway, the existence of switching costs creates difficulties for the option of software alternatives, lowering the competition degree of the market.

Table 47. Easiness of switching statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
17. Easy of switch from Proprietary Software Operating System to Open Source Software Operating System	2.41	2	1.02	1.88	0.00	-4.75	1.00
18. Easy of switch from Open Source Software Operating System to Proprietary Software Operating System	2.85	3	1.16	1.77	0.00	-1.33	0.91
20. Easy of switch between Open Source Software Office Suite and Proprietary Software Office Suite while maintaining the Operating System	3.15	3	1.16	2.01	0.00	1.32	0.10

Construct "Easiness of switching Operating System"

From the questions 17 and 18 about the switch costs in each of directions between Operating Systems where the null hypothesis was not rejected we create a construct, the "Easiness of switching Operating System" (Appendix 15 and Appendix 16).

The Wilcoxon test, that tested the null hypothesis about the easiness of switch between Proprietary and Open Source Operating Systems and Office Suites is not rejected, there exist Operating System and Office Suite switch costs (Table 48).

Are the switching costs significantly higher when considering Operating Systems or Office Suites? We now will make the statistical test considering the null hypothesis of equal means between both types of software means. The null hypothesis of equal means is rejected (Table 49). The switching costs of Operating Systems are higher than the switching costs of Office Suites.

Table 48. Easiness of switching OS and OFS statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Easiness of switching Operating System	2.62	3.00	0.95	1.87	0.00	-3.59	1.00
Easiness of switching Office Suite	3.15	3.00	1.16	2.01	0.00	1.32	0.10

Table 49. Easiness of switching means difference statistical tests

	Easiness of switch paired sample Wilcoxon test				
Operating System easiness of switch -	Mean	Std. Deviation	Std. Error Mean	Wilcoxon Z	Sig. (2-tail)
Office Suite easiness of switch	-0.51	1.20	0.13	- 3.50	0,00

Switching costs factors

We concluded that users consider that they have switching costs when they decide to switch to alternative software. But what factors influence the result of high switching costs that users consider? Let's start with the Operating System. What factors influence the switching costs of the Operating System? Question 19 tries to answer about these influential factors on the Operating System switch option.

H3d	The higher the lock-in *(Farrel, Saloner 1985, 1986), (Liebowitz, Margolis 1990, 1994, 1995) (Liebowitz 2000),* …	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Computer, training, knowledge, Compatibility with himself: computer,,applications and peripherals owned, IS knowledge quest19a, ... quest19e, quest19h
H1d	The higher the network effects in the market (Katz, Shapiro 1985), (Economides 1996), …	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Direct Network Effect-compatibility with others quest19f Indirect Network Effect-applications availability quest19g

While we can see by the statistical tests in Table 50, that users agree about the importance of all the factors presented as influencing the switch costs of exchanging the Operating System (H0 rejected), there are some of the factors they seem consider more relevant, like the presented in questions 19e and 19h about compatibility with owned peripherals and number of owned applications for actual Operating System, that are forms of weak lock-in, and the indirect network effect (19f), number of applications available of Operating System. In all these cases the incumbent and dominant Operating System has advantage that can turn the switching costs in something insurmountable when the decision about Operating System switching is made, even if the alternative Operating System has free licensing like happens with Open Source Software.

Table 50. Operating Systems switching costs factors statistics and statistical tests

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
19a. Computer features	3.29	3	1.03	2.11	0.00	2.55	0.01
19b. Knowledge need to install a new Operating System	3.63	4	0.98	3.12	0.00	5.06	0.00
19c. Knowledge need to switch computer Operating System	4.01	4	0.85	2.49	0.00	7.08	0.00

Table 50. (continuation)

Variables	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
19d. Learning needs with new Operating System	4.10	4	0.89	2.43	0.00	7.21	0.00
19e. Compatibility with the organization peripherals (printers. scanners. external discs. etc.)	4.54	5	0.64	3.66	0.00	8.40	0.00
19f. Capacity of use of the same applications of business partners (suppliers. costumers. etc.)	3.98	4	1.20	2.39	0.00	5.91	0.00
19g. Quantity and categories of applications available for Operating System	4.39	5	0.74	3.14	0.00	8.02	0.00
19h. Quantity and categories of applications we have for actual Operating System	4.52	5	0.67	3.56	0.00	8.32	0.00

Construct “Operating System weak lock-in”

From the questions above regarding compatibility of the user with himself where the null hypothesis was rejected we will create a construct, the “Operating System weak lock-in”. The Cronbach α was 0.65 (little lower than the 0.70 rule of thumb) and the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity showed that we could make the factor analysis. But the cumulative percentage of variance extracted by the factors reaches a level of 39.70% of variance explained and the factorial analysis resulted in two factors and not just one as happened in all other constructs building (Appendix 17 and Appendix 18).

By studying the output, including the communalities and the rotated component matrix we conclude that inside the weak lock-in we have two different situations that cause it, the compatibility with himself regarding technical knowledge and personal computers available and the compatibility with himself regarding peripherals and applications owned. From this we build two constructs, Operating System weak lock-in – hardware (personal computers available) and IS knowledge and made the internal consistency tests (Appendix 19).

The cumulative percentage of variance extracted by the factors reaches a level of 50.16% of variance explained so we take out question1a from the construct (Appendix 20). While the Cronbach α and the cumulative percentage of variance extracted by the factors raised to respectively to 0.72 and 64.57%, the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were lower, respectively 0.65 and 58.52. Since the main objective of factor analysis was to build the construct from the factor scores, the relationship of the scores between question 19b, 19c and 19d are similar with or without the inclusion of question 19a, and in question 19a the null hypothesis of median less or equal to 3 was rejected, we build the construct including it.

The t-test presented in Table 51 rejected the null hypothesis of mean less or equal to 3, so we can consider that the weak lock-in created by the computers available in the company and the IS knowledge as a factor influencing the switch costs between Operating Systems.

Table 51. OS weak lock-in–hardware and IS knowledge statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test	Asymp. Sig. (1-tail)
Operating System weak lock-in hardware and IS knowledge	3.84	4.00	0.67	1.20	0.11	11.88	0.00

The second construct, weak lock-in consider peripherals and applications owned by the company (Appendix 21 and Appendix 22)

The Wilcoxon Z test rejected the null hypothesis of median less or equal to 3 so (Table 52) we can consider that the weak lock-in created by the companies own peripherals and applications as a factor influencing the switch costs between Operating Systems.

Table 52. Operating System weak lock-in – peripherals and applications owned statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Operating System weak lock-in peripherals & applications owned	4.54	5.00	0.57	2.91	0.00	8.36	0.00

A third construct that will be built considered the network effect in Operating Systems.

H1d	The higher the network effects in the market (Katz, Shapiro 1985), (Economides 1996), …	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Direct Network Effect-compatibility with others quest19f Indirect Network Effect-applications availability quest19g

The internal consistency reliability and factor analysis tests were made (Appendix 23 and Appendix 24) and the construct build. The Wilcoxon Z test rejected the null hypothesis of median less or equal to 3 (Table 53), so we can consider the network effect as a factor influencing the switch costs between Operating Systems.

Table 53. Operating System network effect statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
Operating System network effect	4.18	4.50	0.83	1.77	0.00	7.54	0.00

Office Suites

We concluded that more users consider that is easier to switch between Office Suites than Operating Systems (Table 49), even with switch costs in both cases. Questions 21a to 21f are switching costs factors, including the possibility of Operating System switch need in case of switching between Office Suites not available for all Operating Systems.

H3d	The higher the lock-in *(Farrel, Saloner 1985, 1986), (Liebowitz, Margolis 1990, 1994, 1995) (Liebowitz 2000), ...*	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Computer, training, knowledge, Compatibility with himself: computer owned, IS knowledge, files owned, Quest21a, to d Quest21f
H1d	The higher the network effects in the market (Katz, Shapiro 1985), (Economides 1996), …	Lower probability that the consumer will choose the alternative standard against the incumbent standard	Direct Network Effect-compatibility with others Quest21e

The statistical tests (Table 54) shows that the only computer features aren't considered relevant in the Office Suite switch decision (H0 not rejected). The most important factors seem to be the learning needs (weak lock-in, question 21d) and the file compatibility (network effect, question 21e).

Table 54. Office Suite switching costs factors statistics and statistical tests

	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	Wilcoxon Z	Asymp. Sig. (1-tail)
21a – Computer features	3.11	3	1.13	2.10	0.00	0.76	0.22
21b. Knowledge to install a Office Suite	3.52	4	1.06	2.60	0.00	4.08	0.00
21c. Knowledge need to switch the OS	3.62	4	1.09	2.52	0.00	4.43	0.00
21d – Learning needs with new Office Suite	4.03	4	1.03	2.29	0.00	6.57	0.00
21e – Capacity of exchange Office files with business partners	4.27	5	0.94	2.82	0.00	7.30	0.00
21f – Quantity owned Office files for actual Office (legacy)	3.90	4	1.03	2.26	0.00	5.98	0.00

Construct "Office Suite Weak Lock-in.Knowledge"

From the questions above about the switch costs between Office Suites where the null hypothesis was rejected, we build a construct (Appendix 25 and Appendix 26) with all the aspects regarding knowledge as a form of weak lock-in (questions 21b to d).

Questions 21e and 21f are respectively the variables Office Suite network effect (file compatibility) and the Office Suite weak lock-in (legacy files).

The construct statistics and statistical tests presented in Table 82 show that the IS knowledge to switch the Office suite has statistical significance as a form of weak lock-in.

Table 55. Office Suite weak lock-in knowledge statistics and statistical tests

Construct	Mean	Median	S.D.	K.S.	Asymp. Sig. (2-tail)	t-test	Asymp. Sig. (1-tail)
Office Suite weak lock-in knowledge	3.70	3.90	0.92	1.06	0.21	7.27	0.00

5.5. Information Systems Market, the "Big Picture"

From the results obtained, what are the factors that we can consider as influencing the decision of consumers namely in their choice of Operating Systems and Office Suites for personal computers?

In Table 56 to Table 58 we present the several factors that are statistically significant considering the thesis hypothesis, and are expected to influence the decisions regarding the choice of Operating Systems and Office Suites for personal computers, and also the software beside these two.

We have factors that can be considered to influence all kind of software purchasing, but also Operating Systems and Office Suite choices specific factors. The tables present the variables or constructs, the associated hypothesis, the related questions on the questionnaire with the percentage of missing answers and their mean and median statistics.

Table 56. Software choice influencing variables and constructs

Variable or Construct	H	Questions	Missing	Mean	Median
Direct network effect	H1d	1a	1%	3.74	4.00
Weak lock-in path dependence	H3d	4	0%	3.89	4.00
Actual needs	H5d	5a	1%	4.51	5.00
Actual and potential needs		5b	1%	4.58	5.00
Software global costs	H7d	5c, 5d, 5e	0%	3.90	4.00
Supplier global image perception	H5d	5f, 5g, 5h	1%	3.95	4.00
Local network effect	H4d	5l, 5m	1%	3.95	4.00
Open Source cheaper	H7d	15	4%	3.77	4.00
OSS better globally than PS	H5d	13a to 14c	7%	2.96	3.00
OSS better support than PS		16a, 16b	6%	2.29	2.00

Table 57. Operating System decision variables and constructs

Variable or Construct	H	Questions	Missing	Mean	Median
Apple MacOS	H5d	7, 8, 9 (a to f)	7%	4.13	4.30
Caixa Mágica Linux			21%	3.25	3.30
Mandriva Linux			22%	3.24	3.00
Microsoft Windows			4%	3.45	3.60
Novell/Suse Linux			15%	3.50	3.70
RedHat Linux			13%	3.49	3.70
OS homogeneity degree	H6d	so22	0%	4.96	5.00
Switch costs easiness OS	H2d	17, 18	9%	2.62	3.00
Operating System weak lock-in computer and knowledge	H3d	19a to 19d	2%	3.84	4.00
Operating System weak lock-in peripherals and applications	H3d	19e to 19h	2%	4.54	5.00
Operating System network effect	H1d	19f to 19g	2%	4.18	4.50

Table 58. Office Suite decision variables and constructs

Variable or Construct	H	Questions	Missing	Mean	Median
Apple iWork	H5d	10, 11, 12 (a to h)	24%	3.66	3.70
Corel WordPerfectOffice			29%	3.26	3.00
EPress OneOffice			40%	2.95	3.00
IBM Lotus SmartSuite			25%	3.38	3.30
KDE KOffice			34%	2.99	3.00
Microsoft MSOffice			11%	3.78	3.70
OpenOffice.org OpenOffice			22%	3.52	3.70
Sun StarOffice			29%	3.26	3.00
Office homogeneity degree	H6d	officesuite22	1%	4.80	5.00
Switch costs easiness Office	H2d	20	6%	3.15	3.00
Office Suite weak lock-in knowledge	H3d	21b,c,d	6%	3.74	3.90
Office Suite weak lock-in legacy files	H3d	21f	6%	3.90	4.00
Office Suite network effect	H1d	21e	3%	4.27	5.00

After considering this factors we can conclude that the IS markets are different from other markets where the main choice influencing factors are product brand image, product characteristics and price. In IS markets there exist other additional factors that influence the purchasing choice, as presented in the literary review and hypotheses of the thesis. We have three kinds of influencing factors:

1. Perception of the product brands present in the market;

2. Perceptions of the category of products present in the market (Open Source Software versus Proprietary Software Products);

3. Company IS reality and other factors that the users consider relevant when choosing software.

From all these factors we have different results and conclusions when studying the Operating Systems market and Office Suite market, even if some decision influencer factors are common to both markets. They are all present in Table 59.

5.5.1. Influencing factors of software choices (Operating System)

Starting with Operating Systems brand global image perceptions (hypothesis H5d), we see that while Microsoft Windows dominate with its large market share, it is not the product with better global image. Apple MacOS or even Novell/Suse Linux or Red Hat Linux have better image even if the difference for the last two is not statistically significant. In specific aspects like software security Microsoft Windows has the worse perception. Microsoft Windows also has a higher cost than its Linux competitors. In this case, why only 20% of companies would switch to an alternative Operating System?

Included in the influencing factors we have perceptions for each kind of software category, in this case Open Source Software versus Proprietary Software, regarding global perception of software and support availability perception.

When comparing the global image perception of Open Source Software against Proprietary Software considering hypothesis H5d, Proprietary Software has advantage even if not statistically significant. While Microsoft Windows global image is worse than two versions of Linux, even if not statistically significant, the statistically significant best MacOS global image has influence on the advantage of Proprietary Software. The lack knowledge of two Linux companies (Caixa Mágica and Mandriva) by the users could have influenced their lower assessment of these companies' versions of Linux, lowering the Open Source Software global image perception. The perception of support availability, also part of software global characteristics (hypothesis H5d), is more favorable to Proprietary Software than to Open Source Software in a statistically significant way and because of this, it's expected that influence choices toward Microsoft Windows and Apple MacOS.

When comparing the perception of Open Source Software versus Proprietary Software costs, considering that costs influence software choice (hypothesis H7d), we concluded that there exist the perception that global costs of Open Source Software are significantly lower than Proprietary Software costs.

We can conclude that we have an incumbent Operating System not perceived as the best or even as one of the best in the market, that is at same time perceived as more expensive comparing with some of the alternatives, but still preferred over alternatives the majority of the companies. Is the perception of higher availability of technical support the only reason for this market situation?

The literature review showed several other factors that influence software choices and were considered in the questionnaire. From these factors, we considered the statistical significant market and user realities as choice influencing factors.

We concluded that the market heterogeneity (hypothesis H6d) regarding Operating Systems and Office Suite installed is low and that could favor the incumbent software (Dalle 1997). In addition, companies have old applications updated with new versions and that can create lock-in (Hypothesis 3d), that favor incumbent software (Liebowitz 2000). There exist local network effects through advice from IS staff (Dalle 1997), people with technical know-how about the market and software, but we can't say in which direction (incumbent software or alternative) this advice can go.

Several factors considering user realities and opinions influence user choices:

. File compatibility with business partners, creating network effect (Hypothesis 1d) that favors the incumbent software (Katz and Shapiro 1985);

. Supplier's global reputation image (hypothesis H5d) that showed that the global image of the different Operating Systems is a factor that influence software choices (Liebowitz and Margolis 1996);

. Software actual and possible future requirements that showed that software features are important in choices (hypothesis H6d) (Liebowitz and Margolis 1996);

. Global cost of software is also a relevant factor in software choices (hypothesis H7d) favoring the cheaper software, considered to be Open Source Software, as (Bonaccorsi and Rossi 2003) showed in their research.

Beside these influential factors, there are also switching costs between installed software or did the users considered easy to switch between installed Operating Systems and their alternatives (hypothesis H2d)?

The companies consider that is not easy to switch to alternative Operating Systems because of the switching costs. The main reasons for these switching costs are related with: lock-in regarding computers available, IS know-how and training needs and also applications and peripherals owned (hypothesis H3d); network effects regarding compatibility with applications of business partners and applications available for the Operating System (hypothesis H1d). We can conclude that all thesis hypotheses considered have influence on software purchasing of Operating Systems and by that way influence over the market situation and evolution. The exception was the weak lock-in created by older files or older applications, if still in use, and the network effect considering the possibility of using same applications of business partners, that were considered statistically less or no relevant.

5.5.2. Influencing factors of software choices (Office Suite)

When comparing results of Operating System with Office Suites perceptions we can conclude that while the incumbent Microsoft Windows was not considered the best Operating System of the market, the incumbent Microsoft Office was considered the best Office Suite, even if the null hypothesis of equal means with Apple iWork was not rejected. With these results, why only 20% of the companies consider switch to an alternative Operating System and near 30% of the companies consider to switch to an alternative Office Suite?

Besides influencing factors that are common with Operating System factors, as showed in Table 59 and already analyzed, there exist specific Office Suite influencing factors that could explain it. For instance, the Office Suite switching costs are lower than Operating System switching costs.

Table 59. Market situation and influencing factors

Operating System Installed ***Microsoft Windows in majority of computers*** 48% companies: 100% of PCs MS-Windows 41% companies: > 90% MS-Windows 7% companies: 81 to 90% MS-Windows 1% companies: 71 to 80% MS-Windows 3% companies: 61 to 70 % MS-Windows	**Office Suite Installed** ***Microsoft Office in majority of computers*** 96% companies: Microsoft Office Suite 4% companies: OpenOffice
Brands Global Image Perception Perception of product brands present in the market (innovation, quality, security)	
Hypothesis H5d (Software company/brand image regarding quality, security, innovation, etc.)	
Operating Systems Mean and median of Microsoft Windows (3.43;3.58) lower than Apple MacOS (4.13;4.32), Novell/Suse Linux (3.50;3.69) and Red Hat Linux (3.49;3.68) but null hypothesis of equal means rejected only for Microsoft Windows versus Apple MacOS.	**Office Suites** Microsoft Office (3.78;3.70) with the higher mean of all Office Suites and with the same median than Apple iWork (3.66;3.70) and OpenOffice (3.52;3.70). Null hypothesis of equal means not rejected only for Microsoft Office versus Apple iWork.
Perception of the product categories in the market (OSS versus PS) Global product image, support availability and global cost	
Hypothesis H5d (Software image regarding security, quality, innovation and support)	
Proprietary Software global image higher than Open Source Software global image, with means respectively of 3.53 and 3.43 and medians of 3.35 and 3.63, but null hypothesis of equal means not rejected. Perception of availability of quality support higher for Proprietary Software than for Open Source Software Support. Means respectively of 4.01 and 2.98 and medians of 4 and 3. Null hypothesis of equal means rejected.	
Software costs Open Source Software versus Proprietary Software	
Hypothesis H7d (Costs (licensing, maintenance, training) influence choice of adoption of the alternative standard.)	
Open Source Software perceived with lower cost (license, maintenance and training) than Proprietary Software, with null hypothesis of median lower or equal to 3 rejected (median value=4).	
Factors and considerations influencing software purchasing choices Network effect; lock-in; local network effect; perception regarding innovation, quality, security, support and image of software brand and supplier; market heterogeneity; global software cost. Hypothesis H1d, H3d, H4d, H5d, H6d, H7d	
Market and user realities: Market heterogeneity is low (incumbent Operating System and Office Suite present in the majority of the computers of all companies); companies have old applications updated with new versions (mean =3.89, median=4); there exist a local network effect through advice from ICS staff (mean=3.95, median=4). **Factors that users consider**: File compatibility creating network effect (mean=3.74; median=4); supplier's global reputation image (mean=3.95; median=4); software actual and possible future requirements (mean=4.95; median=5); global cost of software (mean=3.90; median=4). All are statistically significant.	

Table 59. (continuation)

Switching Costs Costs
Easiness of switch between different brands of Proprietary Software and Open Source Software Operating System or Office Suite

Hypothesis H2d
(Switching costs between standard benefit incumbent software)

Operating Systems
With variable mean of 2.62 and median 3.0, and by not rejecting the null hypothesis of median lower or equal to 3 regarding easiness of Operating System switch, we can consider that there exist switching costs in the switch between Operating Systems.

Office Suites
With variable mean of 3.15 and median 3.0, and with the test p-value of 0.10, we reject the null hypothesis of median lower or equal to 3. The test p-value can be considered as inconclusive, even more if we had considered an α of 10%.

The null hypothesis of equal means between easiness of switch between Operating Systems and between Office suites is rejected, the user consider that there exist higher switching costs when the software is an Operating System.

Operating Systems reasons for the existence of switching costs.
(statistically significant)

H1d- Network effect (need of use same applications as business partners and software available for Operating System): Mean=4.18; median=4.50.

H3d-Lock-in (hardware available and IS know-how): Mean=3.84;median=4

H3d-Lock-in (peripherals and applications owned): Mean=4.54;median=5

Office Suite reasons for the existence of switching costs.
(statistically significant)

H1d-Network Effect (file compatibility with business partners): Mean=4.27; median=5

H3d-Lock-in (IS know-how): Mean=3.74;median=3.90

H3d-Lock-in (legacy files): Mean=3.90;median=4

Operating System to install if new computers without software bought by the company
Near eighty percent of companies will install the same Operating System
Software installed in majority of computers (percentage of sample companies)

Actual Situation	Install in new PC
Windows=100%	Apple MacOS=4.3%
	Caixa Mágica Linux=2.2%
	Microsoft Windows=79.6%
	Novell/Suse Linux=4.3%
	Red Hat Linux=9.7%

Office Suite to install if new computers without software bought by the company
Near sixty-nine percent of companies will install the same Office Suite
Software installed in majority of computers (percentage of sample companies)

Actual Situation	Install in new PC
MS-Office=95.7%	Apple iWork=1.1%
OpenOffice=4.3%	IBM Lotus SSuite=1.1%
	Microsoft-Office=68.8%
	OO OpenOffice=26.9%
	Sun StarOffice=2.2%

Could be this the main reason why users could feel more “free” to switch to another Office Suite than to another Operating System, even if in the first case the incumbent brand has global perception advantage?

Could factors like software cost, considered relevant by users but surpassed by other considerations in the Operating Systems choice, be more considered in the case of Office Suite, maybe also influenced by the fact that usually the cost of Operating System is included in the computer cost while there is a “visible” separate cost in case of the Office Suite? On other hand while applications availability and compatibility between Proprietary Software and Open Source Software Operating Systems is difficult or impossible for many applications, file compatibility between Proprietary Software and Open Source Software Office Suites is getting better and better, even more with the recent Open file formats. All this seems to overcome other influential factors that benefit the incumbent software, allowing more users to consider switch their Office Suite even if they do not consider significant strong features benefits of the alternative options.

5.5.3. Information System market analysis further considerations

After studying the several factors that together influence the choices of Operating Systems and Office Suites for personal computers, we will now make some further analysis about the market, namely the difference between answers of companies with or without IS department and between companies that consider or not consider to switch their actual software.

IS department existence influence on questionnaire answers

The majority of companies (86%) that answer this enquiry have an IS department. Usually the existence of an IS department in a company is associated with the company dimension regarding the number of personal computers, servers, etc. and IS knowledge. We will test the influence of the existence of an IS department on answers with t or Mann-Whitney tests.

For all the variables and constructs obtained from the questionnaire we will make a statistical test to verify if there is a difference between the answers from respondents of companies with IS departments and from respondents of companies without IS department. After the Kolgorov-Smirnov test if the null hypothesis of normal distribution is rejected, we apply the non-parametric Mann-Whitney test, if not we apply the Levene equality of variance test. If the variance equality null hypothesis is not rejected, we apply the homocedastic t-test, if is rejected we apply the heterocedastic t-test. In Table 60, we have the results where we reject the null hypothesis of equality of means at 5% and 10% significance level. We can assume that companies with IS departments have more knowledge about IS and can better evaluate the products and factors of market.

That can be showed by a different evaluation of software brands like Novell/Suse Linux and Sun StarOffice. Also the importance given to network effect as cause of switching costs in Operating Systems and Office Suites is different in companies with IS departments.

When considering the 10% significance level we conclude that companies with IS department also evaluate differently brands like Red Hat Linux and OpenOffice and less known brands like KDE KOffice. They also consider differently the influence in the switching costs of the weak-lock-in caused by upgraded applications and also the peripherals and applications available for the actual installed Operating System.

Since companies without IS department represent less than 14% of the respondents, the sample data available is influenced by the better IS knowledge of the near 86% of the sample companies that have IS department.

Table 60. t or Mann-Whitney test considering IS department existence

Independent samples Test	Levene's test for equality of variances	t or Mann-Whitney test t(a) or M-W(b) test	Sig (2-tail)
5% significance level			
Operating System Network Effect	Null hypothesis not rejected	-2.49(b)	0.01
Sun StarOffice		-2.46(b)	0.01
Office Suite Network Effect		-2.43(b)	0.02
Novell/Suse Linux		-2.32(b)	0.02
10% significance level			
Operating System Weak Lock-in.PA	Null hypothesis not rejected	-1.95(b)	0.05
Weak Lock-in		-1.80(b)	0.07
KDE KOffice		-1.80(b)	0.07
OpenOffice.org OpenOffice		1.86(a)	0.07
Red Hat Linux		1.77(a)	0.08

Operating System switch choice influence on answers

We will now analyze how companies choosing to switch or not their Operating System differ in their answers, by applying the t or Mann-Whitney tests.

The statistical methodology will be the same as with the tests considering the existence of IS department, with results present in Table 61.

There exist different evaluations of Red Hat Linux between companies that choose to keep or switch their Operating System when buying a new computer. At 10% significance level, there are also different evaluations in software brands like Apple Mac OS and Novell/Suse Linux. There is a different evaluation of factors like the influence of software global costs and Operating System switching costs in their software choices. Companies that have a higher probability of software switch are also the same that evaluate in a more positive way the software alternatives, and also evaluate differently the global cost (almost all alternatives are cheaper Open Source Software) or consider differently the switching costs.

Office Suite switch choice influence on answers

In the case of the Office Suite switch (Table 62), we can see that there are different evaluations of the OpenOffice Office Suite and about the easiness of switch between Office Suites. The costs seem to be relevant in Office Suites choices with both constructs present and evaluated in different ways, even if only at a significance level of 10% in the last case.

Table 61. t or Mann-Whitney difference test considering Operating System choice

Independent samples test	Levene's test for equality of variances	t or Mann-Whitney test t(a) or M-W(b) test	Sig (2-tailed)
	5% significance level		
Red Hat Linux	Null hypothesis not rejected	2.14(a)	0.04
	10% significance level		
Apple MacOS	Null hypothesis not rejected	-1.94(b)	0.05
Software Global Costs		-1.80(b)	0.07
OS Switching Costs		-1.74(b)	0.08
Novell/Suse Linux		-1.69(b)	0.09

Table 62. t or Mann-Whitney test considering Office Suite choice

Independent samples test	Levene's test for equality of variances	t or Mann-Whitney test t(a) or M-W(b) test	Sig (2-tail)
	5% significance level		
Office Suite Switching Costs	Null hypothesis not rejected	-4.86(b)	0.00
Open Source Cheaper		-2.66(b)	0.01
OpenOffice.org OpenOffice		2.31(a)	0.02
	10% significance level		
Software Global Costs	Null hypothesis not rejected	-1.74(b)	0.08

As expected the existence of an IS department, that can be considered as giving more IS knowledge to the company, cause different evaluations regarding the less known software brands and factors like network effects or weak lock-in.

Companies that have different options regarding Operating System or Office Suite switch have in different consideration alternative brands, software costs and switching costs. Table 63 showed the relevant constructs and the hypothesis behind them. In the case of the Operating System switch, several alternative brands but also software global costs and switching costs are considered in a different way. In the case of Office Suite switch, only OpenOffice brand is evaluated in a different way, but switching costs and software costs are also considered. The Open Source Software cost seems to be more relevant in the Office Suites maybe because many organizations consider MS-Windows as “coming with the computer” (a hidden cost) while the Office Suite is usually considered as an additional cost.

We can conclude in this analysis that hypothesis H2d (switching costs), H5d (software features, quality, security, support, brand image) and H7d (software costs) seem relevant but we must not forget that network effects (H1d) and weak lock-in (H3d) are considered by users as influencing their answers about switching costs (H2d).

Table 63. Difference between answers of software switchers and not-switchers

Choice specific influencing factors	Rejected null hypothesis of equal answers between companies who switch or not switch their software	
	Hypothesis	Description
Operating System		
Red Hat Linux	H5d	Incumbent versus alternative software global perception
Apple MacOS	H5d	Incumbent versus alternative software global perception
Software global costs	H7d	Software costs (licensing, training, maintenance)
Easiness of OS switch	H2d	The higher agreement the lower the switching costs to alternative software. This costs include the caused by network effects or lock-in
Novell/Suse Linux	H5d	Incumbent versus alternative software global perception
Office Suite		
OpenOffice.org OpenOffice	H5d	Incumbent versus alternative software global perception
Open Source cheaper	H7d	Comparison between Open Source Software and Proprietary Software global costs. The higher agreement the higher the perception that OSS is cheaper than PS.
Easiness of OFFS switch	H2d	The higher agreement the lower the switching costs to alternative software. This costs include the caused by network effects or lock-in
Software global costs	H7d	Software costs including licensing, training and maintenance.

5.6. Impact of independent variables and constructs on software choice

After testing what variables and constructs have influence in the software choices, confirming the hypothesis behind them, and also analyzing how they can have different evaluations between companies that have or don't have IS department or choose to switch or not switch their software, we will now try to measure the influence of the different variables and constructs on the Operating System and Office Suite choice. We will make models that include all the variables and constructs except when the missing data is more or equal to 25%. One model will be made for Operating Systems choice and other for Office Suites choice.

To make these models, while we could use discriminant analysis that can be applied when the dependent variable is non-metric, strict assumptions like the normality of the variables make us to opt for the logistic regression. Other advantages of the logistic regression over discriminant analysis are: logistic regression is less affected by the variance-covariance inequalities across groups; can handle categorical independent variables without need of dummy variables; interpretation of results is easier, similar to the interpretation of multiple linear regression (Hair et al. 1992).

There is a limitation regarding the sample small size in logistic regression. In small samples, one may get high standard errors. Peduzzi et al. (1996) recommend at least 10 as number of events per variable (EPV) to avoid the conservatism of the Wald statistic under the null hypothesis and increased paradoxical associations (significance in the wrong direction). Pedhazur (1997) recommend a sample size at least 30 times the number of parameters to estimate. Menard (1995) also warns that for large coefficients, standard error is inflated, lowering the Wald statistic (chi-square) value.

Beyond the impact of the sample dimension on the Wald statistic results, also multicollinearity can have influence on the Wald statistic. Multicollinearity in logistic regression models is a result of strong correlations between independent variables that inflates the variances of the parameter estimates. That may result, particularly for small and moderate sample sizes, in lack of statistical significance of individual independent variables while the overall model may be strongly significant. Multicollinearity may also result in wrong signs and magnitudes of regression coefficient estimates, and consequently in incorrect conclusions about relationships between independent variables and the dependent variable. To search for multicollinearity we can analyze the Variance Inflation Factor (VIF) for each variable. If the VIF values are less than the rule-of-thumb cut-off of 10, is not expected collinearity. However, in "weaker" a model, which is often the case in logistic regression, values above 2.5 may sometimes be a cause for concern (Allison 1999). It is always advised to analyze the correlation matrix, the Kendall tau_b correlation matrix when we have normal and non-normal data as in our model.

While the collinearity among the variables can make the discriminatory power redundant among variables, and we have in our research several variables and constructs for the same hypothesis but considering different decision influence factors, redundancy does not make variables irrelevant from a perspective of explanation (Hair et al. 1998). Because of all this, multicollinearity diagnostics while made are not discussed in this thesis, unless is diagnosed and actions to minimize its impact, the withdrawing of correlate variables, have relevant impact on the explanatory objectives of the model, namely change of parameters sign.

We could also make the logistic regression by using the more statistically rigorous stepwise methodology, even considering the statistical limitations and influence that the available data can have on the results. These stepwise methods, forward or backward, determine automatically which variables to add or drop from the model considering statistical parameters. However, as pure data-driven methods, stepwise procedures run the risk of modeling noise in the data and are considered useful only for exploratory purposes. For selecting model variables on a theoretic basis the methodology used, the "Enter" method is preferred. Stepwise regression is used in the exploratory phase of research but it is not recommended for theory testing (Menard 1995). Because of the reasons cited and because the objective of this thesis is a global explanation of all the factors that influence IS choices in the Operating System and Office Suite for personal computers markets considering the theoretical hypotheses, these methods will not be used in this thesis.

Even with these limitations, as a further explanation of Operating System and Office Suite markets we will make the logistic regression for both kind of software, analyze the results with an explanatory objective, and as such, include all the variables and constructs considered relevant in previous statistical tests. The variables and constructs included in the binary logistic regressions of the Operating System choice and the Office Suites choice are present in Table 64, respectively the applied to both software choices, only to Operating System choice and only to Office Suite choice.

Table 64. Logistic Regression abbreviation list.

Variable or construct	Abbrev.	Variable or construct	Abbrev.
Software choice factors			
Direct Network Effect	DNE	Weak Lock-in Path Dependence	WLPD
Actual Needs	AN	Actual and Potential Needs	APN
Software Global Costs	SGC	Supplier Global Image	SGI
Local Network Effect	LNE	Open Source Cheaper	OSC
OSS Better Globally vs. PS	OSSBG	OSS Better Support than PS	OSSBS
Operating System choice factors		Office Suite choice factors	
Apple MacOS	AM	Apple iWork	AiW
Caixa Mágica Linux	CML	Microsoft MSOffice	MSOFF
Mandriva Linux	ML	OpenOffice.org OpenOffice	OOOO
Microsoft Windows	MW	Office Homogeneity Degree	OFHD
Novell/Suse Linux	NSL	Switch Costs Easiness Office	SCEOF
Red Hat Linux	RHL	Office Suite Weak Lock-in.K	OFWLK
OS Homogeneity Degree	OSHD	Office Suite Weak Lock-in.LF	OFWLLF
OS Switch Costs Easiness	SCEOS	Office Suite Network Effect	OFNE
OS Weak Lock-in.PCK	OSWLPCK		
OS WeakLockin.PA	OSWLPA		
OS Network Effect	OSNE		

5.6.1. Operating System logistic regression model

The logistic regression model for Operating System choice is:

$$\text{Logit}(p) = \ln\left(\frac{p}{1-p}\right) = \beta_1 \times DNE+ + \beta_2 \times WLPD + \tag{1}$$

$$\beta_3 \times AN + \beta_4 \times APN + \beta_5 \times SGC + \beta_6 \times SGI + \beta_7 \times LNE + \beta_8 \times OSC +$$

$$\beta_9 \times OSSBG + \beta_{10} \times OSSBS + \beta_{11} \times AM + \beta_{12} \times CML + \beta_{13} \times ML +$$

$$\beta_{14} \times MW + \beta_{15} \times NSL + \beta_{16} \times RHL + \beta_{17} \times OSHD + \beta_{18} \times SCEOS +$$

$$\beta_{19} \times OSWLPCK + \beta_{20} \times OSWLPA + \beta_{21} \times OSNE$$

In this logistic regression model p is the probability of NewPCOS =1, the probability that in a new PC the company will install a different Operating System from the Operating System installed in the replaced PC. The probability of event occur (p) versus probability of the event non-occur (1-p) is p/(1-p) (Sharma 1996).

5.6.2. Assessing Overall Model Fit

We will now use several measures to assess overall model fit. The -2 Log likelihood value is 53.70. Considering 50 degrees of freedom (df) (72-21-1) we have a chi-square p-value of 0.33, not rejecting the null hypothesis that the model fit the data. The Likehood Ratio statistic is obtained from the difference between the initial and final -2 Log likelihood considering a chi-square distribution with df = number of independent variables, 21 in this model. For a chi-square value of 46.11 with 21 df, we have a p-value of 0.00 that means a strong relationship between de dependent variable and the independent variables set. We will now assess the overall fit of the binary logistic regression model by using the Hosmer and Lemeshow (1989) test. The test can be considered robust and a good alternative to the chi-square test, particularly if sample size small, has happen in this thesis. The Hosmer-Lemeshow test will assess the model fit to the data considering the null hypothesis "there is no difference between observed and model-predicted values". From the chi-square value 11.00 and df=8 we have a p-value of 0.20, we fail to reject the null hypothesis, that is no difference between observed and model-predict values, implying that the model's estimates fit the data at an acceptable level.

We will now assess the data variance that is explained by the model using measures similar to the R^2 of the multiple linear regression. The first one is the Nagelkerke-R^2, that is an improvement of the Cox & Snell-R^2 to assure that it can vary between 0 and 1 (Cox & Snell-R^2 usually has a maximum lower than 1). The Nagelkerke-R^2 value is 0.63. That means that the variance of NewPCOS is explained in 63% by this logistic regression model. Another measure, based on the log-likehood, is the McFadden-R^2. The McFadden-R^2 value is obtained from the ratio between of the final and initial -2LL and subtracting a unit. In this case, the McFadden-R^2 t value is 0.46.

If we consider the average of these two measures, a value of 0.55, we conclude that the model explain 55% of the variance of the dependent variable.

5.6.3 Assessing the Model Discriminatory Power

The discriminatory power of the model is obtained by assessing the model capacity to differentiate between users that choose to switch or not switch their software, considering the classification table of the logistic regression model. We will do it by observing the values of the classification table (Table 65) and making a ratio of a random choice between observations, considering two different assumptions.

We start by comparing the overall correct percentage that is 83.3% against the random choice ratio if a naive observer chooses always the option “Choose same OS”. In this situation, we have a random choice ratio of 55/72=76.4%, lower than the 83.3% of the logit model. If we make the same ratio using the weight of the users that choose the same OS versus the user that switch, we have $(55/72)^2 + (17/72)^2$ that is 63.9%, lower than 83.3% of model. We can conclude that the logistic model has a better discriminant power to separate OS switchers from non-switchers than a random choice.

Table 65. Operating System choice logistic regression classification table

Observed (Cut value =0.50)		Predicted NewPCOS: Choose same OS	Predicted NewPCOS: OS Switch	Percentage correct
NewPCOS	Choose same OS	53	2	96.4
	OS Switch	10	7	41.2
Overall Percentage				83.3

5.6.4. Parameter Estimates Interpretation

We will now interpret the parameter estimates of the binary logistic regression considering the limitations explained above. We will start by interpreting all the parameters in the order of significance by the Wald statistic, considering p-value lower than 0.10 due to the logistic regression potential problems cited above, to see if the coefficients sign support the thesis hypothesis (Table 66).

The statistical interpretation of the parameters of a logistic regression is the following, giving as an example the β_{16} parameter associated with Red Hat Linux, β_{16} = 2.305 with exp(β_{16}) = 10.026.

This parameter β_i represents the variation in ln(odds ratio) when the independent variable change by one unit. The exp(β_i) represents the effect of the independent variable on the odd ratio. A positive unitary variation in Red Hat Linux evaluation will increase the probability of switching Operating System, the odd ratio p/(1-p). The percentage change of odd ratio is 100 x (β_{16} – 1) = 100 x (10.026 – 1) = 902.6%. A positive unitary variation of Red Hat Linux evaluation increases the probability of Operating System by 902.6%.

By analyzing the coefficients starting with the ones that statistically (significant at 10%) confirm the thesis hypothesis, we can conclude that users have a higher probability to switch their OS in the following situations:

1. Open Source Software alternative Red Hat Linux evaluation is higher. If the alternative software has better features, security and quality users could switch (H5d). The same apply for other alternatives like Apple MacOS or Novell/Suse Linux. On other hand and as expected, the higher the evaluation of the incumbent Microsoft Windows, the lower the probability that people will switch from this dominant Operating System. There are incoherent results for Caixa Mágica Linux and Mandriva Linux that could be affected by the lower knowledge of the companies, lower evaluation and more missing answers;

2. The easier the switching between Operating Systems, the lower switching costs (H2d). We must take into account that in this switching costs evaluation we have influence of network effects and weak-lock-in;

3. The Operating System Weak Lock-in through Peripherals and Applications is lower. If users have many peripherals and software that they fear that will not work with the new Operating System they will not switch (H3d);

4. The higher the evaluation of Microsoft Windows the higher the probability that the user will not switch their Operating System as theoretically expected (H5d).

5. The higher the local network effect, in this case through IS staff inside or outside the company, the larger the switch probability. It's expected that IS people with more knowledge can show and assure in a better way the possible advantages of an alternative Operating System (H4d).

On the parameters not statistically significant we have:

6. The higher the IS environment homogeneity degree, the lower the heterogeneity of the IS market with a largely dominant Operating System the lower the probability of Operating System switch (H6d);

7. The higher the consideration of actual needs the higher the switch probability (H5d). Users seem to consider their actual needs satisfied OSS products;

8. The higher the consideration of the importance of the Software Global Cost, the more probability of OS switch, mainly to the cheaper OSS alternatives (H7d);

9. The higher the network effects, here through compatibility with business partners, the lower the probability of OS switch (H1d);

10. The higher the consideration of actual and potential future needs for software, the more probability that the user keep the same OS. This could be influenced also by the global image and support availability perceptions of OSS versus PS where PS has advantage and also by the consideration that in long term PS companies have more innovation capabilities (H5d);

11. With the rise of the perception of lower costs of the OSS, the probability of switching the OS mainly to OSS alternatives also rise (H7d);

Table 66. Operating System choice logistic regression parameters estimates

Variables and constructs	H	β_i	S.E.	Wald	Sig.	Exp(β_i)
RedHatLinux	H5d	2.305	1.005	5.264	0.022	10.026
SwitchCostsEasinessOS	H2d	1.168	0.566	4.263	0.039	3.216
OperatingSystemWeakLockin.PA	H3d	-2.928	1.438	4.147	0.042	0.054
MicrosoftWindows	H5d	-1.445	0.750	3.708	0.054	0.236
LocalNetworkEffect	H4d	1.478	0.866	2.914	0.088	4.384
OSHomogeneityDegree	H6d	-1.210	0.988	1.499	0.221	0.298
Actualneeds	H5d	0.824	0.706	1.360	0.244	2.279
SoftwareGlobalCosts	H7d	0.670	0.657	1.042	0.307	1.954
AppleMacOS	H5d	0.796	0.785	1.028	0.311	2.216
DirectNetworkEffects	H1d	-0.365	0.361	1.024	0.312	0.694
NovellSuseLinux	H5d	0.810	0.974	0.692	0.406	2.248
ActualPotentialNeeds	H5d	-0.577	0.726	0.633	0.426	0.562
OpenSourcecheaper	H7d	0.297	0.440	0.455	0.500	1.345
SupplierGlobalImagePerception	H5d	0.103	0.591	0.031	0.861	1.109
CaixaMágicaLinux	H5d	-1.791	0.951	3.549	0.060	0.167
OperatingSystemNetworkEffect	H1d	1.881	1.010	3.471	0.062	6.562
OSSBetterGlobalPS	H5d	-1.812	1.116	2.637	0.104	0.163
MandrivaLinux	H5d	-1.350	0.905	2.226	0.136	0.259
OperatingSystemWeakLockin.PCK	H3d	0.579	0.630	0.845	0.358	1.785
WeakLockin.PD	H3d	0.398	0.472	0.712	0.399	1.490
OSSBetterSupportPS	H5d	-0.495	0.805	0.378	0.539	0.610

12. The higher the consideration of the importance of the Supplier Global Image, the more probability that the user will switch to another OS (H5d). This can signify that when Supplier Global Image is more relevant to switch choices the worse evaluation of

the incumbent Microsoft Windows is more considered. We must take notice that the significance in this case is very low.

There are also a few other constructs where the sign of the coefficients is incoherent with the thesis hypothesis, even if only two of them statistically significant. This could be caused by the users' same opinions about specific aspects of the market switching or not switching or because of statistical problems as cited before. Beside the situation with of Caixa Mágica Linux and Mandriva Linux, already analyzed, the comparison between OSS and PS in Global Image and Support Available also goes against the hypothesis H5d. In the logistic regression model, as the advantage of OSS rise the switch probability gets lower. That means that companies that showed interest in switch their Operating System were also the companies that consider OSS software as not better or even worse than PS in terms of Global Image or Support Availability. Considering that Apple MacOS is Proprietary Software, this may help in the explanation. Also can mean that exist companies that while considering PS superior than OSS keep their switch decision because other factors influence their choice like costs or factors like technical support are less relevant as in Office Suite support. The weak lock-in regarding path dependence (company with same applications upgraded through the years), the Operating System network effect and the Operating System weak lock-in through computer availability and knowledge also had a coefficient sign that goes against the hypothesis made. This could be result of statistical problems like collinearity problems or sample size dimension influence and interaction with the other variables, or because as before the opinions are keep with both decisions.

In global terms we analyzed all the variables and constructs that users considered in their Operating System choices. There are complex interconnections between all of them that make the modeling more difficult to make and interpret. Perceptions of software costs, features, quality and technical support, that in their aggregated dynamics difficult market forecasting, are accompanied by market and companies realities that create network effects, switching costs and lock-in creating more inertia in the market and results that can be against what is expected when the expectations are founded on the other markets assumptions. For instance, if we consider only costs and product global features, maybe it was expected a larger switch to an alternative OSS Operating System or even to an alternative PS Operating System if costs less relevant and global image more relevant.

5.6.5. Multicollinearity diagnostics

Multicollinearity diagnostics were made and showed, for instance, correlation problems between the weak lock-in regarding path dependence (company with same applications upgraded through the years) and the Operating System weak lock-in through computer availability and knowledge and between some Linux brands. From these diagnostics and taking out variables and constructs with higher correlations, we arrived to a model where the significant (10% significance) parameters were almost the same as in the first model, with the addition of Microsoft Windows, without improvement on other indicators like goodness-of-fit or change in the market explanation offered by the model. However, by withdrawing correlated variables, these variables that help to explain the IS market and are considered relevant by users disappear due to these statistical methods.

5.7. Office Suite Logistic Regression Model

We will now make a logistic regression model of the Office Suite choices, by applying the same methodology as the applied in the Logistic Regression model of the Operating Systems choices. Due to a high percentage of missing answers and/or low company knowledge recognized by users, several Office Suites were not included.

The logistic regression model for Office Suite choice is:

$$\text{Logit}(p) = \ln\left(\frac{p}{1-p}\right) = \beta_1 \text{ x } DNE + \beta_2 \text{ x } WLPD + \beta_3 \text{ x } AN + \qquad (2)$$

$$\beta_4 \text{ x } APN + \beta_5 \text{ x } SGC + \beta_6 \text{ x } SGI + \beta_7 \text{ x } LNE + \beta_8 \text{ x } OSC \ +$$

$$\beta_9 \text{ x } OSSBG + \beta_{10} \text{ x } OSSBS + \beta_{11} \text{ x } AiW + \beta_{12} \text{ x } MSOFF + \beta_{13} \text{ x } OOOO$$

$$+ \beta_{14} \text{ x } OFHD + \beta_{15} \text{ x } SCEOF + \beta_{16} \text{ x } OFWLK + \beta_{17} \text{ x } OFWLLF + \beta_{18} \text{ x } OFNE$$

5.7.1 Assessing Overall Model Fit

We will now use several measures to assess overall model fit. The -2 Log likelihood value is 25.833. Considering 44 degrees of freedom (df) (63-18-1) we have a chi-square p-value of 0.99, not rejecting the null hypothesis that the model fit the data. The Likehood Ration statistic is obtained from the difference between the initial and final -2 Log likelihood considering a chi-square distribution with df = number of independent variables, 18 in this model. For a chi-square value of 61.50 with 18 df we have a p-value of 0.00 that means a strong relationship between de dependent variable and the independent variables set. We will now assess the overall fit of the binary logistic regression model by using the Hosmer and Lemeshow (1989) test, considering the null hypothesis “there is no difference between observed and model-predicted values”. From the chi-square value 9.78 and df=8 we have a p-value of 0.28, we fail to reject the null hypothesis, that is no difference between observed and model-predict values, implying that the model's estimates fit the data at an acceptable level.

We will now assess the data variance that is explained by the model using measures similar to the R^2 of the multiple linear regression. The Nagelkerke-R^2 value is 0.83. That means that the variance of NewPCOffice is explained in 83% by this logistic regression model. The McFadden-R^2 value, based on the log-likehood, is 0.70.

If we consider the average of these two measures, a value of 0.77, we conclude that the model explain 77% of the variance of the dependent variable.

5.7.2. Assessing the Model Discriminatory Power

The discriminatory power of the model is obtained by the assessing of the model capacity to differentiate between users that choose to switch or not switch their software, considering the classification table of the logistic regression model. We will do it by observing the values of the classification table (Table 67) and making a ratio of a random choice between observations, considering two different assumptions.

We start by comparing the overall correct percentage that is 96.8% against the random choice ratio if a naive observer chooses always the option "Choose same Office". In this situation, we have a random choice ratio of 47/63=74.6%, lower than the 96.8% of the logit model. If we make the same ratio using the weight of the users that choose the same Office Suite versus the user that switch, we have $(47/63)^2 + (16/63)^2$ that is 62.3%, lower than 96.8% of model. We can conclude that the logistic model has a better discriminant power to separate Office Suite switchers from non-switchers than a random choice.

Table 67. Office Suite choice logistic regression classification table

Observed (Cut value =0.50)		Predicted NewPCOffice: Choose same Office	Predicted NewPCOffice: Office Switch	Percentage correct
NewPCOffice	Choose same Office	46	1	97.9
	Office Switch	1	15	93.8
Overall Percentage				96.8

5.7.3. Parameter Estimates Interpretation

We will now interpret the parameter estimates of the binary logistic regression considering the limitations explained above. Like in the Operating System logistic regression we will start by interpreting all the parameters in the order of significance by the Wald statistic, considering p-value lower than 0.10 due to the logistic regression potential problems cited above, to see if the coefficients sign support the thesis hypothesis that were made (Table 68).

By analyzing the coefficients starting with the ones that statistically (significant at 10%) confirm the thesis hypothesis, we can conclude that users have a higher probability to switch their Office Suite in the following situations:

1. The easier the switching between Office Suites, the lower switching costs (H2d). We must consider that in this switching costs evaluation there is influence of network effects and weak-lock-in through knowledge and legacy files owned;

2. The Proprietary Software alternative Apple iWork is considered a quality alternative to the incumbent product MS-Office. But while this incumbent alternative has statistical significance, we must consider that for the large majority of the

companies will force to switch also the Operating System and the computer. That's way only 1.1% of the answers considered the possibility of include iWork in a new personal computer. Even if statistically no significant and with a lower exp(βi), we expect that OpenOffice will have larger impact on Microsoft Office as an Open Source Software alternative if its global perception improves (H5d);

3. The Office Suite Weak Lock-in through Legacy Files shows that companies that have many MS-Office files are afraid of "loose" them because of files incompatibilities or not perfect conversion if they install an alternative Office Suite (H3d). This is one of the factors that contribute to the Office Suite switch costs.

On the parameters not statistically significant we have:

4. The weak lock-in regarding path dependence (company with same applications upgraded through the years) seems relevant in the Office Suite choices. The existence in the company of the incumbent product upgraded with the last version seems to, together with other influencing factors, create inertia toward the Office Suite switch (H3d).

5. The Office Suite network effect seems important in Office Suite choices and influencing the switching costs, not in the same way of the Operating System, but by the need of file compatibility with business partners (H1d). That's way the Office Suite market assist from time to time to "standard wars" because the incumbent must maintain as possible their "incompatibility" with other alternative Office Suites while defending the openness of file formats.

6. The higher the evaluation of MS-Office and OpenOffice the larger the impact in the direction respectively of not switching and switching the Office Suite considering that the first one is dominant with near 96% of the market as considered in hypothesis H5d.

7. The results of Actual Need and Actual and Potential Needs seem to show users are satisfied with the actual Office Suites and don't expect that for this product their potential needs will oblige them to stay with the same incumbent software. Some of market complains about "over-features" of Microsoft Office could help to explain this result (H5d).

8. The more the needs of knowledge to install and uninstall applications or learn how to work with new applications, Office Suite in this case, the stronger the weak-lock in through knowledge (H3d).

9. The higher the consideration of the importance of the Supplier Global Image, the more probability that the user will switch to another OS (H5d). This can signify that when Supplier Global Image is more relevant to switch choices maybe the worse evaluation of the incumbent Microsoft Windows has impact even if Microsoft Office is considered as one of the best products in the market.

10. The higher the local network effect. In this case through IS staff inside or outside the company. It's expected that IS people with more knowledge can show and assure in a better way the advantages of an alternative Office Suite (H4d);

11. The higher the consideration that Open Source Software is cheaper, the higher the probability that there is a switch to an alternative Office Suite, mainly the cheaper Open Source Software alternatives (H7d);

Also in this logistic regression model there are a few constructs where the sign of the coefficients is incoherent with the thesis hypothesis, even if not statistically significant. It seems that there is no impact of the IS environment homogeneity degree on the Office Suite switch choice, the sign is contrary to the theoretical expected.

Table 68. Office Suite choice logistic regression parameters estimates

Variables and constructs	**H**	**β_i**	**S.E.**	**Wald**	**Sig.**	**Exp(β_i)**
SwitchCostsEasinessOffice	H2d	4.014	2.109	3.623	0.057	55.374
AppleiWork	H5d	6.000	3.326	3.254	0.071	403.28
OfficeSuiteWeakLockin.LegacyFiles	H3d	-3.409	2.036	2.803	0.094	0.033
WeakLockin.PD	H3d	-1.544	1.095	1.988	0.158	0.214
OfficeSuiteNetworkEffect	H1d	-1.541	1.196	1.661	0.197	0.214
MicrosoftMSOffice	H5d	-3.163	2.731	1.341	0.247	0.042
Actualneeds	H5d	1.064	1.143	0.867	0.352	2.898
OpenOffice.orgOpenOffice	H5d	2.406	2.795	0.741	0.389	11.089
OfficeSuiteWeakLockin.Knowledge	H3d	-1.090	1.473	0.548	0.459	0.336
SupplierGlobalImagePerception	H5d	1.004	1.771	0.321	0.571	2.729
LocalNetworkEffect	H4d	0.480	1.351	0.126	0.723	1.615
ActualPotentialNeeds	H5d	0.492	2.089	0.055	0.814	1.635
OpenSourcecheaper	H7d	0.039	0.873	0.002	0.964	1.04
OfficeHomogeneityDegree	H6d	2.307	1.458	2.504	0.114	10.04
OSSBetterSupportPS	H5d	-5.711	3.489	2.679	0.102	0.003
SoftwareGlobalCosts	H7d	-2.929	1.803	2.64	0.104	0.053
OSSBetterGlobalPS	H5d	-2.618	2.225	1.384	0.239	0.073
DirectNetworkEffects	H1d	0.573	0.841	0.464	0.496	1.774

The market still has a large homogeneity degree in Office Suite around the incumbent software, but still considers switching their Office Suite maybe because here we are mainly concern only with files compatibility while in the Operating System market there is also application compatibility and availability, making this factor more relevant in the software choices of Operating Systems.

The comparison between OSS and PS in Global Image and Support Available and influence on switching costs goes against the hypothesis H5d. In the logistic regression as the advantage of OSS rise the switch probability gets lower. That means that companies that showed interest in switch their Office Suite were also the companies that consider OSS software as not better or even worse than PS in terms of Global Image or Support Availability. Considering that Apple iWork or other alternatives considered are Proprietary Software, maybe this influenced this result. The network effect also had a coefficient sign that goes against the hypothesis made while is considered in the specific Office Suite network effect. Also here this could be result of collinearity problems or sample size dimension influence and interaction with the other variables where the result is coherent with hypotheses tests.

We have an Office Suite market with the same complexity of the Operating System market but with different results, with a larger percentage of companies considering switching their Office Suites even if the competitive position of Microsoft Office Suite regarding features, quality, security or support is better than the competitive position of Microsoft Windows in the Operating Systems market. It's this kind of situations that make the IS market unpredictable in turning points or if analyzed with other markets assumptions, because in the IS markets we have more inertia if factors like network effects, switching costs, lock-in or homogeneity degree, that have strong influence on is evolution when a dominant supplier in place.

5.7.4. Multicollinearity diagnostics

As in the Operating System logistic regression, also here multicollinearity was expected. The consequences and statistical methodologies to lead with collinearity were the same as in the case of Operating System model. We keep the same considerations about the balance between the explanatory objectives of the model versus the impact of take away correlated variables and as in the Operation System model, that process didn't implied any relevant change on the explanation objectives of the original model and his not presented.

5.8. Summary

In this chapter the IS market was studied from the point of view of the supply and demand. The supply side of the market was studied through the Soft Systems Methodology (Checkland 1981, 1999 and 2006) while the demand side was studied through statistical analysis of the several variables and constructs related with the different thesis hypothesis, with priority given to the explanation of the global market and all the variables and constructs that influence it.

We started with the study of the supply side of the market with the point of view of some of the main companies in the market. The results showed that it's expected that Open Source Software business model to be as innovated as the Proprietary Software model and that companies funded around that model can survive in the market with a service focus as revenue source. Considering that even in Open Source Software model there are revenues, Open Source Software is not completely free for all users of this software.

On the demand side we confirmed that all the factors included in the thesis hypotheses are considered by users. We can conclude that in this market more factors than just product features, price and features/price relationship have influence in the company software choices. Factors like network effects, local network effect, switching costs, lock-in, etc. are not only considered in the situation but also influence it. Deepening the market explanation was studied how the answers in the company sample differ with the presence or not of an IS department in the company or with their decision to switch or not their software. Finally we tried to study the statistical relationships of these factors with a logistic regression model for the Operating System market and Office Suite market, with this modeling made with only a market explanatory objective.

VI. Research Conclusions

6.1. Introduction

The objective of this thesis was to offer a more detailed knowledge of the IS market in general terms. Different methodologies and different sets of hypotheses were applied to study and explain the supply and demand of the market, Soft Systems methodology in the first case and with the application of statistical tools in the second case.

6.2. Main Results of the Research

We had three research questions, the first one about the influencing factors on demand side of the market, the other two research questions concerning the supply side of the market, about Open Source Software cost for the user and innovation and market survivability capacities of Open Source Software companies.

6.2.1. <u>Supply Side</u>

Four hypotheses were made regarding the supply side of the software market and we tried to confirm them by the Soft Systems methodology. The results obtained confirmed the four hypotheses:

Hypothesis 1s: Not only the Open Source Software model is viable considering the capacity of attraction of the needed skilled developers, but also its developing model is as capable as the developing model of Proprietary Software, to each the Open Source model approaches as the software projects get more complex and professionalized.

It's expected that from the worldwide developer's pool Open Source Software will continue to attract the needed numbers for this model viability, even if the motivations and rewards (no-monetary and monetary) can change during the life cycle of the developer and also the life cycle of the market. There is consensus that both developing models, more hierarchal centralized in the case of Proprietary Software and decentralized and sometimes with lower coordination in Open Source Software, can allow the supply of quality software. There was also recognized that as the Open Source Software projects get more complex and/or controlled by professional commercial organizations the development model approaches the more hierarchical centralized model of Proprietary Software.

By all this the Hypothesis 1s is confirmed.

Hypothesis 2s: The Open Source Software innovation process can be at least as innovative with capacity of introducing the innovations in the market as the Proprietary Software innovation market.

Even if in the literature review we concluded that there was no consensus of the advantages of one or another of the Open Source Software or Proprietary Software development models, there was consensus between the market suppliers that since innovation is a human creation, innovation can happen everywhere where is a developer so they didn't recognized a insurmountable advantage of one development model over the other in the innovation process, each of them with their strength points and also their weaknesses.

As we see, Hypothesis 2s is also confirmed.

Hypothesis 3s: Even if the Open Source Software licenses are free, Open Source Software has costs at least for some of the consumers that want to use it.

This hypothesis, that in Open Source Software there are costs exist for some costumers even with free licensing, was answered through the suppliers' feedback regarding the different revenues sources they have, that allow them to have financial sustainability even when offering Open Source Software with a GPL license. By the recognition of viability of different business models for Open Source Software, the existence of monetary revenues even for companies that work only with Open Source Software and the confirmation of Hypothesis 4s that also implied the survival of organizations that work with Open Source Software, we confirm Hypothesis 3s.

As the Sun manager cited, paraphrasing MySQL's Marten Mickos 'There's a difference between organizations that have more time than money and organizations that have more money than time', "the first ones have time to test and install Open Source Software, don't buy it but give it more notoriety. The second ones don't have time but have money. They buy Open Source that includes support and consulting services. The second ones are the consumer target that allows the survival of Open Source companies, a viable business model."

Hypothesis 4s: Open Source Software can compete in the market against Proprietary Software and even compete and obtain market gains when Proprietary Software is the dominant incumbent.

There exists consensus in the research theory, confirmed from the answers of the supply side suppliers that Open Source Software can compete against Proprietary Software. This consensus happen even considering that the first is characterized by the openness of his code and the free licensing and that in many specific categories of software the IS market is dominated by Proprietary Software, that is almost monopolistic in some cases with all the benefits that for instance network effects give to that position in the market. The suppliers also agree that is the inner organization (management and development) of Open Source Software companies, the features and quality of the software they offer, and also the quality and relation price/quality of his service, support and maintenance, besides market factors like network effects, that will be the main factors of competition, not the free licensing "advantage" of Open Source Software. This confirms Hypothesis 4s.

As we see, the Open Source software and his business and development model is in the market to stay, being competitive and innovative enough to compete against the Proprietary Software that in many cases is the dominant in the market. The financial survival of Open Source Software can be regarded as possible like happen with Proprietary Software, even if the business models are different. This result also shows that the "price" of Open Source Software cannot be zero for all customers.

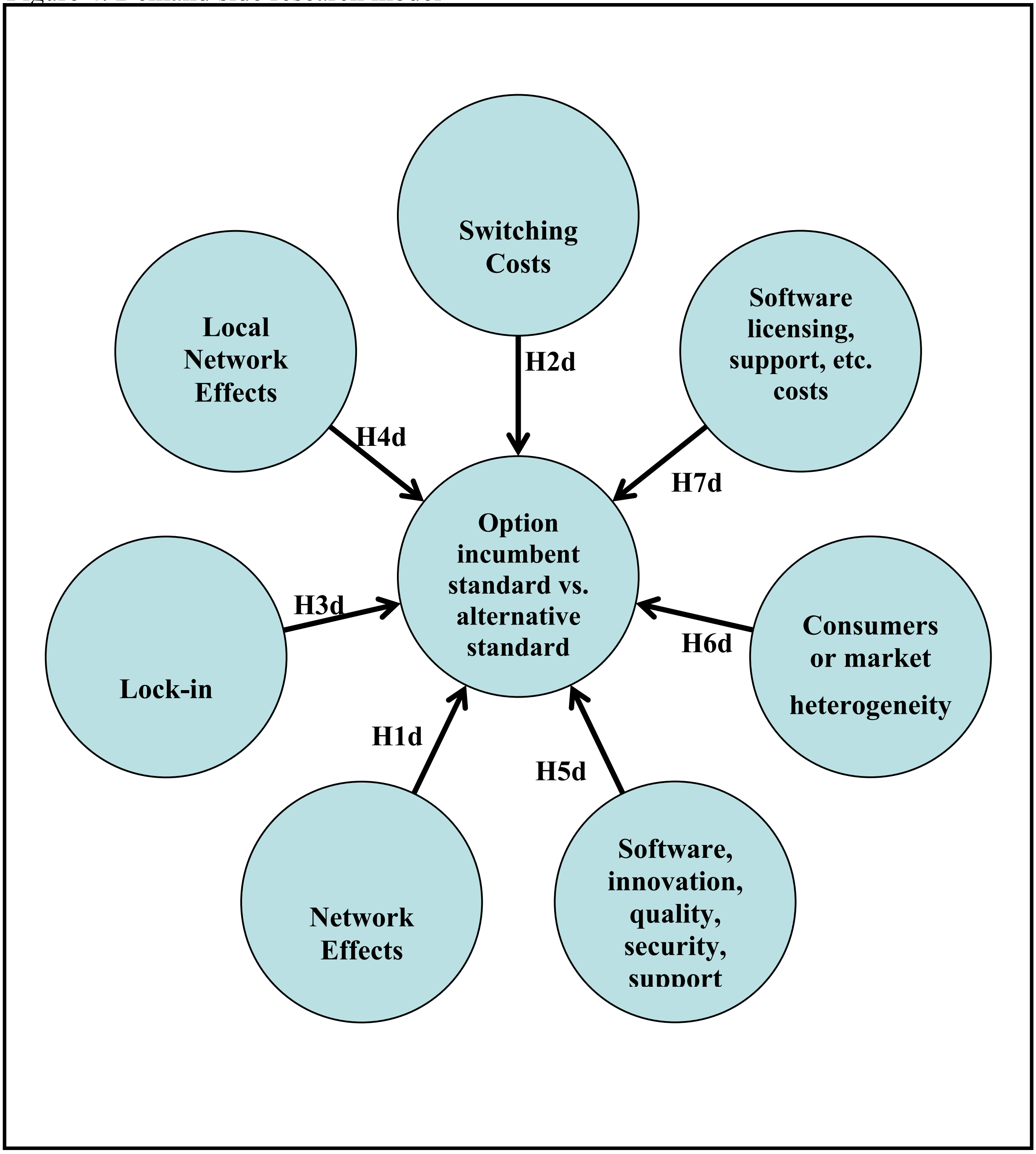
6.2.2. Demand Side

Figure 4 present the demand model with all the factors (thesis hypotheses) that can have influence in the IS user decisions. Some of these thesis hypotheses were studied considering different viewpoints (brand, market, market category (Operating System versus Office Suite) and software business model (Open Source Software versus Proprietary Software). Some of the factors have different analysis subjects like the weak lock-in that can happen because of the user knowledge (or lack of it), hardware or peripherals owned, application and files owned, etc.

The software choice influencing factors, present in the questionnaire filled by the companies sample, were statistically confirmed with the exception of: network effect considering the possibility of installation of same applications that business partners; weak-lock-in considering the use of old applications and files not updated with new software versions; local network effect through advice from sources other than IS professional staff; and Office Suite weak lock-in due the personal computer available. However, all the hypotheses associated with these factors were confirmed considering other aspects like file compatibility in the network effect; knowledge and peripherals and applications owned in the weak lock-in; advice from IS staff inside or outside the company in the local network effect.

To have a stricter analyzes, the statistical tests were made such as only when the mean or median answer was greater than 3, in a Likert scale of one to five, and the hypothesis beyond the question considered was statistically confirmed. The results obtained demonstrated that the IS market is influenced by several factors that confirmed the seven thesis hypothesis, present in Figure 4.

Figure 4. Demand side research model



Further statistical research was made, namely a logistic regression model for each of the software categories, Operating System and Office Suite. The sample dimension and the expected multicollinearity created because several aspects were considered for each of the influencing factors associated with the thesis hypothesis, had influence in the significance results of the parameters. Nevertheless both models showed that the influence of a large majority of the variables and constructs were coherent with the hypothesis made, while the “incoherent” parameters signs were analyzed considering reasons beyond sample characteristic problems.

We can consider the different levels of analysis made to confirm the thesis hypotheses, as presented in Table 69:

1. The statistical tests to evaluate the relevance of the several constructs and variables associated with the thesis hypotheses, the influence factors in Operating System and Office Suite choices (A);

2. The logistic regression considering only hypothesis coherent sign variables and constructs, even if not Wald statistical significant (B);

3. The logistic regression considering only hypothesis coherent sign variables with statistical significance (significance level of 10%) (C).

Table 69. IS market and thesis hypotheses

Variables and constructs	Hyp.	A	B	C
Network Effects	H1d	X	X	X(3)
Switching costs	H2d	X	X	X
Lock-in	H3d	X	X	X
Local network effects	H4d	X	X	X(2)
Software innovation, quality, security, support	H5d	X	X	X
Market heterogeneity degree	H6d	X	X(1)	-
Software costs (licensing, support, etc.)	H7d	X	X	-

(1) Only in Operating System model; (2) Only in Office Suite model; (3) Indirectly through H2d

Considering the research question “Which factors have influence on the buying process decision and the option between Proprietary Software and Open Source Software in the IS market?” and the associated hypotheses, we conclude that with the exceptions already cited above, regarding some constructs and variables, all the hypotheses were confirmed as being considered in the IS choices, through influence of market or company actual IS situation, brands, software business model categories (OSS and PS) and software categories (Operating System and Office Suite).

When modeling the market with a logistic regression model, even considering the possible distorting impact on statistical results because of the sample limitative characteristics and the variables and constructs included, still only H6d (market heterogeneity degree) is not confirmed in Office Suite choices, when considering the variables and constructs with the theoretical “right” sign even if not statistical significant. When considering only variables and constructs with the “right” sign and statistical significance, still four of the hypotheses in the Operating System choice and three hypotheses in the Office Suite choices were confirmed, with hypothesis H1d that could be considered indirectly confirmed.

6.2.3. Open Source Software versus Proprietary Software competition

On the supply side of the market there was an almost unanimous agreement between the software suppliers that the Open Source Software business model allows software innovation and can successfully survive in the market with income sources from several kinds of services. While we have two business models, the Proprietary Software with larger investment in R&D and software development and licensing as the main income source where the variable cost is almost negligible, and Open Source Software with lower R&D and software development investments because they are shared by all in the Open Source Software community and income source mainly from services where the variable cost is bigger, the last market developments are trough hybrid business models like “Cloud Computing” or “Software as a Service” that can use a mix of the two kinds of software licensing.

The results of the demand side research, considering only Operating Systems and Office Suites for personal computers, concluded that it seems difficult that Open Source Software can have relevant market share gains anytime soon.

The free licensing and perception that Open Source Software global cost is lower than Proprietary Software global cost aren’t enough arguments against the Open Source Software lack of perceived features advantage and disadvantage in technical support availability. The influence of market factors like network effects, lock-in or switching costs also favors the incumbent Proprietary Software. While Microsoft Windows has OSS alternatives with better perception and Microsoft Office is better perceived then all other OSS alternatives, the differences aren’t statistically significant in both cases so there is no incentive to switch.

The higher switch probability to Open Source Software Office Suite can be explained, considering all the conclusions above and the considerations in Table 70, that while Microsoft Office has a better global image (even if not statistically significant), there is a cost advantage of the alternative OSS OpenOffice and at same time exist the perception that technical support is less important and also that file compatibility is getting better and better lowering network effects and weak-lock-in through owned Microsoft Office files.

We can conclude that is not expected, at least in the short to medium term, that for this kind software categories were there is a dominant incumbent Proprietary Software, OSS alternatives achieve significant market gains unless they achieve significant advantage perception regarding features and technical support while keeping the cost advantage, as a way of overcoming other market factors that favor the incumbent software. It’s expected that this conclusion while applicable to both software categories is more applicable to the Operating System market.

Only in markets almost starting or markets where the incumbent is not strongly positioned and don’t have yet strong benefits from factors like network effects, lock-in or switching costs, can Open Source Software with a competitive price and at least comparable characteristics have a higher probability of achieve leadership or at least have a relevant presence in market like happens with Linux in Operating Systems for servers, Apache in web servers or MySQL in databases. The growth of Firefox browser in a market that had a strong incumbent Internet Explorer (IE) can be explained by the Microsoft lack of incentive to improve and innovate the dominant IE 6 (achieve 95% of market share staying 5 years in the market) and strong publicized security problems that “forced” many fearful users to switch to the OSS alternative Firefox. That showed users that the switch costs and network effects through compatibility in the browser market where low or not existent while the Firefox security and features were perceived as higher and better.

Considering the competition between Open Source Software against Proprietary Software and the statistically significant factors influencing the buying choices as cited in the literature review, we can see the impact of each of the factors and associated hypotheses in the Operating System (OS) and Office Suite (OFFS) choices and if benefit the (I)ncumbent Proprietary Software or the (A)lternative Open Source Software (Table 70).

Table 70. Incumbent PS versus OSS alternatives influencing factors (OS and OFFS)

Variables and constructs	Hyp	Comments	OS	OFFS
Network Effects	H1d	. Applications available in market for OS and possibility of use same application as business partners (Operating System). *Note: While the possibility of use same application as business partners was not statistically confirmed as relevant when asking about it Operating System choice (question 1d), was statistically confirmed as relevant as influencing the switching costs.* . File compatibility with partners (Office Suite)	I	I
Switching costs	H2d	Are considered as existing, being lower for the Office Suite switch	I	I
Lock-in	H3d	. Weak lock-in caused by path dependence (same application updated through the years) and also influencing switching costs: . Computer, peripherals and applications owned (Operating System) . Knowledge to install, uninstall, and work with software (Operating System and Office Suite) . Incumbent files owned (Office Suite)	I	I
Local network effects	H4d	Exist through IS staff inside or outside the company. While the advice can go one way or another, it seems to favor OSS (ISS staff means less need of search of technical support and less knowledge lock-in)	A	A

Table 70. (continuation)

Variables and constructs	Hyp	Comments	OS	OFFS
Software brand image, innovation, quality, security, support	H5d	Brand global perception and consideration of actual and potential future needs relevant in choice and: . Comparison between OSS and PS Operating Systems and Office Suites concluded that there is no statistically significant difference between them. . Comparison between OSS and PS global perception (image, quality, security) concluded that there is no statistically significant difference between them. . Comparison between OSS and PS technical support availability concluded that PS has statistically significant advantage.	I	I
Heterogeneity degree	H6d	Low IS heterogeneity with Microsoft Windows and Microsoft Office dominating the IS environment	I	I
Software global costs	H7d	Software global costs relevant in choice and OSS perceived as cheaper than PS	A	A

Advantage for: I – Incumbent Proprietary Software; A – Alternative Open Source Software

6.3. Research Contributions

We think that this thesis contribute in several ways for a better knowledge of the IS market regarding the specific interests of the several publics. The thesis relevance comes from the knowledge contributions that it will give to both academic and non-academic world, considering the academics, consumers (professionals and non-professionals), managers and Government.

1. Academics

   a) Identification of the factors that influence the strategies adopted by the software suppliers when they considered the IS market situation and its features;

   b) Explanation of how the consumer chooses between incumbent and alternative software standards;

   c) Prospective analysis of all these strategies and decisions impact on the evolution of the IS market.

2. Users

   Better knowledge of the market, better knowledge of the decision factors that can be considered in IS purchases and also how to expect the market to evolve and with that knowledge make better purchasing choices.

3. Supplier Managers.

   Understand in a better way the buying decision process of IS users, how that can influence the market evolution, the competition level and also the success critical factors needed to obtain success in this market.

4. Government and Regulation Authorities

   This thesis showed to Government and Market Regulation Authorities one thing. That all the involved in the market, including both Proprietary Software and Open Source Software suppliers and also customers, want it to be competitive and without any intervention that could distorted the market precluding the competition and the innovation that is the result of that competition and is benefic for the consumers. The only intervention that companies ask from

Governments is that they intervene to keep the competition present while avoiding anti-competitive actions of dominant companies. Nobody expect that Governments support the survival of a company or a specific software business model by giving preference for it. In short, Government intervention can be needed to defend competition and not for distorting it or stopping it by favoring any of the competitors.

6.4. Research Limitations

Several research limitations happened in this thesis, some of them that we must try to avoid in future research developments.

6.4.1. Market sample dimension

The supply side research using Soft Systems Methodology considered only the "Point of View" of the manager interviewed representing the company. Even if we consider that in global terms the answers from the different managers of the same company will be similar, different "Points of View" of the same company will be more on line with the Soft Systems Methodology.

On demand side, we have problem of the low answers percentage and consequent sample size, because of the sensibility of the subject. Inquiries about IS infrastructure of a company are not easy in a country still with a big percentage of software piracy. On other hand with workers changing between companies, companies closing in these years of world economic crisis and email spam filters, the collecting of data for research was more difficult and the sample dimension was below what was expected and need for deep statistical analysis without the problems associated with the sample dimension.

6.4.2. Worldwide generalization

There is no guarantee that the results obtained in this thesis in the demand side of the market can be generalized worldwide. The market conditions, the economic situation and even cultural aspects are very different from country to country considering market segments like organizations, professionals, students or home consumers. The factors influencing the decision process can be different and must be studied in each country, even for countries that are similar in cultural aspects or geographically near Portugal.

6.4.3. Missing answers in demand side questionnaire

While the missing answers bring problems to the statistical analysis, some of the missing answers also seem to show the failure of some software suppliers in the Portuguese market, because we could conclude that the missing answers were caused by the low to none awareness of these suppliers and their products.

6.4.4. Dynamics of the IS markets

The Information Systems markets are the more dynamic in the world, with continuous technological and architectural philosophies changes. This thesis was made to specific software markets, Operating Systems and Office Suites, in the first decade of the XXI century where the dominant software philosophy still is, at least for Operating

Systems and Office Suites, mainly of installed software running from the computer, independently of the development or business model behind it.

This kind of infrastructure started to change recently, with the appearance for instance of Cloud Computing. However this thesis will be still useful to understand the starting point for deep changes that are expected to happen in the IS market in the future and also to understand the evolution of the actual IS philosophy, that while can be replaced by other in the medium to long term, it's not expected to vanish completely anytime soon.

6.5. Future Research

Several research developments can be made from this thesis, even more when the research subject, IS market, is very dynamic in its evolution over time. We can consider the following:

6.5.1. Statistical modeling of the market

Considering the results of the logistic regression models, new statistical models and research around them can be done, including structural equation modeling to confirm the first hints offered by this thesis about the influence direction of the factors considered in the thesis on software choices. Since this kind of research is always "sensitive" for the reasons already presented, only data collection with the support of entities like Government or Government research institutes like the National Statistics Institute, may allow the collection of the data needed to create a sample with enough dimension to allow deeper statistical studies.

6.5.1. Evolution of demand and supply factors in the IS market

Over time and as the markets develop the demand and supply factors that have influence over it also change. It’s possible to keep the monitoring of that development over time through questionnaires made to the supply and demand side of the market, similar to the questionnaires made for this research and for similar audiences.

It’s also possible to change the sample characteristics on the supply and demand sides. On the supply side we can include other suppliers that become relevant to the market, like Google or even the new Oracle-Sun or the ones that weren’t available for this thesis like Adobe or Apple.

On the demand side we can improve the sample characteristics by enlarging it to more market segments that can be considered a relevant object of study, like students, professional classes (lawyers, doctors, engineers, accountants, etc.) or State organizations.

6.5.2. New trends in the IS market

By the time of this research and when considering the personal computer Operating System and Office Suite, the main architecture of the market was simply the installation of both types of software in the computer. But new developments like “Cloud Computing or “Software as a Service” are arriving and getting strong on the market and they will have a strong influence over the way suppliers develop and offer their products and services to the market, and also how consumers made their choices.

The impact of these market developments are also an important research field. For instance, if the Operating Systems become less relevant, with “Cloud Computing” of

Open Standards, the impact on the software competition will be huge and the research of it very important.

6.5.3. File Formats

One of the factors that have influence over the software markets are the application file formats. The file format compatibility is one the factors that have influence over competition benefiting the incumbent supplier that has the dominant file standard. The analysis of the developments in file compatibility between Office Suites or other applications, with formats more or less “open”, can have influence over the application market competition and Operating Systems market evolution and are a relevant research field.

As an example, the recent introduction of free open file formats like the OSS Open Document and Microsoft Office Open XML will have impact on the way consumers choose their Office Suites. Research will be needed in this relevant influencing factor of the competition in the Office Suite market.

6.5.4. Other software categories research

This thesis focus was on two specific software categories, namely Operating Systems and Office Suites. Interesting additional research would be the appliance of the same or improved research methodology to study other software categories like Operating Systems and applications for servers, image treatment software, browsers and even social network software, to try to confirm if the hypothesis presented in this thesis are the same in other software categories.

6.5.5. Differences between countries

Can the results of this research be applied to other countries? If on the supply side lots of similarities are expected, the majority of the suppliers are multinationals, what can we say about the demand side?

Research can be made to verify if there are differences between the IS decisions influencing factors in different countries, considering several market segments (organizations, professionals, home consumers, students).

If differences are confirmed we have different competitive environments between countries and suppliers will need to apply different marketing strategies.

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VIII. Appendix

Appendix 1. Operating System global construct perception internal consistency test

	Operating System Global Perception					
	Apple Mac OS	Caixa Mágica Linux	Mandriva Linux	Microsoft Windows	Novell/Suse Linux	Red Hat Linux
Cronbach α	0.85	0.88	0.91	0.76	0.80	0.92

Appendix 2. Operating System global perception factor analysis

Factor Analysis	Operating System global perception
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.64
Bartlett's Test of Sphericity Approx. Chi-Square	817.63
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.33
1st Component Initial Eigenvalues (% of Variance)	77.58
Component Score Innovation	0.350
Component Score Quality	0.404
Component Score Security	0.380

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 3. Office Suite global perception construct internal consistency test

	Office Suite global perception							
	Apple iWork	**Corel WordPerfect Office**	**E-Press Corp One Office**	**IBM Lotus SmartSuite**	**KDE KOffice**	**Microsoft Office**	**OpenOffice.org OpenOffice**	**Sun StarOffice**
Cronbach α	0.85	0.88	0.91	0.79	0.91	0.69	0.84	0.91

Appendix 4. Office Suite global perception factor analysis

Factor analysis	Office Suite global perception
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.67
Bartlett's Test of Sphericity Approx. Chi-Square	1758.19
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.59
1st Componente Initial Eigenvalues (% of Variance)	86.37
Component Score Innovation	0.336
Component Score Quality	0.374
Component Score Security	0.365

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 5. Suppliers global reputation relevance construct internal consistency test

	Suppliers reputation relevance
Cronbach α	0.73

Appendix 6. Suppliers global reputation relevance factor analysis

Factor analysis	Suppliers global reputation relevance
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.48
Bartlett's Test of Sphericity Approx. Chi-Square	108.11
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.00
1st Componente Initial Eigenvalues (% of Variance)	66.57
Component Score Question 5f	0.312
Component Score Question 5g	0.472
Component Score Question 5h	0.425

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 7. Software global cost construct internal consistency test

	Software Global Cost
Cronbach α	0.84

Appendix 8. Software global cost factor analysis

Factor analysis	Software global cost
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.63
Bartlett's Test of Sphericity Approx. Chi-Square	131.89
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.27
1st Componente Initial Eigenvalues (% of Variance)	75.53
Component Score Question 5c	0.349
Component Score Question 5d	0.412
Component Score Question 5e	0.387

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 9. OSS and PS global image constructs internal consistency test

	Open Source Software global image	Proprietary Software global image
Cronbach α	0.82	0.76

Appendix 10. OSS and PS global image factor analysis

Factor analysis	Open Source Software global image	Proprietary Software global image
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.67	0.61
Bartlett's Test of Sphericity Approx. Chi-Square	111.81	83.48
Bartlett's Test of Sphericity Sig.	0.00	0.00
1st Component Initial Eigenvalues Total	2.23	2.05
1st Componente Initial Eigenvalues (% of Variance)	74.41	68.47
Component Score Question 13a; 14a	0.347	0.366
Component Score Question 13b; 14b	0.406	0.399
Component Score Question 13c; 14c	0.404	0.440

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 11. OSS better global image than PS construct internal consistency test

	Open Source Software better global image than Proprietary Software
Cronbach α	0.69

Appendix 12. Local network effect IS staff construct internal consistency test

	Local network effect IS staff
Cronbach α	0.53

Appendix 13. Local network effect IS staff factor analysis

Factor analysis	Local network effect IS staff
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.50
Bartlett's Test of Sphericity Approx. Chi-Square	12.80
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	1.36
1st Componente Initial Eigenvalues (% of Variance)	68.16
Component Score Question 5l	0.61
Component Score Question 5m	0.61

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 14. Software features requirements construct internal consistency test

	Software features requirements
Cronbach α	0.39

Appendix 15. Easiness of switching Operating System construct internal consistency test

	Easiness of switching Operating System
Cronbach α	0.65

Appendix 16. Easiness of switching Operating System factor analysis

Factor analysis	Easiness of switching Operating System
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.50
Bartlett's Test of Sphericity Approx. Chi-Square	22.02
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	1.48
1st Componente Initial Eigenvalues (% of Variance)	74.07
Component Score Question 5l	0.581
Component Score Question 5m	0.581

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 17. Operating System weak lock-in construct internal consistency test

	Operating System weak lock-in
Cronbach α	0.65

Appendix 18. Operating System weak lock-in factor analysis

Factor analysis	Operating System weak lock-in
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.68
Bartlett's Test of Sphericity Approx. Chi-Square	109.41
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.38
1st Componente Initial Eigenvalues (% of Variance)	39.70

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 19. OS weak lock-in – hardware and IS knowledge construct internal consistency test

	Operating System weak lock-in – hardware and IS knowledge
Cronbach α	0.63

Appendix 20. Operating System weak lock-in – hardware and IS knowledge factor analysis

Factor analysis	Operating System weak lock-in – hardware and IS knowledge
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.66
Bartlett's Test of Sphericity Approx. Chi-Square	62.15
Bartlett's Test of Sphericity Sig.	0.00
1^{st} Component Initial Eigenvalues Total	2.01
1^{st} Componente Initial Eigenvalues (% of Variance)	50.16
Component Score Question 19a	0.179
Component Score Question 19b	0.389
Component Score Question 19c	0.423
Component Score Question 19d	0.369

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 21. OS weak lock-in – peripherals and applications owned construct internal consistency test

	Operating System weak lock-in – peripherals and applications owned
Cronbach α	0.70

Appendix 22. OS weak lock-in – peripherals and applications owned factor analysis

Factor Analysis	Operating System weak lock-in – peripherals and applications owned
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.50
Bartlett's Test of Sphericity Approx. Chi-Square	30.95
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	1.54
1st Componente Initial Eigenvalues (% of Variance)	77.03
Component Score Question 19e	0.570
Component Score Question 19h	0.570

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 23. Operating System network effect construct internal consistency test.

	Operating System network effect
Cronbach α	0.57

Appendix 24. Operating System network effect factor analysis

Factor analysis	Operating System network effect
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.50
Bartlett's Test of Sphericity Approx. Chi-Square	72.21
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	1.44
1st Componente Initial Eigenvalues (% of Variance)	72.21
Component Score Question 19f	0.588
Component Score Question 19g	0.588

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Appendix 25. Office Suite weak lock-in knowledge construct internal consistency test

	Office Suite weak lock-in knowledge
Cronbach α	0.81

Appendix 26. Office Suite weak lock-in knowledge factor analysis

Factor analysis	Office Suite weak lock-in knowledge
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.67
Bartlett's Test of Sphericity Approx. Chi-Square	103.190
Bartlett's Test of Sphericity Sig.	0.00
1st Component Initial Eigenvalues Total	2.19
1st Componente Initial Eigenvalues % of Variance	72.89
Component Score Question 21b	0.403
Component Score Question 21c	0.413
Component Score Question 21d	0.353

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

Appendix 27. Demand side questionnaire

Questionnaire

Organization profile

. Organization name (Opcional)
(multiple choice drop-down menus)
. Main economic activity (CAE code)
. Shareholder Structure
.Number of employees
. Revenues
. Localization district (headquarters)
. Existence of Information System department or professionals in the organization
. Number of Personal Computers
. Percentage of computers that are notebooks (portables)
. Percentage of each Operating System in personal computers of organization

Software choice factors

(Choose between "No relevant" (1) to "Very relevant" (5)
1. a) In Operating Systems choice, the capacity of install the same aplications than our costumers and/or suppliers
1. b) In applications choice, the possibility of exchange files with our costumers or suppliers

(Choose between "Totally disagree" (1) to "Totally agree" (5)
2 - Our company still use (outdated without new versions or upgrades) applications.

(Choose between "Totally disagree" (1) to "Totally agree" (5)
3 - Our company still use old files saved in old applications

(Choose between "Totally disagree" (1) to "Totally agree" (5)
4 - Our company use many applications from same years ago that are being updated with new versions.

5 - Our company select software considering the following factors :
(Choose between "Totally disagree" (1) to "Totally agree" (5)
a. Software Features (considering the organization's actual needs only)
b. Software Features (considering the organization's actual and planned future needs)
c. Software Cost (software price, licensing cost)
d. Software Cost (installation, implementation)
e. Software Cost (training)
f. Software supplier market image/reputation
g. Software supplier quality reputation (software without bugs or working problems)
h. Software supplier security reputation (without problems that allow virus or hackers to breakin in our computers)
i. Advice from employees
j. Advice from costumers
k. Advice from suppliers (not IS specialists)
l. Advice from IS inside specialists
m. Advice from IS outside specialists (including IS suppliers)
n. Advice from friends or family
o. Advice from IS shops staff
p. Advice from IS specialized press
q. Advice from IS specialized Internet sites
r. Applications and files used by clients or suppliers

Software and software suppliers
6 - About my knowledge of software suppliers
(Choose between "Completely unknown" (1) to "Completely known" (5)
Apple
Caixa Mágica
Corel
E-Press Corp
IBM
KDE
Mandriva
Microsoft
Novell/Suse
OpenOffice.org
Red Hat
Sun

Software brands/products perception
7 - About innovation degree (new and innovative features introduction) of Operating Systems suppliers
(Choose between "No innovative (1) to "Totally innovator" (5)

8 - About quality reputation degree (software without bugs or working problems) of Operating Systems suppliers
(Choose between "Bad reputation (1) to "Good reputation" (5)

9 - About security reputation degree (virus or hackers to breakin in our computers) of Operating Systems suppliers
(Choose between "Bad reputation (1) to "Good reputation" (5)
Operating Systems considered in questions 7, 8 and 9
Apple (Mac OS)
Caixa Mágica (Linux)
Mandrake (Linux)
Mandriva-Mandrake (Linux)
Microsoft (Windows)
Red Hat (Linux)
Suse (Linux)

10 - About innovation degree (new and innovative features introduction) of Office Suites suppliers
(Choose between "No innovative (1) to "Totally innovator" (5)
11 - About quality reputation degree (software without bugs or working problems) of Office Suites suppliers
(Choose between "Bad reputation (1) to "Good reputation" (5)
12 - About security reputation degree (virus or hackers to breakin in our computers) of Office Suites suppliers
(Choose between "Bad reputation (1) to "Good reputation" (5)
Office Suites considered in questions 10, 11 and 12
Apple (iWork)
Corel (WordPerfect Office)
E-Press Corp (Easy Office-One Office)
IBM (Lotus SmartSuite)
KDE (KOffice)
Microsoft (MS-Office)
OpenOffice.org (OpenOffice)

Sun (StarOffice)

Open Source vs. Proprietary Software
Considering of Open Source Software (free licensing (Linux, OpenOffice, etc.)) and Proprietary Software (with licensing costs (Microsoft, Corel,etc.))
13. Open Source Software
(Choose between "Totally disagree" (1) to "Totally agree" (5)
Is innovative with regular introduction of new useful features and upgrades
Has good security with not many fixtures (patches) to security problems
Has good quality (without bugs or working problems)

14 - Proprietary Software
(Choose between "Totally disagree" (1) to "Totally agree" (5)
Is innovative with regular introduction of new useful features and upgrades
Has good security with not many fixtures (patches) to security problems
Has good quality (without bugs or working problems)

15 - Consider as software cost the licensing cost, training and maintenance with supplier patches and updates
(Choose between "Totally disagree" (1) to "Totally agree" (5)
Open Source Software use is cheaper than Proprietary Software use

16 - If needed:
(Choose between "Totally disagree" (1) to "Totally agree" (5)
Good technical support is easily available for Open Source Software
Good technical support is easily available for Proprietary Software

Operating System and Office Suite switch
(Choose between "Totally disagree" (1) to "Totally agree" (5)
17 - If we wanted we could easily switch from a Proprietary Operating System like Windows or Mac OS to a free license Open Source Operating System like Linux

(Choose between "Totally disagree" (1) to "Totally agree" (5)
18 - If we wanted we could easily switch from a a free license Open Source Operating System like Linux to a Proprietary Operating System like Windows or Mac OS

19 - The decision of switch (or not) the Operating System would consider the following factors:
(Choose between "Totally disagree" (1) to "Totally agree" (5)
a. Computer features needed
b. Operating System install easiness
c. Needed knowledge to switch the computer Operating System
d. Learning needs for the new Operating System
e. Compatibility with owned peripherals (printers, scanners, external discs, etc.)
f. Capacity of install the same applications that business partners (clients, suppliers, etc.) use
g. Quantity and type of applications available in the market for the actual Operating System
h. Quantity and type of applications owned for the actual Operating System

(Choose between "Totally disagree" (1) to "Totally agree" (5)
20 - If we wanted we could easily migrate from a Proprietary Office Suite like MS-Office or Corel WordPerfect Office to a free license Open Source like OpenOffice and vice-versa (consider not need Operating System switch)

21 - The decision of switch (or not) the Office Suite would consider the following factors :

(Choose between "Totally disagree" (1) to "Totally agree" (5)

a. Computer features needed
b. Needed knowledge to switch (install) the computer Office Suite
c. Needed knowledge to switch the computer Operating System (if needed)
d. Learning needs for the new Office Suite
e. Capacity of file exchange with business partners (file compatibility)
f. Quantity of files owned for the actual Office Suite

22 - In computers with installed software, please select the Operating System + Office Suite set in the majority of computers
(choice between combinations of the Operating Systems and Office Suites considered in the questionnaire)

23 - If you had computers without installed software, what Operating System + Office Suite set would you choose?
(choice between combinations of the Operating Systems and Office Suites considered in the questionnaire)

24 - Considering the Operating System + Office Suite set, if you want to switch, which set would you choose (put the actual set if not wanting to switch)
(choice between combinations of the Operating Systems and Office Suites considered in the questionnaire)

Appendix 28. Supplier side questionnaire

Presence in market

1. What are the main sources of revenue of your organization?

2. It's that revenue enough to guarantee the long term survival of your organization in the market? Why?

3. It's that revenue enough to guarantee the long term survival of similar organizations in the market? Why?

Innovation in the market

4. What is the relation between investment in R&D and innovation in the market (including upgrades and introduction of new products)?

5. What are the factors that you think that influence the innovation degree in the market?

6. What factors influence the innovation degree in your company?

7. When thinking about Open Source software and Proprietary Software, in which category is innovation more expected? Why?

8. How is the innovation based in each of these organizations (Open Source software and Proprietary Software)? (Own engineers and developers, costumer's feedback, market research, around the world developers?)

Environment influence

9. What are the main factors of the environment (costumers, competitors, government as costumer, laws, economic variables, social variables, other variables, etc.) that have influence on the market?

Developers and development

10. What are the market methodologies of compensation for developers (monetary and non-monetary)?

11. How are organized the developers in the company to achieve efficiency the software development?

Appendix 29. IDC site information about thesis and link to questionnaire (demand side)

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Tese de Doutoramento na Área do Open Source

17-12-2008

No âmbito do Programa de Doutoramento em Gestão do Instituto Superior de Economia e Gestão / Universidade Técnica de Lisboa, a IDC está a colaborar com o Dr. João Rosário na tese com o título "INFLUENCE OF NETWORK EFFECTS ON THE DIFFUSION OF INFORMATION SYSTEMS: THE CASE OF OPEN SOURCE", cujo principal objectivo é o estudo do mercado de software e do processo de decisão dos consumidores nesse mercado, nomeadamente Sistemas Operativos e aplicações "Office".

No âmbito do desenvolvimento dessa tese, vimos desta forma informar que poderá colaborar através da resposta a um inquérito sobre o processo de decisão de compra de Sistemas de Informação na vossa organização.

O seu contributo é indispensável para o sucesso deste trabalho de investigação pelo que agradecemos desde já a sua colaboração.

Por favor clique no seguinte endereço e será encaminhado para o inquérito que se armazenado no Instituto Superior de Economia e Gestão.

Clique aqui para responder

As respostas serão tratadas confidencialmente e os resultados apenas apresentados no seu conjunto.

Os resultados e metodologia da tese ser-lhe-ão enviados posteriormente caso o solicite no próprio inquérito.

Obrigado

Gabriel Coimbra, Research & Consulting Director da IDC
João Rosário, Instituto Superior de Economia e Gestão/Universidade Técnica Lisboa

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Vídeo do Directions 2008

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