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The economic impacts of compatibility standards

The case of Office Open XML

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Executive summary

The focus of this thesis is twofold; first the focus is on general standardization theory, and thereafter the theory is applied to the Office Open XML (OOXML) case. The thesis analyses the economic impacts of compatibility standards, and hereunder applies the results to examine the economic impacts of the international document standard OOXML. A focus will be on markets characterised by network externalities. Another focus will be comparing the private and social incentives for standardization. In order to answer the research questions, relevant economic theories is presented and economic models are derived. The authors will also present independent work and new interesting findings.

The main findings are that in a market characterised with network externalities, complete compatibility increases equilibrium prices and total output. This is shown in the compatibility model by Katz and Shapiro. The increase in prices is also supported by the network model related to compatibility. The reason is that in a network market, incompatibility decreases prices since consumer demand becomes more sensitive. However, when introducing compatibility, consumer's buying decision is not affected by the network externalities. The move to complete compatibility is found to be socially beneficial in the compatibility model.

Regarding the private and social incentives for achieving compatibility, both the Katz and Shapiro model and the oligopoly quality model show that these deviates. A result is that the private incentives are inadequate since the firms are unable to extract the full social benefit of achieving compatibility.

The thesis discusses the compatibility and openness of the international standard OOXML, and relates this discussion to it's the economic implications. The findings suggest that OOXML offers compatibility. Given this is so for the future full implementation of OOXML; it might be possible to conclude that the OOXML standard leads to increased total output, and hence increased welfare for consumers through achieving compatibility. Based on the analysis of how the openness requirements are met by OOXML, it is possible to see that the openness of OOXML is somewhat controversial.

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Preface

This master thesis is written as a part of the Master of Science in Business and Economics study at BI Norwegian School of Management, with a major specialization in Economics. A challenge related to the thesis has been to apply economic theories on real agents in real markets. We have experienced that what in theory may seem obvious and simple, is more complex when involving the real world. Nevertheless, we hope that we have been able to describe both theory and the case in a comprehensible way, so that the reader is able to evaluate our findings and conclusions on an individual basis.

Another challenge has been the short coming of scientific analysis of Office Open XML since the standard is not yet fully implemented. This means that the information about the case may have been affected by which proponent side it origins from. As Office Open XML is not fully implemented, our conclusions will to some extent be based on assumptions. It will therefore be interesting to see whether the results will still be valid when full implementation is completed.

The process of developing our own models has been a challenging and motivating task. We have experienced that model building is difficult, but at the same time an exciting exercise.

We would like to thank our supervisor Professor Espen R. Moen for helpful advice and supportive guidance throughout this process.

Karoline Flåten and Ellen M. Burud
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1. Introduction

When starting the process of writing this thesis during the spring semester 2008, the authors had experienced a problem of incompatibility between different software versions of Microsoft Word. One of the authors used Microsoft Word 2003, and was therefore unable to open and edit files created by the other author in Word 2007, unless the document was made compatible by converting it to the Word 97-2003 version. This became a source of inspiration for the general analysis of standards and whether achieving compatibility is socially beneficial. It will therefore be interesting to study the economic implications of compatibility standards in general, and the case of Office Open XML.

The move towards open standards has been a strong trend within office document file formats since users demand compatibility. Software vendors have therefore had incentives to ensure that their preferred document file formats are endorsed as open standards. Microsoft does not publish the market share of Microsoft Office, however it is assumed to have a global market share of approximately 95% (Business Week 2006). Since the majority of the global market use Microsoft's document software, the thesis will focus on the modifiable office document file format standard "Office Open XML" (OOXML). The OOXML standard was initiated for standardization by Microsoft, together with its industry partners and supporters. It is therefore interesting to study the economic implications of the XML-based standard that is supported by the dominant firm in the market Microsoft, i.e. OOXML.

This thesis consists of six parts. In the first part the reader will be introduced to the background for the case, as well as the aim of the thesis and the research question. In the second part, definitions of standards and the motivation for standardization will be given. This part will provide examples illustrating why standards are important. This basic introduction of standards is provided in order to facilitate the understanding of the models which will be presented in the subsequent parts.

The third part of the thesis will study the economic implications of compatibility standards, where a thorough description and derivation of different models will be given. Hereunder, first, network externalities will be explained and described as these characterise the software market. A network model with a monopoly producer will be presented, and the authors of this thesis will here extend the network model by Pepall et al. (2005) to include a constant marginal cost. Thereafter, a network model related to compatibility, developed by the authors of this thesis, will be presented. Thirdly, a compatibility model by Katz and Shapiro (1985) will be presented. The compatibility model will derive the economic impacts of achieving compatibility on the market equilibrium and the effects for the agents. Hereunder, a parallel will also be drawn to an oligopoly quality model, developed by the authors of this thesis. This model will show that firms provide a too low level of quality or compatibility compared to what is socially optimal. The models can be studied independently of the OOXML case; hence, they provide valuable theoretical insight into the economic effects of standards. Additionally, the models may provide insight about the economic implications of Office Open XML. In the fourth part of the thesis, open standards will be described and a model of economics of open standards will be presented. The model can provide insight about the economic implications of open versus proprietary standards.

The fifth part of the thesis will discuss the case of OOXML. The theory discussed in the preceding three parts will here be applied in the analysis of the international standard OOXML. Hereunder, the background of office document formats and the OOXML standard will be presented. Thereafter, the compatibility and openness of OOXML will be analysed. Finally, the sixth part of the thesis will present the conclusion for the research questions based on the results found in the preceding parts.

1.1. Background for the case of OOXML

1.1.1. ISO/IEC 29500:2008

In addition to analysing the economic implications of compatibility standards, this thesis will also analyse the standard "ISO/IEC 29500:2008, Information technology – Document description and processing languages - Office Open XML

(OOXML) file formats". ISO/IEC 29500 is a standard for word-processing documents, presentations and spreadsheets. It is intended to be implemented by multiple applications on multiple platforms. ISO/IEC DIS 29500 was originally developed as the Office Open XML specification by Microsoft Corporation, and received in April 2008 the necessary number of votes for approval as an ISO/IEC International Standard (ISO 2008a). The International Organization for Standardization/International Electrotechnical Commission Join Technical Committee 1 (ISO/IEC JTC 1) approved the standardization of OOXML through a fast-track process.

ISO is the leading organisation of formal standards bodies. It is a network of national standards institutes of 157 countries with one member per country (ISO 2008b). Membership is a mixture of national partnerships of industry associations and institutions which are a part of the governmental structure or mandated by the governments of their home countries (Ditch 2007:10-11).

1.1.2. The format that is causing the debate

Computer software for reading, creating and editing content can be grouped into two categories; software which enables creation and editing of content, and software which display or print content. These two software categories manipulate content which is stored as a file on for example a hard disc, and it is the format of this file which is causing the debate that motivates this analysis (Ditch 2007). Document file formats are the way a computer stores documents like memos or spreadsheets.

Early in the product lifecycle of personal computers there was a great amount of different word processing applications available. These applications often used binary file formats[1] with a proprietary, undocumented standard as the basis for the exact representation or encoding. As a result, software vendors were unable to read formats from other vendors, and there was a strong connection between the content and the software that had created it. This made it difficult for users to exchange documents with each others, since there was a great variety of

[1] A computer file containing machine-readable information that must be read by an application; characters use all 8 bits of each byte (WordnetPrinceton 2009)

incompatible software. When the personal computer market matured in the 1980s a fairly small number of proprietary file formats dominated the market. The dominating proprietary file formats were amongst others generated by companies as Corel Corporation, with their word processing format WordPerfect, Lotus Software with their spreadsheet format Lotus 1-2-3 and Microsoft with its Word (.doc), Excel (.xls) and PowerPoint (.ppt) file types. (Ditch 2007:4).

1.1.3. Developing a common document format

The challenges related to the lack of interoperability between documents created in different software, resulted in a process of developing a common document format. There was also a need for abstracting the information in a document and separating this from its presentation. Thereby, the information could be independent of the software that created it. The final outcome was the new mark-up language standard "Extensible Mark-up Language (XML)" developed by The World Wide Web Consortium (W3C) in the 1990s. This is a standard format that enables the storage and organisation of information. Information stored in an XML file is in plain text format, enabling the separation of content from representation. Hence, information stored as XML will be readable and changeable for a long time, as opposed to binary file formats. In fact, there is diminishing acceptance for the use of binary file formats, especially those that require the use of proprietary software (Ditch 2007:5).

1.1.4. Move towards standardization of XML file formats

There has also been increased pressure to standardize file formats, involving formal standards setting organisations (SSO). This encourages software producers, such as Microsoft, to "open" previously closed file formats, i.e. proprietary, binary file formats (Ditch 2007:11). In addition to OOXML there is another internationally recognised office document file format for editing, namely ISO/IEC 26300:2006 Open Document Format (ODF) for Office Applications. This standard was approved by ISO in May 2006 and was voted unanimously by the participating members (Mathew 2008:6). It was Sun Microsystems which led the creation of the ODF standard as a response to Microsoft's proprietary formats. For non-revisable office documents, Adobe Portable Document Format (PDF) has become a *de facto* standard for display and distribution of such documents.

However, the ODF standard and the Adobe PDF standard will not be in focus in this thesis. The OOXML file formats has caused substantial controversies concerning both the need for two co-existing ISO standards for open XML document formats and the OOXML format's supposed lack of openness.

1.2. The aim of the thesis

The aim of the thesis is to apply relevant, acknowledged economic theories to describe and analyse compatibility standards in general. The thesis will also, based on the general standardization theory, analyse the case of the international standard OOXML. The analysis will therefore concentrate around the compatibility and openness of standards in general, and OOXML in particular. Hence, this thesis is twofold; first the focus will be on general standardization theory and thereafter this theory will be applied to the case. The aim of the thesis is to provide a better understanding of standards for achieving compatibility and open standards. It will be important to analyse standards' economic implications on the market. Regarding the economic implications, it is the effect on the market equilibrium that is of interest. Thereby, it is possible to study the effect on the producers and the consumers. When analysing the case of OOXML it will be its economic implications that are in focus, rather than its technological aspect.

1.3. The research question

The main research question of this thesis is therefore:

"What are the economic impacts of compatibility standards?"

Hereunder, a sub-research question for the thesis will be:

"What are the economic impacts of "ISO/IEC 29500:2008 Information technology – Document description and processing languages - Office Open XML file formats?"

The research questions will be addressed by using applied microeconomics. The thesis will give an economic analysis of compatibility standards and, hereunder, the international standard OOXML, with focus on the compatibility and openness of standards. When analysing the economic impacts of compatibility standards, it is the effects on the market equilibrium for producers and consumers that will be in focus. In other words, the effect for software suppliers and software users will be in focus for the case of OOXML. It will also be relevant to study whether the private incentives for achieving compatibility are in line with the social incentives, and thereby studying whether firms have sufficient incentives for standardization.

2. Standardization

In this section of the thesis, first definitions and classification of various standards will be given. Thereafter, motivation for standardization will be discussed. This is in order to provide a better understanding of standards before presenting the theoretical models and analysis of the case. Standards can be studied from different perspectives and this review will focus on the economical perspective.

2.1. Definition

There are several definitions of standards and some will now be presented. One definition of standards is that standards "define any common set of product features, which can range from loose sets of product characteristics to precise specifications for technical interfaces" (Grindley 1995:21). This is similar to Ditch's definition, who defines standard as "commonly accepted agreements for doing or making things" (Ditch 2007:39). The official definition by ISO and the IEC is the following: a standard is a "document, established by consensus and approved by a recognized body. It provides rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards should be based on the consolidated results of science, technology and experience and aimed at the promotion of optimum community benefits" (IEC 2009).

Following, standards will be further classified into the difference between quality- and compatibility standards, the control the firm has over the standard, the standardization process, and standards as common goods.

2.1.1. Difference between quality- and compatibility standards

There is a classification difference between quality standard, which is related to a product's features, and compatibility standards, which is related to the links a product has to other products and services. Quality standards may further be divided into minimum attributes, such as measurement and quality, and product characteristics. Compatibility standards will be of interest for this thesis. They define the interface requirements that allow different products, often from

different producers, to use the same complementary goods and services, or to be connected in networks (Grindley 1995:9). Complementary goods need to be consumed together in order for the user to obtain utility, and two examples are audio speakers and players or computer hardware and software. An example of a complementary service is supporting services like automobile maintenance for automobiles. The complements may also be direct networks of users of the same core product, for example telecommunications networks or railway routes (Grindley 1995:23). Most relevant for the information and communication technologies (ICT) is the standardization which ensures interoperability or compatibility between different parts of a product or between products as part of a system or network (Ditch 2007:39).

2.1.2. The control a firm has over a standard

Additionally, a key distinction of standards is the control the firm has over the standard. This can depend on how accessible a standard is, in other words whether it is proprietary or open. If the standard is proprietary, one firm has proprietary rights over the standard and may therefore restrict the adoption of the standard by other producers or implementers. If the proprietor holds intellectual property rights to the technology a standard is based on, like patents or copyrights, it may charge royalties for access to it. With a completely open standard no restrictions are placed on other firms adopting the standard (Grindley 1995:25). Proprietary standards are excludable since the proprietor of the standard control the licensing of the standard. Open standards are non-excludable and might therefore be classified as a public good (Mathew 2008:3). Bresnahan (2001) also divides document format standards into two concepts; proprietary and open. Proprietary standards imply that each software brand for word processing stores files differently. An open standard implies that any program for word processing will be able to read files from other programs. The openness of standards will be further discussed in part four of this thesis.

2.1.3. The standardization process

The method by which standards are established and maintained can be two different processes. Either it can be through market forces, i.e. a *de facto* standard, which results from the interaction between “clubs” of agents or through a single

agent. In other words standard setting is through a market-mediated process. The other process is standardization through official standards bodies, i.e. a *de jure* standard. *De jure* standards are specified by standards bodies before adoption in the market. The latter include government legislations, industry committees, and quasi-official standards associations (David and Greenstein 1990).

Many standards may in practice be developed by a dominant firm in the market or be an outcome of a standards contest. Even consensus or legislated standards may originate from the dominant firm. Standards that may now seem as universal may at one point have been a result of a standards contest, for instance railway gauges, electric supply voltages and screw threads (Grindley 1995:25). The difference between *de facto* and *de jure* standards is hence not precise.

2.1.4. Standards classified as economic goods

Standards may be characterised as non-rival, implying that the distribution of a standard will not decrease its availability. This means that the use by one person will not prohibit other people from using the standard and will not cost additional resources. Hence the cost of distributing or using standards is approximately zero. It is the knowledge in the standard that is non-rival, not the specific product that has implemented the standard (Scotchmer 2004).

Public goods are non-rival and non-excludable. However, since standards are not necessarily non-excludable, they cannot automatically be considered as public goods. This is because it may be possible to selectively exclude agents from using and adopting a standard through ownership or licensing terms, and excluding agents in the standardization process. If only a limited amount of firms cooperate to set standards, the process of standard setting will be excludable, even though the adoption of a standard might be freely licensed and thereby non-excludable. Influential firms in the standard setting process can therefore gain competitive advantage because they are able to encode the standard based on their own skills and knowledge (Mathew 2008).

As mentioned in the previous sections, is it possible to classify standards into proprietary and open, *de jure* and *de facto* standards. In Figure 1 standards are

classified along the two axes *De facto/De jure* and Proprietary/Non-proprietary and thereafter related to economic goods:

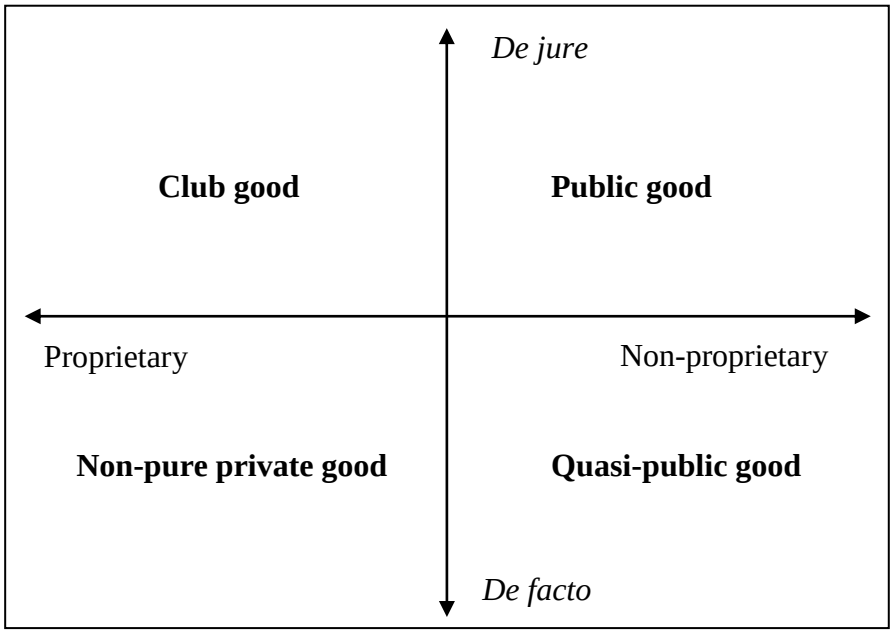

Figure 1: Classification of standards related to economic goods
(Mathew 2008:3)

A standard may be classified as a non-pure private good under monopoly conditions, where a single firm or coalition of firms sets a proprietary standard. Such a standard is hence proprietary and *de facto*. An example is Microsoft Office since Microsoft has never released complete format specifications for the binary file formats.

Standards may also be classified as a club good if one of the following two conditions is met; firstly, no new firms are allowed to join the group of firms sponsoring the standard or, secondly, no new firms are allowed to join the group of firms licensed to adopt a standard. Under the first condition, the sponsoring club has a large competitive advantage since they may be able to form standards to fit their particular skills and knowledge. Under the second condition, the licensing club may result in a closed network of firms which cooperates as a cartel to create service systems.

A standard may further be classified as a public good if the standard setting involves negotiations within a standard setting organisation (SSO), i.e. a non-

proprietary and *de jure* standard. Thereby the standard is often freely licensed, which yields low adoption costs, and the standard may be considered as open if the standardization process fulfilled certain open characteristics.

Standards which are set through *de facto* standardization and not submitted to a SSO, but remains freely licensed, may be classified as a quasi-public good. An example is Adobe's PDF file format since Adobe published complete technical specifications for PDF with every new version of the format. Now, various forms of PDF are ISO standards, while Adobe remains a key technical sponsor (Mathew 2008).

2.2. Motivation for standardization

This section will draw attention to the motivation for standardization. In our everyday life, we are surrounded by standards. A few examples are paper size, the three-letter code for currency names, the size of bolts and screws, the basic features of credit cards and the ISBN-number in a book. The examples mentioned are probably not something people are aware of; nevertheless, standards play a key role as they can have economic impacts on the society. Since these implications can be considered as significant, it is interesting to analyse the effects a standard has on the market. The following sections will therefore discuss the advantages of standards, systematisation through standards and standards' role in the ICE sector.

2.2.1. Advantages of standards

This section will give some examples of advantages that have been obtained through standards. For instance, standard setting may lead to economies of scale, which the following example will illustrate. A classic example that is often illustrated to show that having one standard leads to economies of scale is the standard railway gauge. The British Parliament enacted the Gauge Act in 1846, requiring all railroads to conform to the standard gauge (Kindleberger 1983). Having the same standard on railway gauge made it easier and more cost efficient for trains to travel across region borders without the need of changing coaches or transhipping the goods.

Standard can also be used to fulfil safety requirements. For example, when buying an electronic device in Norway the user can be sure that the plug will fit the socket and that it is adapted to the country's level of voltage. An example of how a non-existing safety standard led to severe damages can be illustrated from the fire in Baltimore on February 7, 1904. The enormous fire required help from the nearby city, Washington DC. However, when the fire-fighters arrived, their hoses would not fit the Baltimore hydrants and this resulted in over 1000 burnt houses and damages for over 100 million dollars (Weitzel et al. 2006:55).

Another reason for why a standard may be advantageous is that it signals the fulfilment of a certain level of defined characteristics. Being so, it can for instance decrease the transaction costs for agents. Standards can for instance assure a user that an intermediary good or component can be integrated successfully in a larger system that includes complementary goods. This may be illustrated by the example of the hi-fi stereo system. Since the components conform to the same compatibility standard, the consumer can be assured that when buying for instance a new sound amplifier from one producer, it can be integrated successfully in the larger system of the stereo with products from another producer (David and Greenstein 1990). Other relevant examples are the DVD standard or the CD standard.

2.2.2. Systematisation through standards

Standards can help to systematise our surroundings as they can simplify and make things more efficient, and can further reduce risk since standards are known in the market. One meter is one meter regardless of whether you are in China, the US, Bolivia or Norway, and this is because the metric system is described as a standard. Before standardising the metric system, there were differences of the length of a foot or an inch depending on where in the world one was situated. This could be challenging when trading across national borders, as disagreements could occur on which foot that was correct. The need for systematising measurement arose, which was solved by introducing a common agreed set of standards, i.e. the metric system.

2.2.3. The role of standards in the ICE sector

Further motivation for standards is that they can be considered a key fundament in the world and drive an extensive part of the information economy. They are a result of systems where complementary products work together to meet the needs of consumers. The importance of standards is also increasing because of its significant influence for a rapidly growing sector of the economy, namely the information, communication and entertainment (ICE) sector. Standards are required in information systems in order to store, retrieve and manipulate information (Shapiro 2000). Most new industry initiatives in this sector focus on the concept of compatibility, which is one of the fundamental goals of standardization (Cargill and Bolin 2007:298). It is argued that standards form one of the pillars in the information society and that the Internet would not exist, as we know it today, without standards (West 2007). One of the most valuable technological advances of the late 20th century is proclaimed to be standards that connect computers to large servers with web paged, electronic commerce sites and corporate databases (Bresnahan and Yin 2007).

Markets for system goods are relevant for the case that this thesis will analyse since document software can be characterised as a system good. In such markets compatibility standards play a crucial role. These standards are technical specifications that determine how compatible various technologies are, e.g. that you are able to run a particular software on your computer or playing music on your CD-player. These standards are important in system goods markets since standard setting is linked to the exploitation of network externalities (Bresnahan and Yin 2007). More and more people demand to take part in networks that allow them to for instance exchange documents, communicate directly, share databases, having access to a wider selection of compatible software or combine products made by different vendors. The above demands can be achieved through compatibility standards, as this is often a requirement for multiple parties to be able to share and distribute information (West 2007:93).

3. Economics of compatibility standards

In economic terms compatibility generally means interoperability between competing products. The main concern for standardization in the information and communication technologies (ICT) industry is compatibility in the presence of network externalities. Hence, in the ICT industry, standardization mainly signifies achieving compatibility.

A presumption for achieving compatibility might be that compatibility will lead to more competition within a market, and hence lower prices. However, as the following economic models will show, the prevailing equilibrium market price under compatibility will increase due to network externalities. Although compatibility increases market prices, achieving full compatibility may be socially beneficial due to higher market output. The economic impacts of standardization should therefore be analysed in terms of costs and benefits of firms, consumers and the society.

In the following sections, first network externalities will be explained and described as these characterise the software market. A network model with a monopoly producer will be presented. The authors of this thesis will here extend the network model by Pepall et al. (2005) to include a constant marginal cost. The model will analyse the potential for multiple equilibria in a market with a monopoly provider of a network service. Thereafter, a network model related to compatibility, developed by the authors of this thesis, will be presented. It is based on the network externality model by Moen (2008) with our own modifications for compatibility, hereunder to include a parameter for compatibility. This model is developed in order to analyse how the degree of compatibility can affect the price competition in a software market with two firms. The anticipated conclusion is that compatibility will decrease price competition. Thirdly, a compatibility model by Katz and Shapiro (1985) will be presented. The compatibility model will derive the economic impacts of achieved compatibility on the market equilibrium and the effects for the agents. The model will also analyse whether private incentives for achieving compatibility are consistent with the social incentive. Hereunder, a parallel will also be drawn to an oligopoly quality model, derived by

the authors of this thesis, which will show that firms have insufficient incentives to provide quality, in other words compatibility. The anticipated conclusion of the compatibility model by Katz and Shapiro (1985) is that achieving compatibility will increase output and hence the social welfare. Examining these models can give important insights when analysing the economic impacts of standards.

3.1. Network externalities

The document software market is characterised by an important feature, namely network externalities. A reason that many consumers use Microsoft Office may be that they expect others to use it as well. The more consumers who use Microsoft Office, the more utility Microsoft Office will yield for its users since the network of users will increase. Therefore, in the following section of this thesis, network externalities will be explained and analysed.

First, a definition of network externalities will be given. Subsequently, a network model with a monopoly producer based on the work of Pepall et al. (2005) will be presented. The authors of this thesis will here extend the model by Pepall et al. (2005) to include a constant marginal cost. The model will show that in a market with a monopoly provider of a network service, multiple equilibria may occur. Thereafter, distinctions between direct and indirect network externalities will be discussed related to compatibility.

3.1.1. Definition

Network externalities can change both the characteristics of a market and the nature of the industry competition. A network externality will exist when a consumer's valuation of a product increases as the number of users increases. Each additional consumer will obtain private benefits by joining the network, but also provide external benefits on existing consumers. A definition of a network externality can therefore be "a benefit conferred on users of such a product by another's purchase of the product" (Page and Lopatka 1999:953).

With network externalities the value of a product to any one consumer will increase due to the additional consumers that buy the product. It is the existence

of interdependence between the portion of the market being served and consumers' willingness to pay that will lead to network externalities (Pepall et al. 2005). An individual consumer will only take into account her own value of joining the network. She will, in other words, not take into consideration the external advantages she generates when becoming a member of the network, nor the impact when leaving it. When a consumer becomes a member, this will increased the value of the network since the network size will be larger, and in contrast, the value will decrease when a consumer leaves the network (Pepall et al. 2005:617).

As a network generally must be large in order to become feasible, an observed tendency is the outcome of either one, i.e. monopoly, or two suppliers, i.e. duopoly. A supplier will have strong incentives for reaching the so-called "critical mass" (Rohlfs 1974), which is the lower fraction that must be obtained in order for the network to become sustainable. If the network has not breached this point, customers will then have an interest to wait to join until others do so. This critical mass point will be illustrated in Figure 2.

Since consumers do not take into consideration the network externalities, a network may never reach an optimal size. In other words, the network will not be equal to the socially efficient network size, thereby, a deadweight loss will occur. Another interesting side of this phenomenon is when incompatible standards compete. This may result in "tipping" of the market, often towards the standard that obtains an early advantage, i.e. the standard which obtains a larger network size in the beginning of a standard contest (Page and Lopatka 1999).

3.1.2. Network model with a monopoly producer

Following, a network model with a monopoly producer will be derived, where the market is characterised by network externalities. The model is based on the work of Pepall et al. (2005) and will be expanded by the authors of this thesis to include a constant marginal cost. The network model is presented for the general understanding of network externalities, in addition to providing a better understanding of the market relevant for the OOXML standard, i.e. the document software market.

The network model that will be derived by the authors of this thesis differs from the network model by Pepall et al. (2005) since it includes a constant marginal cost. In networks like a broadband network, a marginal cost may occur when an additional consumer joins the network. This might be the case when the broadband network is still under development, since the broadband network needs to be expanded for each additional consumer. However, when the broadband network is completely developed, the marginal cost for an additional consumer joining the network will be approximately zero.

Assume that a monopolist operates a network, and charges the consumers an access fee in order to hook up to the network, but no per-usage price. This means that the monopolist charges the consumer price p_f in order to "hook up" to the network, but every single use of the product is free of charge. Assume a constant marginal cost *c* for producing the good. This is a new element to the model by Pepall et al. (2005), extended by the authors of this thesis. The network is more valuable for the consumers the more users that are connected to the network. Consumer i will have a willingness to pay in order to become a member of the network equal to fv_i. The variable f represents the size of the network, which can be considered as the fraction of the population "hooked up" to the network. The variable v_i represents the consumer's reservation price for consuming a good, and the parameter is assumed to be drawn uniformly between 0 and 100. The variable v_i is hence the marginal willingness to pay for network size.

The demand consumer i has to hook up to the network is given by:

$$q_i^D = \begin{cases} 0 \; if \; fv_i < p_f \\ 1 \; if \; fv_i \geq p_f \end{cases}$$

The equation above shows that the influence of network size works through the variable f. For consumer i, the equation states that the consumer's willingness to pay for the service fv_i increases with the portion of possible consumers f that have joined the network. As mentioned earlier in section 3.1, there exists interdependence between the willingness to pay and the fraction the market served. It is this interdependence that leads to network externalities. Additionally, each consumer of the network only considers the value to herself of joining the

network (Pepall et al. 2005:616). Assuming that there are N consumers in the market, the consumers' total willingness to pay (TWP_f) for access to the network is hence:

$$TWP_f = \sum_{i=1}^{N} f v_i = f \sum_{i=1}^{N} v_i$$

There exists a positive externality when the consumers connect to the network. This is because the more consumers who get connected, f will become higher, which again will lead to higher willingness to pay. In other words, a user will improve the value of the network for all the other users by joining, since the network becomes larger. It is important to note that when the fraction of consumers decline, so too will each consumer's willingness to pay also decline.

In order to find the demand the focus is on the marginal consumer. Assume that the marginal consumer has a reservation valuation denoted $\tilde{v}_i$. Her reservation value is equal to $\tilde{v}_i = \frac{p_f}{f}$, since she is indifferent between buying and not buying the service. This means that the consumers with a lower valuation than $\tilde{v}_i$ will not join the network, whilst those who have a higher valuation than $\tilde{v}_i$ will join. As mentioned earlier, $\tilde{v}_i$ is uniformly distributed, $\tilde{v}_i \in [0, 100]$, for $f \in [0, 1]$, which means that those who have valuation lower than $\tilde{v}_i$ is equal to $\frac{\tilde{v}_i}{100}$. The network size f is normalized. Therefore, the fraction of the population who has a higher valuation than $\tilde{v}_i$, and therefore will buy the service, is:

$$f = 1 - \frac{\tilde{v}_i}{100}$$

Substituting $\tilde{v}_i$ with $\frac{p_f}{f}$ gives:

$$f = 1 - \frac{p_f}{100f}$$

In order to find the inverse demand function facing the monopolist, the equation above is solved for p_f which yields the following result:

(1) $$p_f = 100f(1 - f)$$

To maximize p_f, differentiate equation (1) with respect to *f*:

$$\frac{dp_f}{df} = 100 - 200f = 0$$

$$\Rightarrow f_{max} = \frac{1}{2}$$

Note that the maximum price, $p_{f\,max} = 25$, is for $f = \frac{1}{2}$, and that the demand curve is symmetric around $f = \frac{1}{2}$.

The result in equation (1) expresses the relationship between the monopolist's price for the network access and the fraction *f* of potential buyers who actually hook up to the network, i.e. equation (1) is the demand curve, which can be illustrated by the following figure:

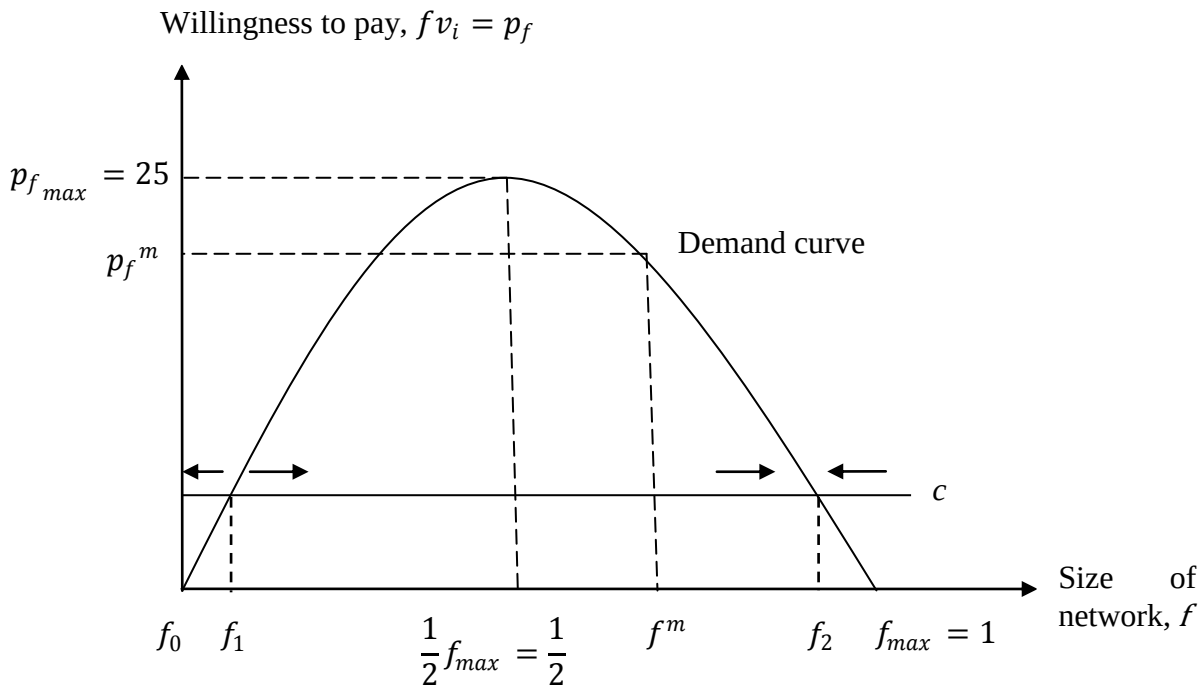

Figure 2: Market characterised by network externalities
(Pepall et al. 2005:617 and own calculations)

As Figure 2 illustrates, the demand curve is dome-shaped which implies that when the network is small, the consumers' willingness to pay is low. As the network size increases, the consumers' willingness to pay becomes higher. The consumers' willingness to pay reaches the turning point of the concave demand function at

$\frac{1}{2}f_{max} = \frac{1}{2}$ and $p_{f_{max}} = 25$, where the willingness to pay decreases with the fraction of the population hooked up to the network. The reason is that when the size of the network is large there are already many consumers that have become member of the network, so that the remaining are those with lower willingness to pay.

For all prices greater than $p_f = 25$ no equilibrium with a positive value of *f* exists. For each price p_f that the monopolist charges, except $p_{f_{max}}$, there exists two possible equilibria for *f*, one unstable and one stable. The low-fraction equilibrium will be unstable. This is because in a low-fraction equilibrium, a small loss of consumers will reduce the value of the network for the remaining consumers. Eventually, the outcome is that all consumers leave and the network will fail (Pepall et al. 2005:618). When the willingness to pay is lower than the price, then f will decrease. The possible equilibrium f_1 is said to be unstable, i.e. "tippy", thus the two arrows going away from the point. The possible equilibrium f_1 can be referred to as a "tipping point", which is a point where demand will either take off or the network will fail. The low-fraction equilibria, which are unstable, will be the critical mass for the network. If the fraction of users is just a bit larger than the critical mass, the network can grow to a high-fraction equilibrium. The points f_0 and f_2 are said to be stable. If the price is lower than the willingness to pay, the fraction of population, f, joining the network will increase. Consider the effect of a small reduction in price or one extra user joining the network starting in the possible low-fraction equilibrium f_1. Then the value of the network will increase above the reservation price for all consumers within the interval (0, f_2). This will hence lead to the establishment of a high-fraction equilibrium f_2. In the possible stable equilibrium f_0 the demand will not take off and the network will fail.

This section will analyse the monopolist's behaviour in the network market. The monopolist will maximize profits with respect to the fraction of potential consumers connected to the network. To solve for the monopolist's profit-maximizing choice, denote equation (1) to the general form such that
$p_f = rf(1-f)$. This is a new method for solving the model, extended by the authors of this thesis.

The monopolist's profit will hence equal:

$$\pi(f) = p_f f - cf$$

Substituting for the general form of p_f yields:

$$\pi(f) = rf^2(1-f) - cf$$

Differentiating with respect to *f* yields:

$$\frac{d\pi(f)}{df} = 2rf(1-f) - rf^2 - c = 0$$

$$2rf - 2rf^2 - rf^2 - c = 0$$

$$-3rf^2 + 2rf - c = 0$$

Since a quadratic equation $Ax^2 + Bx + C = 0$ has the solutions $x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$, this yields:

$$f^m = \frac{-2r \pm \sqrt{4r^2 - 12rc}}{-6r} = \frac{-2r \pm \sqrt{4r^2(1 - \frac{3c}{r})}}{-6r} = \frac{-2r \pm 2r\sqrt{(1 - \frac{3c}{r})}}{-6r}$$

of which the positive root is:

(2) $$f^m = \frac{1 + \sqrt{1 - \frac{3c}{r}}}{3}.$$

From equation (2) it is possible to find the monopolist's profit maximizing network size *f* depending on the level of *c*:

1. If $c = o \Rightarrow f^m = \frac{2}{3}$
2. If $c > o \Rightarrow f^m < \frac{2}{3}$
3. If $c = \frac{r}{4} \Rightarrow f^m = \frac{1}{2} \Rightarrow \pi(f) = 0$

Hence,

$$\frac{1}{2} \leq f^m \leq \frac{2}{3} \quad for \quad \frac{r}{4} \geq c \geq 0$$

Of course, if $c > p_{max}$ there will be no network. In case 1 with $c = 0$, the monopolist's profit maximizing choice of network size will be $f^m = \frac{2}{3}$. As seen from the different levels of *c*, the monopolist's profit maximizing choice of

network size will be somewhere between $[\frac{1}{2}, \frac{2}{3}]$, when the marginal network cost, *c*, is positive. This is a novel result, based on the extensions made by the authors of this thesis to include a marginal cost *c* in the model by Pepall et al. (2005).

It is possible to compare the monopolist's profit maximizing choice of network size to the choice of the social planner. The social optimum requires that the network is as large as possible at a price equal to marginal cost. From the social planner's point of view, the network will therefore be maximized at point f_2, i.e. the point where price equals marginal costs. Hence, the monopolist will not choose the socially optimal network size. Comparing the case when marginal costs are equal to zero, $c = 0$, the social planner will maximize welfare, resulting in a network size of f_{max}. The monopolist will maximize profit and choose the network size $f^m = \frac{2}{3}$. Hence, the monopolist will in case 1 restrict the network size to $\frac{2}{3}$ of what is socially optimal.

3.1.3. Direct and indirect network externalities related to compatibility

It is possible to distinguish between direct and indirect network externalities. Direct network externalities, often found in a physical two-way communications network (Rohlfs 1974) can be exemplified from the telecommunication industry. Here, there exists a positive relationship between the value of the network for a consumer and the number of subscribers of the network. For a software market this will imply that a user can easily share files with other users of the same software. If you were on the other hand the only user of specific word processing software, it would probably be impossible to exchange a document as no one else would have the necessary software to open the document file.

For communication networks, the concern for compatibility is whether consumers using one firm's services can contact consumers who use the service of other firms. If two firms' systems are interlinked, i.e. compatible, then the aggregate number of consumers in the two systems will comprise the appropriate network. If the systems are incompatible then it will be the size of an individual system will constitute the proper network measure (Katz and Shapiro 1985).

Indirect network externalities can be explained from the computer industry, as the value of a product or a system depend on the complementarity between the different components. The combination of these goods or services will complete some desired task (Page and Lopatka 1999), and this means that the complementarity leads to consumers shopping for systems rather than individual products (Shy 2001). Katz and Shapiro (1994) name the above a hardware-software network and exemplify it by the operative system-market. If there are very few that have bought a specific operative system, there will also be few or none software developers that wish to write applications for the specific platform. The reason is as follows. The demand for a given operative system will depend on how many applications that have been developed for that specific operative system. However, the demand for applications will depend on how many users there are of the specific operative system.

For hardware-software markets, the concern for compatibility is whether software produced for use on one brand of hardware may be run on another brand of hardware. Two brands of hardware will be compatible if they can use the same software (Katz and Shapiro 1985).

3.2. Model of network externality related to compatibility

In this section of the thesis, the authors of this thesis will extend a network model by Moen (2008) to include the impact of compatibility. The model by Moen (2008) expands the general spatial model of product differentiating, i.e. the Hotelling model presented amongst others by Tirole (1988), to include for network externalities. The Moen (2008) model examines how network externalities can influence the competition, i.e. the prices, in a market. Here, the main finding is that network externalities will make demand more price sensitive, which again will lead to fiercer competition between the firms. The reason is that by reducing the price, the network will become more attractive, which again yields more consumers buying the product. When a market is characterised by network externalities, it is important for a firm to become large in order for the network to be stable, which was shown in section 3.1.2.

In the following, the model developed by the authors of this thesis, will link network externalities and compatibility. What is new in this model compared to Moen's model (2008) is the aspect of compatibility, which the authors of this thesis have included. The aim is to examine whether compatibility can affect competition in a market dominated by network externalities. The model setup is relatively similar to the standard Hotelling model (Tirole 1988).

3.2.1. Model setup

The setup for the network model related to compatibility is as follows. There are two companies located at each end point of a line, whilst consumers are spread on the line with unit length. It is in other words a duopoly market, with heterogeneous consumers who have diverse preferences for different networks which the line represents. Assume that the two firms have constant unit costs c and that consumer travel cost is t per unit of length. The consumer travel cost is distributed as $t \in [0,1]$. The travel cost can be interpreted as the cost a consumer must "pay" for not getting her ideal product/network. The prices p_1 and p_2 are set by the firms independently and simultaneously. As mentioned earlier, the model aims to link network externalities with the degree of compatibility. Therefore, the parameter n represents network externalities where the user obtains positive utility from belonging to a firm with many customers. What the authors of this thesis introduce, compared to the Moen model (2008), is the parameter τ, which represents the degree of compatibility with the other product/network. The consumers obtain positive utility when the networks are compatible. τ is specified as follows: $\tau \in [0,1]$, where 0 specifies complete incompatibility with the other network, whilst 1 specifies complete compatibility with the other network. It is assumed that τ is observable for the consumers, and that the consumers are rational. In what follows it is also assumed that $n < t$.

The location of the indifferent consumer is denoted x^m, which will also be the market share for firm 1. The market share for firm 2 is denoted $1 - x^m$. The distribution of the consumers is $x \in [0,1]$, where x is the location of a consumer measured as the distance from firm 1. Assumptions underlying the model are that the market is entirely covered and that the consumers are uniformly distributed

along the horizontal line. Graphically, the structure of model can be illustrated by the following figure, denoted Figure 3:

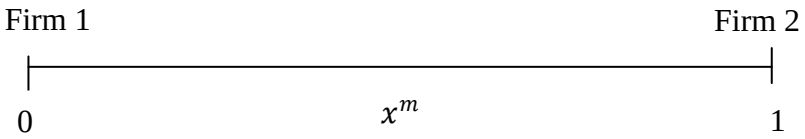

Figure 3: Structure of the Hotelling model, the linear city
(Tirole 1988:97)

Now a consumer with location *x* will be considered. Her utility of joining firm 1's network is respectively:

(1) $$u_1 = V - p_1 - tx + nx^m + \tau(1 - x^m)n$$

The above function states that her utility will increase through the term nx^m by being member of the network 1. Her utility will also increase if firm 1's network is compatible with firm 2's network through the term $\tau(1 - x^m)n$. Collecting the terms yields the following result:

$$u_1 = V - p_1 - tx + nx^m + \tau n - \tau n x^m$$

(2) $$u_1 = V - p_1 + \tau n - tx + n(1 - \tau)x^m$$

Similarly, the utility function for a consumer in network 2 is respectively:

$$u_2 = V - p_2 - t(1 - x) + n(1 - x^m) + \tau n x^m$$

As seen for network 1, the consumer's utility in network 2 will increase due to the network externality, through the term $n(1 - x^m)$, and also by network 2 being compatible with network 1, which is represented through the term $\tau x^m n$. Collecting the terms yields the following result:

$$u_2 = V - p_2 - t + tx + n - nx^m + \tau n x^m$$

(3) $$u_2 = V - p_2 - t + n + tx - n(1 - \tau)x^m$$

The consumer that is indifferent between joining network 1 or network 2, i.e. the indifferent consumer x^m, can be found by setting the equation (2) and (3) equal to each other and adjusting for consumer x^m:

$$V - p_1 + \tau n - tx^m + n(1-\tau)x^m = V - p_2 - t + n + tx^m - n(1-\tau)x^m$$

The equation above can be rewritten in order to find an expression for the indifferent consumer, x^m:

$$-tx^m + n(1-\tau)x^m - tx^m + n(1-\tau)x^m = p_1 - p_2 - \tau n - t + n$$
$$-2tx^m + 2n(1-\tau)x^m = p_1 - p_2 - t + n(1-\tau)$$
$$2tx^m - 2n(1-\tau)x^m = p_2 - p_1 + t - n(1-\tau)$$
$$x^m = \frac{p_2 - p_1 + t - n(1-\tau)}{2t - 2n(1-\tau)}$$
$$x^m = \frac{p_2 - p_1}{2(t - n(1-\tau))} + \frac{t - n(1-\tau)}{2(t - n(1-\tau))}$$

(4) $$x^m = \frac{1}{2} + \frac{p_2 - p_1}{2(t - n(1-\tau))}$$

From equation (4) is it possible to observe that the market share will depend on the price difference $p_2 - p_1$, transportation cost t and the product of network externalities and degree of compatibility $n(1-\tau)$.

Replace $(t - n(1-\tau))$ with t' in order to obtain a similar result as in the standard Hotelling model:

(5) $$x^m = \frac{1}{2} + \frac{p_2 - p_1}{2t'}$$

The above equation (5) represents the location of the indifferent consumer. In order to find the firms reaction curves and thereafter the equilibrium prices, firm 1 will be considered. Firm 1's profit is given by:

(6) $$\pi_1 = (p - c)x^m$$

Substitute x^m with the expression found in equation (5), in order to get the following expression:

(7) $$\pi_1 = (p - c)\left[\frac{1}{2} + \frac{p_2 - p_1}{2t'}\right]$$

The above expression in equation (7) is identical to the expression in the standard Hotelling model (Moen 2008), however the t is now replaced by t'. The firms maximize profit with respect to price:

$$Max\ \pi_1 = (p - c)\left[\frac{1}{2} + \frac{p_2 - p_1}{2t'}\right]\ w.r.t\ p_1$$

$$\frac{\partial \pi_1}{\partial p_1} = \frac{\partial[(p_1 - c)\left[\frac{1}{2} + \frac{p_2 - p_1}{2t'}\right]]}{\partial p_1} = 0$$

$$\frac{1}{2} + \frac{p_2 - p_1}{2t'} - \frac{p_1 - c}{2t'} = 0$$

$$\frac{1}{2} + \frac{p_2 - 2p_1 + c}{2t'} = 0$$

$$\frac{2p_1}{2t'} = \frac{1}{2} + \frac{c + p_2}{2t'}$$

$$p_1 = \frac{c + p_2 + t'}{2}$$

The following result is hence obtained for the reaction functions for firm 1 and 2 respectively:

(8)

$$p_1 = \frac{c + p_2 + t'}{2}$$

$$p_2 = \frac{c + p_1 + t'}{2}$$

In order to find the equilibrium prices, the above expression for p_2 is substituted into reaction function for firm 1:

$$p_1 = \frac{c + t'}{2} + \frac{1}{2}\left(\frac{c + p_1 + t'}{2}\right)$$

$$p_1 - \frac{p_1}{4} = \frac{c + t'}{2} + \frac{c + t'}{4}$$

$$\frac{3p_1}{4} = \frac{3c + 3t'}{4}$$

$$p_1 = c + t'$$

By symmetry, the following result is obtained for the equilibrium prices:

(9) $$p_1 = p_2 = c + t' = c + t - n(1 - \tau)$$

The parameter τ, which is what the authors of this thesis have introduced, was specified to be between 0 and 1, where 0 represents complete incompatibility and 1 represents complete compatibility. Assume that the two firms offer two different software programmes, for instance document software. Whether compatibility between the two document software will affect the prices consumers will face will now be examined. Therefore, the two polar cases of complete incompatibility and complete compatibility will be examined.

3.2.2. Incompatibility

With complete incompatibility, i.e. τ is equal to 0, the result obtained in equation (9) will be equal to $p_1 = p_2 = c + t - n$. This means that network externalities combined with incompatibility will make the competition fiercer and the equilibrium prices will be reduced. With incompatible systems, the firms will have an incentive to decrease its price in order to attract as many consumers as possible along the horizontal line because of the network externality. In the situation of complete incompatibility, being big becomes important, as the network becomes more valuable the more consumers that are hooked up to the network.

3.2.3. Compatibility

With complete compatibility, i.e. $\tau = 1$, the result obtained in equation (9) will be equal to $p_1 = p_2 = c + t$. If the two firms offer compatible software programmes, the network effect will not matter for which programme the consumer uses, as she can exchange documents with every user of the two document software. Consumers' buying decision will not be affected by the network externality, as both software programmes "speak the same language". Therefore, complete compatibility will cancel out the effect of network externality. Hence, only the travel cost *t* will matter. The firms will then have the possibility to charge higher prices compared to the situation of complete incompatibility, i.e. $\tau = 0$, and will in the case of complete compatibility obtain increased profits (Shy 2001). These results for the network model related to compatibility are new and interesting

economic implications to the model by Moen (2008) and the Hotelling model, which were proven by the authors of this thesis.

Shy (2001) argues that in these circumstances, compatibility may be seen as anticompetitive. An example is from the banking industry where banks can increase their profits by making their automatic-teller machines (ATMs) compatible with the ATMs of its competitors. The reason is as follows. In the situation of incompatibility, the relative utility each user gain from each machine will depend on the relative network size and the price difference between the two competitors. Under incompatibility the firm will reduce its price in order to attract as many consumers as possible to their network. However, under compatibility, the price competition will be relaxed since the network size of each firm will become irrelevant to the consumers' purchase choice. An economic effect under compatibility is that equilibrium prices will become higher (Shy 2001).

3.2.4. The effect on consumer surplus

In order to examine whether a consumer will be better off in the case of compatibility or not, the consumer surplus for a consumer can be calculated as follows:

$$CS = U_1(x) = u_1 - p_1$$

where $u_1 = V + \tau n - tx^m + n(1-\tau)x^m$, and $p_1 = c + t - n(1-\tau)$ as seen in equation (9).

Assume that $x^m = \frac{1}{2}$ when considering the average consumer. This yields the following result for the consumer surplus:

$$CS = U_1(x) = u_1 - p_1 = V + \tau n - \frac{1}{2}t + \frac{n(1-\tau)}{2} - c - t + n(1-\tau)$$

Solving the above equation yields:

$$CS = U_1(x) = V - \frac{1}{2}t - c - t + n + \frac{n(1-\tau)}{2}$$

(10) $$CS = U_1(x) = V - \frac{3}{2}t - c + \frac{3}{2}n - \frac{n\tau}{2}$$

Equation (10) is the expression for the consumer surplus and it decreases with τ. In the presence of network externalities and when the two networks are compatible, i.e. $\tau = 1$, equation (10) shows that the consumer is worse off in this situation compared to the situation of complete incompatibility, i.e. $\tau = 1$. It is also possible to examine the effect on consumer surplus due to a small change in compatibility:

$$\frac{\partial U_1(x)}{\partial \tau} = -\frac{n}{2}$$

Hence, any consumer is worse off with an increase in compatibility, and consumer surplus is reduced with a product of the network externality.

The network model related to compatibility show that the price effect dominates the network benefits, thereby resulting in reduced consumer surplus under complete compatibility. However, a possible limitation of the model may be that it cannot consider an effect on total output because of its horizontal linear specification. The effect on total output will therefore be considered in the model by Katz and Shapiro (1985) in section 3.3. The increase in price and the reduction in consumer surplus under complete compatibility may imply that the firms have too strong incentives for achieving compatibility. It is therefore possible that the firms undertake too high costs related to achieving compatibility compared to what might be socially optimal.

3.2.5. Conclusion

The model of network externalities related to compatibility, derived by the authors of this thesis, showed that if two firms offer complete compatible networks, the prices will increase. Having compatible networks will "cancel out" the network externalities, since a firm does not have to reduce its price in order to attract consumers to his network. The consumers' buying decision will not be affected by network externalities since they will be able to communicate with both compatible networks. With complete incompatible networks, the network externalities will lead to reduced prices. The prices will be reduced by the competing firms in order to attract consumers. With compatible networks the effect for consumer surplus was shown to be negative, and the firms may have too strong incentives for achieving compatibility. These results for the network model related to

compatibility are new and interesting economic implications to the model by Moen (2008) and the Hotelling model. The results were proven by the authors of this thesis when extending the Moen (2008) model to include a parameter for compatibility.

3.3. Model of compatibility

The following analysis will be in an oligopolistic setting. A simple and static model of oligopoly developed by Katz and Shapiro (1985) is used to analyse markets characterised by network externalities. Hence, the assumptions for the model are that network externalities are present in the market where a given amount of producers are present, the consumers' utility function gives rise to the demand function, and the equilibrium is a fulfilled expectations Cournot equilibrium. First, the model will be derived by considering the consumers and the firms. The equilibrium is characterised by rational consumers, where their expectations about the network are fulfilled, hence the equilibrium is fulfilled expectations equilibrium. Network externalities will yield demand-side economies of scale, which will depend on consumer expectations. Secondly, the welfare will be analysed by studying both the consumer and producer surplus. Thirdly, the compatibility decision will be discussed by considering the equilibrium characterisation. Regarding compatibility, important issues are whether compatibility is socially desirable and whether the private incentives for compatibility are consistent with the social incentive. In other words, do firms have sufficient incentives to produce compatible goods or services (Park 2005:257). The central findings when viewing all firms together are that total output increases with compatibility and that the firms' joint incentives for product compatibility might be lower than the social incentives. Thereafter, the divergence between the social and private incentives to achieve compatibility will be discussed. Hereunder, a parallel will be drawn to an oligopoly quality model derived by the authors of this thesis. Finally, a conclusion based on the previous results will be provided.

3.3.1. Consumers

The compatibility model is a partial equilibrium oligopoly model where consumers act to maximize their utility. It is assumed that a consumer will buy either one or no unit of any brand (Katz and Shapiro 1985:426). The surplus a consumer obtains from consuming a unit of good will depend on the number of other consumers who join the network related with that product. It is the expected network sizes that will be the basis for consumers' purchase decisions; therefore, it is assumed that consumers must make their purchase decisions before the actual network sizes are known. Networks are assumed to be homogeneous, meaning that all consumers will view two networks of equal size as perfect substitutes. Further, it is assumed that consumers are heterogeneous in their basic willingness to pay for the product, but homogeneous in their valuation of the network utility.

The timing of the model is the following. In the first stage, the consumers form expectations about the size of the network. In the second stage, taking the consumers' expectations as given, the firms play an output game which will generate a set of prices. Subsequently, consumers decide whether to purchase a good by comparing their reservation prices, which is based on their network size expectations, with the prices set by the *n* firms. A requirement is imposed; in equilibrium consumers' expectations will be fulfilled.

The number of users that a consumer expects firm *i* to have is denoted x_i^e, and the consumers' prediction of the network size which is associated with firm *i* is denoted y_i^e. The expectation of network size is identical across all consumers. When products are incompatible, each products' market size will equal its own network $y_i^e = x_i^e$. When *m* firms' products are compatible, for example product 1 through *m*, there will be a single network for these brands (Katz and Shapiro 1985:426):

$$y_i^e = \sum_{j=1}^{m} x_j^e \quad \text{for } i = 1, 2, \ldots, m$$

For a product with expected network size y^e, a consumer of type *r* has a willingness to pay $r + v(y^e)$. The variable *r* can be interpreted as the consumer's basic willingness to pay for the good, and the term *v(y)* is the value the consumer

attaches to the network externality when the number of subscribers is *y* (Katz and Shapiro 1985:426). The function $v(\cdot)$ is increasing. The basic willingness to pay for the good, *r*, varies over consumers and is assumed to be uniformly distributed between minus infinity and A with density one, resulting in a linear demand function. The network benefit is specified as an increasing function of the network size of the compatible products (Park 2005:256). Let p_i denote the price charged for brand *i*. A consumer of type *r* will choose the brand for which her utility is largest. The *r* consumer's utility function for a product *i* in the presence of network externalities is defined as the sum of a stand-alone benefit, i.e. $r - p_i$, and the network benefit, i.e. $v(y_i^e)$, since consumers derive benefit from the product itself and the network size of the product (Park 2005:256):

(1) $$U_{ri} = r - p_i + v(y_i^e)$$

3.3.2. Firms

The firms compete in a Cournot fashion, hence they choose output simultaneously. Given homogeneous products, two firms *i* and *j* will both have positive sales if and only if:

(2) $$p_i - v(y_i^e) = p_j - v(y_j^e) \equiv \phi,$$

where $p_i - v(y_i^e)$ is the expected hedonic price of brand *i* and ϕ denotes the common value of the expected hedonic price. If for example $p_i - v(y_i^e) > p_j - v(y_j^e)$ firm *j* would lose all its customers to firm *i*. This is an essential equation in the model since it shows that it is the expected network that affects output, not the actual network. If the actual number of consumers is increased with one, this will have no effect on the equilibrium because consumers' expectations about the network will be unchanged. In market equilibrium the fact that expectations do not increase may be a reason for why firms do not want to increase output. According to equation (2), the hedonic prices must equal when several firms have positive sales. For a given value of ϕ, only the consumers with a basic willingness to pay for the good larger than the hedonic price, i.e. $r \geq \phi$, will buy the good. There will be $A - \phi$ such consumers in the market. Total output is denoted by z

such that firms totally sell $z \equiv \sum_{i=1}^{n} x_i$ units. The prices must then be set so that $A - \phi = z$ or:

(3) $$A + v(y_i^e) - p_i = z \quad \text{for all } i \text{ such that } x_i > 0.$$

Firm i's inverse demand function is hence:

(4) $$p_i = A + v(y_i^e) - z.$$

The price that firm i will receive will depend on the expected size of its network, y_i^e, and on the total unit sales of the n firms, z.

The two types of costs in the model are cost of production and cost of achieving compatibility. To simplify, it is assumed that the cost of production, consisting of a fixed cost and a variable cost, is zero. The cost of achieving compatibility, which is assumed to be fixed, may consist of development and design costs for a compatible product, negotiation costs for selecting a standard, and the cost of introducing a new, compatible product. Hence the marginal cost of achieving compatibility is assumed to be zero. When all networks are incompatible, i.e. $y_i^e = x_i^e$, the profit of firm i equals:

(5) $$\pi_i = x_i(A - z + v(x_i^e))$$

given sales of x_i and total output z. When all n products are compatible it is such that $y_i^e = \sum_{j=1}^{n} x_j^e \equiv z^e$ for all i. Given total output z and firm i's sales equal x_i, firm i's gross profit is:

(6) $$\pi_i = x_i(A - z + v(z^e))$$

The fixed cost of compatibility incurred by firm i, F_i, must be subtracted from the gross profits in order to obtain profits net of fixed costs of compatibility (Katz and Shapiro 1985:427).

3.3.3. Fulfilled expectations equilibrium

The equilibrium of the model can be characterised as fulfilled expectations Cournot equilibrium. Hereunder, the output level of each firm is chosen under the assumption that consumers' expectations of the network sizes are given, and that the actual output level of the other firms is fixed. The firms maximize profit with respect to quantity x_i:

$$\text{Max}\left[\pi_i = x_i\left(A - z + v(y_i^e)\right)\right] \text{ with respect to } x_i$$

Differentiate profit with respect to quantity in order to obtain the first order condition:

$$\frac{d\pi_i}{dx_i} = \frac{d[x_i(A - z + v(y_i^e))]}{dx_i} = 0$$

When solving the first order conditions of profit maximization of the Cournot game, this yields a vector of the equilibrium sales levels $(x_1^*, x_2^*, \ldots, x_n^*)$ that must satisfy:

$$A - z + v(y_i^e) = 0$$

$$A - x_i - \sum_{j=1}^{n} x_j + v(y_i^e) = 0$$

(7) $$x_i^* = A + v(y_i^e) - \sum_{j=1}^{n} x_j^* = \left\{A + nv(y_i^e) - \sum_{j \neq i} v(y_j^e)\right\}/(n+1)$$

for $i = 1, 2, \ldots, n$.

It is possible to see that quantity, x_i^*, equals price, p_i, since the right hand side of the first part of equation (7) equals the price (Katz and Shapiro 1985:428). This equation represents a firm's equilibrium output level.

3.3.4. Welfare

As seen in the equation (7), in equilibrium firm *i*'s output level will be equal to the price that firm receives. Therefore, the *i*'th firm's profit in equilibrium will be equal to $\pi_i = (x_i^*)^2$.

It is the actual size of the network that determines the surplus a consumer obtains from joining the network, and in equilibrium the actual network size will equal that network's expected size. Substituting equation (4) into equation (1) yields:

$$\begin{aligned} U_{ri} &= r + v(y_i^e) - p_i \\ &= r + v(y_i^e) - A - v(y_i^e) + z \\ &= r + z - A \end{aligned}$$

Hence, when market output is *z*, a type *r* consumer will only join a network if the utility is non-negative, hence $r + z - A \geq 0$, i.e. $r > A - z$, or otherwise stay out of the market and derive no surplus. Consumers' expected surplus, CS, can be obtained by integrating over all consumers who do enter the market:

(8) CS: $S(z) = \int_{A-z}^{A} (\rho + z - A) d\rho = \frac{z^2}{2}$

In the fulfilled expectations equilibrium, the expected and actual consumers' surplus will be equal. Equation (8) show that consumer surplus increases with the total output level z.

The social welfare, W, will consist of the sum of producers' and consumers' surplus. Welfare is hence given by the following expression in the fulfilled expectations Cournot equilibrium (Katz and Shapiro 1985:429):

(9) W: $W(x_1, \dots, x_n) = \pi(x_1, \dots, x_n) + S(x_1 + \dots + x_n) = \sum_{i=1}^{n} x_i^2 + \frac{z^2}{2}$

Hence, the social welfare also increases with the total output level z.

3.3.5. Equilibrium characterisation

Following, the structure of fulfilled expectations equilibrium for compatible and partial compatible products will be studied.

First, the case of complete compatibility will be examined. Since the model is in an oligopolistic setting, it is supposed that any two products are compatible with one another. Then there is a single network of expected size $z^e = \sum_{i=1}^{n} x_i^e$, and for all i we have that $y_i^e = z^e$. The unique Cournot equilibrium that corresponds to a set of expectations (7) becomes:

(10) $$x_i^* = \frac{A+v(z^e)}{n+1} \qquad \text{for } i = 1, 2, \dots, n.$$

By imposing the fulfilled expectations requirement, $z^e = x_1 + \dots + x_n^*$, and adding equation (10) up over all i, the following fulfilled expectations equilibrium value of total output is obtained:

(11) $$z^c = \left(\frac{n}{n+1}\right)(A + v(z^c))$$

When the products are compatible, the fulfilled expectations equilibrium value of total output is denoted z^c. The equation has a unique solution and this unique compatible-products equilibrium is symmetric: $x_i^c = \frac{z_i^c}{n}$ for all i. Hence, one may state that when all products are mutually compatible, there is a unique Fulfilled Expectations Cournot Equilibrium (FECE) which is symmetric (Katz and Shapiro 1985:429). The market equilibrium with complete compatibility can be illustrated by the following figure:

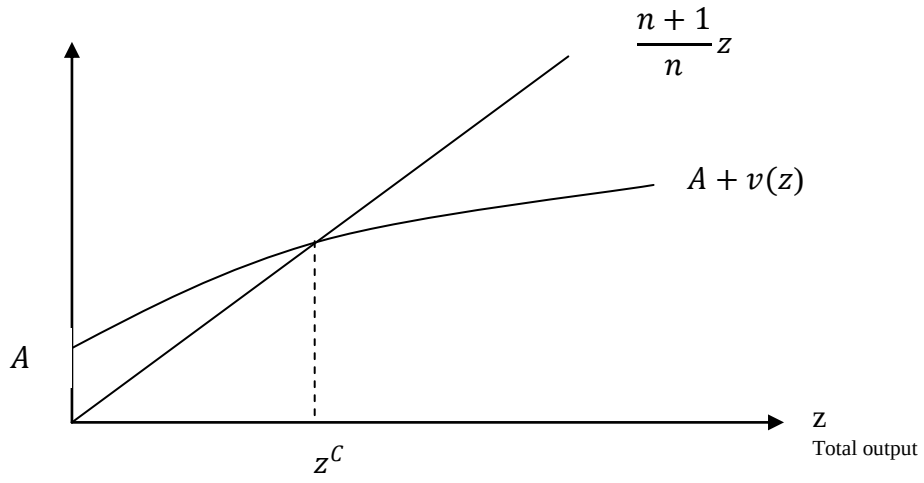

Figure 4: Market equilibrium with complete compatibility
(Katz and Shapiro 1985:429)

As the number of firms *n* increases, the fulfilled expectations equilibrium under compatibility, $z^c = \left(\frac{n}{n+1}\right)(A + v(z^c))$, converges to the perfectly competitive equilibrium; z^c approaches $A + v(z^c)$ and the hedonic price, $A + v(z^c) - z^c$, approaches a zero marginal cost.

Secondly, the case of partial compatibility, i.e. less than complete compatibility, will be examined. If there are more than two firms, the degree of product compatibility may lie in between complete industry-wide compatibility and complete incompatibility, so that at least two products are not compatible with each other. The pattern of compatibility is assumed to be characterised by the set of compatibility groups, $G^j \; j = 1, \dots, J$, where all of the brands within a group are mutually compatible with each other, but incompatible with any brand which is not member of that group. Hence, if firm *i* is in group G^j, the network size equals

$$y_i = \sum_{k \in G^j} x_k \equiv y^j$$

A firm *i* in group *j* maximizes profit $\pi_i = x_i(A - z + v(y^j))$ such that the first order condition is $x_i = A - z + v(y^j)$. Consequently, the same level of output x^j will be chosen by all firms in a given group. The number of firms in compatibility group *j* is denoted by m^j. Therefore, in equilibrium for all $x^j > 0$ (Katz and Shapiro 1995:432) it is such that:

(12) $$x^j = A - z + v(m^j x^j).$$

From firm *i*'s first order condition, by summing up over all firms and rearranging the rational expectations equilibrium under incomplete compatibility yields (Park 2005:258):

(13) $$z^I = \left(\frac{nA + \sum v(y_i)}{n+1}\right)$$

Based on the two equilibria results from equation (11) and (13), Katz and Shapiro (1985:432) give the following proposition (Proposition 1): "The level of total output is greater under industry-wide compatibility than in any equilibrium with

less than complete compatibility". The proof is the following; For all firms with positive levels of output it was observed that $x_i = A + v(y_i) - z$. This gave $(n+1)z = nA + \sum v(y_i)$ when adding up over all firms and rearranging, as shown in Figure 4. Under complete compatibility the network size for firm *i* equals the total output, $y_i = z$, for all firms. Under incomplete compatibility it is such that $y_i < z$ for at least one firm. Complete and incomplete compatibility can thus be compared in the following figure, Figure 5. Here, the curve $nA + nv(z)$ lies above the curve $nA + \sum v(y_i)$ which determines the y_i's under incomplete compatibility:

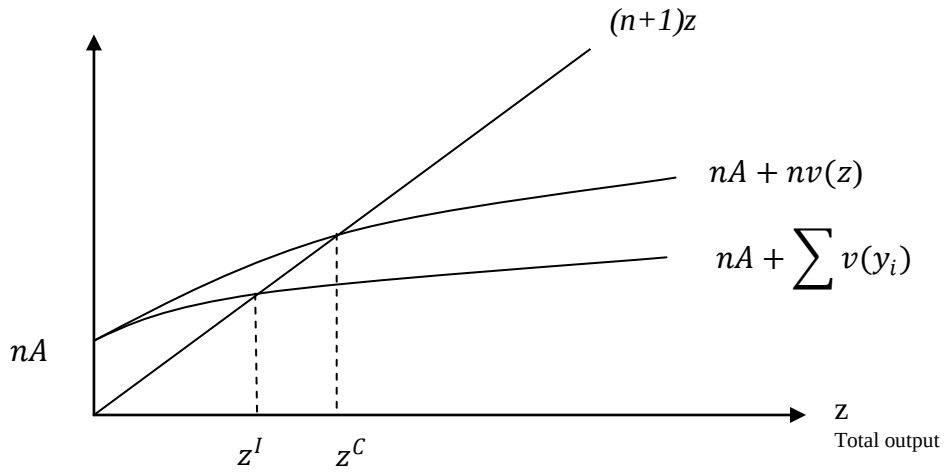

Figure 5: Complete vs. Incomplete compatibility
(Katz and Shapiro 1985:433)

Since $z > y_i$ for at least one firm, we obtain $z^C > z^I$ such that the equilibrium level of output is greater under industry-wide compatibility than under incomplete compatibility.

The equation of a firm's equilibrium output level, x_i^*, indicates that under complete compatibility the equilibrium price will be higher than the price of symmetric equilibrium under incomplete compatibility. Hence, under compatibility price competition is reduced. This result was also shown in the network model related to compatibility in section 3.2. However, in the compatibility model consumer surplus will be larger under complete compatibility. This is because consumer surplus increases with the total output level, which is found to be larger under complete compatibility. In general,

compatibility between competing technologies reduces the competition in the product market, but may increase consumers' network benefits. In the compatibility model by Katz and Shapiro (1985), the positive effects from the increased network benefits dominate the negative effects of the increased price, and thus compatibility will increase consumer surplus (Park 2005:259). Hence, the compatibility model implies that compatibility will increase surplus for consumers and increase prices.

3.3.6. The private and social incentives for compatibility

So far, the compatibility model by Katz and Shapiro (1985) has treated product compatibility as exogenous. In markets where network externalities are important, the compatibility of products will be the result of the firms' explicit decisions. The following analysis will examine incentives for achieving compatibility with standards as a mechanism for achieving this, related to whether side payments amongst firms are possible or not. Firms and the social planner's incentives for achieving compatibility will be studied, in addition to whether firms have sufficient incentives for achieving compatibility.

When analysing the private incentives for compatibility, each firm's change in profit, i.e. $\Delta\pi_i = \pi_i^C - \pi_i^I$, and the change in firms' joint profits, i.e. $\Delta\pi = \sum_{i=1}^{n} \Delta\pi_i$, will be studied and compared to the cost of compatibility. The change in consumers' surplus is denoted $\Delta CS = CS^C - CS^I$, and the social incentives for compatibility are given by the difference in social surplus under compatibility and less than complete compatibility, i.e. $\Delta W = W^C - W^I$ (Katz and Shapiro 1985:435). In the next subsection the divergence between the private and social incentives for compatibility will be discussed.

Private incentives are given by the change in joint profits $\Delta\pi$. The social incentive will be determined by the changes in social welfare, consisting of the sum of the changes in industry-wide profits and the change in consumer surplus; $\Delta W = \Delta\pi + \Delta CS$. Therefore, the social and private incentives will differ when the move to compatibility changes the level of consumers' surplus. Since consumers' expected surplus equal $S(z) = \frac{Z^2}{2}$, consumers' surplus will increase only if output increases. The proposition that the level of total output is greater under industry-wide

compatibility than in any equilibrium with less than complete compatibility (Proposition 1), show that output and hence consumers' surplus will increase with the move to complete compatibility. Thus, if the sum of the change in joint profits is positive, $\Delta\pi > 0$, then the change in social welfare is positive, $\Delta W = \Delta\pi + \Delta CS > 0$. Therefore, another proposition (Proposition 2) will be that when compatibility costs are purely fixed costs, any move to complete compatibility that increase industry profits is socially beneficial (Katz and Shapiro 1985:435). Hence, firms' compatibility incentives will not be socially excessive.

Actually, firms' incentives for achieving compatibility might be inadequate with purely fixed costs of compatibility; $\Delta CS > 0$ and therefore $\Delta W > \Delta\pi$. If the total costs of achieving compatibility in the industry, denoted F, is larger than the sum of the change in total profits across all firms, but lower than the change in social surplus, this is denoted $\Delta\pi < F < \Delta W$. Then the private firms will not achieve a socially desirable level of compatibility, and the private incentives will hence be inadequate. The reason is that firms are unable to appropriate all the benefits resulting from compatibility since consumer surplus increases (Katz and Shapiro 1985:435). An analogous result from economic theory is a monopolist's inadequate incentives for providing a socially desirable product in the presence of fixed costs, when the monopolist is not able to perfectly price discriminate.

A method for achieving compatibility is the joint adoption of a product standard. It is therefore interesting to examine the incentives for compatibility under the adoption of an industry standard. Hereunder, standardization involves that a given set of firms must cooperate in order to make their products compatible with one another. It is assumed that all of the firms in the specific set must decide to make the products compatible, and any firm can veto the move to compatibility. Assume that a set of side payments can be constructed such that all firms' profits will increase individually if and only if compatibility will increase joint profits. In other words, that the change in profits for the firms within the set exceeds the total compatibility costs.

When side payments are not possible, the standard will be adopted if and only if all firms joining the standard benefit from this standard setting. Assuming that side payments are infeasible and that firm *i* incurs cost F_i to adopt the standard

(achieving compatibility), then adoption will occur if and only if firm i's change in profits is larger than the cost of adoption, $\Delta\pi_i > F_i$ for all adopters of the standard. Hence, if firms are not able to make side payments to one another, combined with having a product standard as the method for achieving compatibility, the products of a given set of firms will only be made compatible if all of these firms would earn greater profits as a result.

Assume that it is possible to make side payments among the firms achieving compatibility through the adoption of a standard, for example through licensing fees or compensation for compatibility expenses. Hereunder, an adequate condition for achieving compatibility is that the total profit of the firms who achieve compatible products increases. Hence, when the compatibility method is a standard, allowing for cost sharing through side payments will increase the possibility for the firms to choose compatibility. Therefore, the previous proposition, Proposition 2, can be strengthened by stating that the private standardization rule is more stringent when cost sharing is not possible than when it is possible. The set of cases in which the firms fail to adopt a standard that is socially beneficial is therefore larger when it is not possible to make side payments. Any privately profitable industry-wide standard is still socially desirable (Katz and Shapiro 1985:436).

3.3.7. Distortions related to the compatibility decision

This section will discuss the divergence between the social and private incentives for achieving compatibility, proven in the previous section. Two sources of distortion arise because when firms make their compatibility decision, they ignore the effects this will have on both the level of consumers' surplus and the profits of other firms.

First, the effect on consumers' surplus will be considered. A seen in the previous section, the firms' incentives might be inadequate when the move to compatibility increases consumers' surplus. Contrary, the firms' incentives might be excessive when the move to compatibility decreases consumers' surplus, i.e. $\Delta CS < 0$ and therefore $\Delta W < \Delta\pi$. The change in consumers' surplus can be divided into two components. The first component is the change that arises due to the shift in the

total output level, and the second component is the change that occurs when the marginal consumer values the network externality differently than the average consumer. The following paragraphs will discuss these two components further.

Regarding the first component, the level of consumers' surplus will increase with the level of total output since $S(z) = \frac{z^2}{2}$. If the assumption that the move to compatibility has no impact on marginal costs is relaxed, output may be lower under complete compatibility than under less than complete compatibility. For example is it possible that the adoption of an industry standard may require redesign of some or all of the products, which might lead to changes in the variable costs of production. Previously in the compatibility model it was assumed that the marginal cost of production was zero. Unlike the fixed cost, changes in marginal costs will affect the equilibrium output level. Assuming a marginal production cost *c*, the firm *i*'s profit function $\pi_i = x_i(A - z + v(z^e) - c)$ will depend on *c*, so that changes in *c* will affect the equilibrium. In particular, if marginal costs increases sufficiently relative to the network externalities, complete compatibility will yield lower total output than under incompatibility. Hereunder, because of the lower total output, consumers' surplus will fall as a result of the move to complete compatibility and as $\Delta\pi > \Delta W$ the firms' joint incentives are excessive (Katz and Shapiro 1985:438).

Turning to the second component, the consumer surplus also depends on the relationship between the marginal and average buyer's valuations of the good. In the compatibility model the network externality is equally valued by all consumers. Therefore, when compatibility is achieved, all consumers' valuations of the good will increase by the same amount. However, the consumer surplus will be larger the lower the marginal consumer's valuation is relative to the average consumer's valuation. Unlike the assumption in the compatibility model, more generally, consumers' valuations of the network externality may differ. If the marginal buyer values the network externality more, then the move to compatibility will increase her willingness to pay for the good by more than the increase for the average buyer. Then, for a given level of output, the firms may increase the price by more than the increase in the average buyer's willingness to pay. As a result, consumers' surplus will be reduced. Also, the total private

incentives for achieving compatibility are likely to be higher than the social planner's incentive, $\Delta\pi > \Delta W$, and thereby excessive. This is because the firms consider the marginal consumer's valuation in the profit maximization, whereas the social planner considers the average consumer's valuation. The effect will go in the other direction in the case when the network externality is smaller for the marginal buyer (Katz and Shapiro 1985:438). The relationship between the average and marginal buyer's valuation will be elaborated further in an oligopoly quality model, developed by the authors of this thesis, in the section 3.3.8.

The divergence between the social and private incentives for achieving compatibility is also due to another source of distortion. This distortion arises because when firms make their compatibility decision they ignore the effect this will have on the profits of other firms. If it is not possible to make side payments for achieving compatibility, it is the change in firms' individual level of profit that will motivate the decision to achieve compatibility. The compatibility model assumed a symmetric equilibrium. However, given an asymmetric equilibrium the change in profits may vary from positive to negative for different firms. Then a larger firm may lose market share to a smaller rival firm due to standardization. The relative changes in firms' profit depend on their relative changes in market shares and revenues when achieving compatibility. If one group of firms increase their market share and profits at the expense of others, this group will be more inclined to achieve compatibility. In addition, the relative changes in firms' profit also depend on the relative costs of achieving compatibility. If the costs of achieving compatibility would be larger for some firms than for others, a free-rider problem could arise that would bias the firms away from achieving compatibility.

3.3.8. Parallel to oligopoly quality model

It is possible to draw a parallel from standardization to firms' choice of quality since achieving compatibility through standardization can be interpreted as a quality improvement for consumers. Therefore, the authors of this thesis will now make modifications to the monopolistic analysis of quality by Pepall et al. (2005), by expanding the quality model to an oligopolistic setting. Another new element to this model is the welfare analysis derived by the authors of this thesis.

Assume that two oligopoly firms produce two identical goods for which they choose the price p and the quality z. The inverse demand function facing both firms is specified as:

$$p = P(q_1, q_2, z) = z(\theta - q_1 - q_2)$$

This implies that the market equilibrium price will depend on how much the firms produce, q_1 and q_2, and also on the quality of these units, z. Quality is desirable since p increases with z. Assume that $Q = q_1 + q_2$ where Q is the sum of each firm's quantity. Let $C(q, z)$ denote each firm's cost function for producing q_i units of the good with quality z, and assume it is identical for both firms. It is assumed that $C(q, z)$ increases with z such that:

$$C(q, z) = \alpha z^2$$

The cost function shows that the marginal cost of production is zero, whereas the marginal cost of quality is equal to $C_z(q, z) = \alpha z$. Since the cost function is identical for both firms, the total cost of producing Q units with quality z is equal to $2\alpha z^2$. Since the two firms are symmetric, it is assumed that the market equilibrium will be symmetric; $q_1 = q_2$ and $z_1 = z_2$.

First, the choice of quantity and quality by the oligopolies will be considered in a Cournot setting with two firms. To find the oligopolies profit maximizing level of quantity q_i and quality z, both oligopoly firms maximizes profit with respect to quantity and quality, taking into account the output level produced by the other oligopoly firm:

Max $[\pi_i(q_1, q_2, z) = P(q_1, q_2, z)q_i - C(q, z)]$ with respect to q_i and z.

The profit function for firm 1 equals:

$$\pi_1(q_1, q_2, z) = P(q_1, q_2, z)q_1 - C(q, z)$$
$$\pi_1(q_1, q_2, z) = z(\theta - q_1 - q_2)q_1 - \alpha z^2$$

Differentiating firm 1's profit function with respect to q_1 gives firm 1's reaction function:

$$\frac{\partial \pi(q_1, q_2, z)}{\partial q_1} = z(\theta - q_1 - q_2) - zq_1 = 0$$

$$q_1 = \frac{\theta - q_2}{2}$$

And symmetrically for firm 2:

$$q_2 = \frac{\theta - q_1}{2}$$

Substituting for q_2 into firm 1's reaction function and solving for q_1 yields firm 1's equilibrium output level:

$$q_1^* = \frac{\theta}{2} - \frac{1}{2}\left(\frac{\theta - q_1}{2}\right)$$

$$q_1 = \frac{\theta}{2} - \frac{\theta - q_1}{4}$$

$$\frac{3}{4}q_1 = \frac{\theta}{4}$$

(1) $$q_1^* = \frac{\theta}{3}$$

And equivalently for firm 2:

(2) $$q_2^* = \frac{\theta}{3}$$

Hence, the oligopolies choice of quantity q_i is independent of the choice of quality z and equal to $q_1^* = q_2^* = \frac{\theta}{3}$. The oligopolies choice of quantity is a new result found by the authors of this thesis. From equation (1) and (2) it is possible to find the total output level equal to $Q = q_1 + q_2 = \frac{2\theta}{3}$. Inserting $q_1^* = q_2^* = \frac{\theta}{3}$ into the demand function yields the equilibrium price:

$$p = P(q_1, q_2, z) = z(\theta - \frac{\theta}{3} - \frac{\theta}{3})$$

$$p^* = \frac{z\theta}{3}$$

It is possible to solve for the oligopolies' profit maximizing level of quality z* through the following computations applying the Envelope theorem (Sydsæter et

al. 2005). If the quality level z is changed, this will increase the price. Therefore, to find how much the price increases with when increasing the quality with Δz, you need to consider the marginal consumer's willingness to pay:

$$p^m = z(\theta - q_1 - q_2) = z\left(\theta - \frac{2\theta}{3}\right) = \frac{z\theta}{3}$$

Applying the following mathematical calculation rule
$f(x + \Delta) - f(x) \approx f'(x) \cdot \Delta$ (Sydsæter et al. 2005), the increase in income due to a small increase in quality will equal:

$$\Delta\pi = \pi(z + \Delta z) - \pi(z) \approx \pi'(z) \cdot \Delta z$$

$$\Delta\pi \approx \Delta z \cdot \frac{\theta}{3} \cdot \frac{\theta}{3} = \Delta z \cdot \frac{\theta^2}{9}$$

Equivalently, it is possible to find the increase in costs due to a small increase in quality:

$$\Delta C = C(z + \Delta z) - C(z) \approx C'(z) \cdot \Delta z$$

$$\Delta C \approx \Delta z \cdot 2\alpha z$$

In optimum it is such that the increase in income should equal the increase in costs, so that:

$$\pi'(z) \cdot \Delta z = C'(z) \cdot \Delta z$$

(3) $$\Delta z \cdot \frac{\theta^2}{9} = \Delta z \cdot 2\alpha z$$

Solving equation (3) for z yields the oligopolies' profit maximizing choice of quality z*, equal to:

(4) $$z^* = \frac{\theta^2}{18\alpha}$$

Secondly, the oligopolies profit maximizing level of quality will be compared with the social planner's choice of quality z, given the Cournot quantity level $Q = q_1 + q_2 = \frac{2\theta}{3}$. The following welfare analysis, developed by the authors of this thesis, is a new extension to the monopolistic model of quality by Pepall et al.

(2005). The inverse demand function facing the oligopoly firms can be illustrated in the following figure:

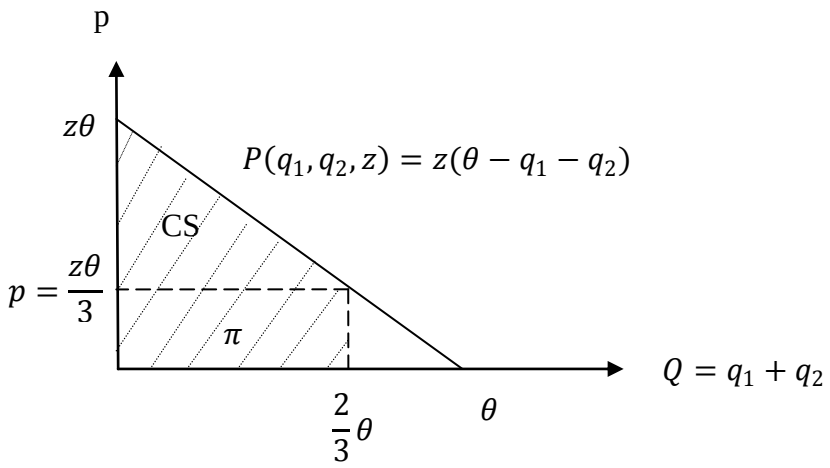

Figure 6: Social surplus in an oligopoly quality model given Cournot quantity (own calculations)

The social surplus given the Cournot quantity level $\frac{2}{3}\theta$ is shown in hatched area in Figure 6, and equals consumer surplus (CS) and producer surplus (π). This social surplus W can mathematically be expressed as:

$$W = CS + \pi = \frac{\theta^2 z}{2} - \left(\frac{1}{3}\theta \cdot \frac{z\theta}{3} \cdot \frac{1}{2}\right)$$

$$W = \frac{\theta^2 z}{2} - \frac{\theta^2 z}{18}$$

$$W = \theta^2 z\left(\frac{1}{2} - \frac{1}{18}\right)$$

$$W = \theta^2 z\left(\frac{4}{9}\right)$$

In order to find the socially optimal quality level, z_S^*, given the Cournot quantity level $\frac{2}{3}\theta$, the social planner maximizes the difference between the social surplus W and the total costs:

$$Max[W - 2C(q, z)] \text{ with respect to } z$$

$$\frac{\partial[W-2C(q,z)]}{\partial z}=\frac{\partial\left[\theta^2 z\left(\frac{4}{9}\right)-2\alpha z^2\right]}{\partial z}=0$$

$$\frac{\partial[W-2C(q,z)]}{\partial z}=\frac{4\theta^2}{9}-4\alpha z=0$$

$$4\alpha z=\frac{4\theta^2}{9}$$

(5) $$z_S^*=\frac{\theta^2}{9\alpha}$$

Hence, the socially optimal quality level z_S^*, given the Cournot quantity level $\frac{2}{3}\theta$, is equal to $\frac{\theta^2}{9\alpha}$.

By comparing the oligopolies profit maximizing choice of quality z^* in equation (4) with the socially optimal quality level z_S^* in equation (5), it is possible to see that the oligopolies choice of quality is lower than what is socially optimal, given the Cournot quantity level:

$$z^*=\frac{\theta^2}{18\alpha}<z_S^*=\frac{\theta^2}{9\alpha}$$

The oligopoly quality model derived by the authors of this thesis hence shows that the oligopolies will choose a too low level of quality to what is socially optimal. This is because the oligopolies will balance the benefits in increased income generated from better quality, *z*, against the increased costs this quality improvement imposes. They are thereby not able to extract the full social value of the increased quality. The social planner is concerned about the average marginal buyer's valuation for quality, whereas the oligopolies are concerned about the "marginal marginal" valuation for quality, where the first marginal refers to the consumer and the second to quality. The reason is that the social planner is concerned with the effect of an increase in quality on all buyers, whereas the oligopolies consider the effect of an increase on the marginal buyer. Hence, the incentive to provide quality is related to the marginal willingness to pay for quality, for the marginal consumer in the case of the oligopolies and for the average consumer in the case of a social planner (Tirole 1988).

With this in regard, it is possible to draw a parallel from oligopolies choice of quality, shown in the model derived by the authors of this thesis, to oligopolies choice of compatibility, derived in the compatibility model. Since achieving compatibility through standardization can be interpreted as a quality improvement for consumers, the oligopoly quality model shows that firms have too low incentives for providing compatibility. The reason is that the firms are not able to extract the full social benefit of increased quality since consumers extract some of this benefit. The result is too low market incentives for providing quality or achieving compatibility. One solution may be to increase the *de jure* standardization. The equilibrium result of the oligopolies' choice of quantity and quality, and the results from the welfare analysis of the oligopoly quality model, are new and interesting findings developed by the authors of this thesis.

3.3.9. Conclusion

To conclude, the mechanism underlying the model by Katz and Shapiro (1985) is the importance of consumers' expectations in markets where network externalities are present. The equilibrium is characterised by rational consumers where their expectations about the network are fulfilled; therefore the equilibrium is fulfilled expectations Cournot equilibrium. The main findings are that network externalities will result in demand-side economies of scale which will depend on consumer expectations. Total output is found to be larger under complete compatibility than under less than complete compatibility. The positive effects from the increased network benefits are found to dominate the negative effects of the increased price, and thus compatibility will increase consumer surplus. Hence, compatibility leads to higher welfare, and if marginal costs of production remain unchanged, compatibility will also increase firms' total profit due to the expectations formations. Finally, it was found that firms' incentives for achieving compatibility might be inadequate compared to the social incentive. This result was supported by the oligopoly quality model, derived by the authors of this thesis, where it was found that oligopolies would provide too low quality to what is socially optimal.

3.4. Benefits and costs of compatibility

By examining the economic consequences of achieving compatibility, the social impacts of a standard can be further analysed. The benefits and costs will be viewed from the consumer, producer and social planner's perspective. The arguments will both be based on the results found in the previously presented models and on additional literature.

3.4.1. Benefits related to compatibility

There are both benefits and costs associated with achieving compatibility. First, the benefits will be discussed with the basis in the previous presented models and supplementary literature. In the model by Katz and Shapiro (1985) a benefit from achieving compatibility is found to be that total output is larger under complete compatibility than under less than complete compatibility. This effect on the market was illustrated in a market equilibrium figure, Figure 4, in the Katz and Shapiro model. Consumer surplus also increases with compatibility as total output increased. In this model compatibility will hence lead to greater welfare, and if it does not involve increasing marginal costs, firms' profits will also increase. The reason for the increase in profits is due to relaxed price competition.

There are further benefits from achieving compatibility. Farrell and Saloner (1986) list three main sources for these benefits. First is the interchangeability of complementary products such as computer software. For hardware/software networks the benefit for consumers occurs as firms supplying software components gain access to a larger market. This may lead to increased number of entrants and greater variety for software components. The second source is the ease of communication. For communication networks, the benefit is attributed to the fact that users can communicate with any other user. The third source is cost savings, since standardization can lead to mass production. This was discussed in section 2.2.1.

Another benefit is the protection consumers' gain in avoiding stranding. Consumers will not fear being stranded when deciding to purchase from a particular supplier if products are compatible (Shapiro 2000:8). Moreover, Katz

and Shapiro (1994) describe the circumstances where two firms are choosing whether to make their competing systems compatible. For hardware/software systems, they state that ultimately the benefits of achieving compatibility are appropriated to lower production costs. With compatible components in different systems there may be increased opportunities of gain through economies of scale, learning effects and technological spillovers in component development and production. For communications networks, in such a case, compatibility may expand the size of each network to the total size of both. This may increase the benefits of gross consumption for a consumer who is initially part of only one of the networks. It also evades the cost of having to hold duplicate equipment to participate in both the networks in order to reach all consumers (Katz and Shapiro 1994:109).

Page and Lopatka (1999) also proclaim the benefit of expanded network size. Consumers of compatible physical networks may obtain direct external benefits from communicating with more users, in addition to cost savings of owning two sets of hardware. Consumers of virtual networks may gain indirect benefits of an increased network, hereunder a larger range of mixable components, in addition to reduced risk of stranding with outdated technology. The benefits of larger scale may be gained by producers (Page and Lopatka 1999:964).

3.4.2. Costs related to compatibility

Conversely, there are also costs related to compatibility. One cost associated with compatibility is increased prices, which was shown in the network externality model related to compatibility from section 3.2 and in the model of compatibility from section 3.3. The price competition will be relaxed under compatibility, as it will be less important for firms to attract consumers in order to become large in the network market. Consumers' purchase choice will therefore be unaffected by the network size of each firm. An economic effect under compatibility is hence that equilibrium prices will become higher. Both the compatibility model by Katz and Shapiro (1985) and the network externality model related to compatibility developed by the authors of this thesis demonstrate that compatibility will lead to higher prices. However, in the network externality model related to compatibility the economic impact for consumers will be negative, whereas the welfare effect

from achieving compatibility in the model by Katz and Shapiro is positive due to the increase in market output and increase in consumer surplus.

In the compatibility model, the move to compatibility increased total output given that marginal cost did not increase. If marginal costs will increase sufficiently relative to the network externalities, complete compatibility will yield a lower total output than under incompatibility. In this case, because of a lower total output, consumers' surplus will then fall as a result of the move to complete compatibility, and the firms' joint incentives for achieving compatibility will be excessive (Katz and Shapiro 1985).

The oligopoly quality model derived by the authors of this thesis also showed that the oligopolies will choose a too low level of quality to what is socially optimal. Since achieving compatibility through standardization can be interpreted as a quality improvement for consumers, the oligopoly quality model shows that firms have too low incentives for providing compatibility. The reason is that the firms are not able to extract the full social benefit of the increased quality, since consumers extract some of this benefit. The result is too low market incentives for providing quality or achieving compatibility.

Another cost related to compatibility is that standardization can lead to "lock-in" to an inferior standard, and the reluctance to switch to a new and perhaps superior standard. A well known example is that the typewriter keyboard standard "QWERTY" which is in use today, is believed to be inferior to the alternative keyboard "DVORAK". The explanation for this persistence for the "QWERTY" standard might be that the benefits from compatibility exceed the costs of switching standards (Farrel and Saloner 1985). This example illustrates that an industry may be "trapped" in an obsolete or inferior standard, even when there might be a superior alternative available. This inefficiency is called excess inertia, i.e. the consumers wait to adopt.

Excess inertia is a cost associated with standardization that is related to the demand side in markets characterised by network externalities. Another cost is excess momentum which means that consumers rush to an inferior technology in fear of getting stranded. Consumers have interdependent utility functions being in

a market characterised by network externalities as mentioned in section 3.1.1. Hence, consumers must anticipate which technology that will be widely used by the other users. Being so, coordination problems in the market may be a result. Assuming that different users have conflicting preferences about which technology to coordinate on, the two potential inefficiencies are excess inertia and excess momentum.

Excess inertia and excess momentum will be further described in the following section. In the following, consider two users (i = 1, 2) who has the choice of either to stick to an old technology or adopting a new one. Assume also that the two technologies are incompatible, which means that the size of the network is firm-specific. *u(q)* denotes a user's utility when holding on to the old technology, whilst the size of the network for the old technology is q (where q = 1 or 2). Similarly, adopting the new technology gives users utility *v(q)* when technology has network size q. Having positive network externalities means that $u(2) > u(1)$ and $v(2) > v(1)$. Also assumed that both users prefer to coordinate their decision, whatever this decision is, such that $u(2) > v(1)$ and $v(2) > u(1)$. The consumer thinks it is better to do what the others do, than to be left alone. The two users will choose simultaneously whether to switch to the new technology, which gives the two pure-strategy equilibria. Equilibria are either when both users stick with the old technology, or when both users adopt the new technology (Tirole 1988:406).

The possibilities for excess inertia and excess momentum can be illustrated as follows. If $v(2) > u(2)$ and yet both users stick to the old technology, this means that the market is inefficient, i.e. excess inertia is present. Coordinating, i.e. through perfect symmetric information, on the new technology would be Pareto superior. However, each user is afraid of moving alone. If $v(2) < u(2)$ and yet both switch to the new technology due to fear of getting stranded with the old technology, this will lead to excess momentum. A means to avoid excess inertia could be one user adopting the new technology, and persuading the others to switch, for instance through setting market standards (Tirole 1988:406).

4. Open standards

It is difficult to categorise standards as "open" or "closed" because there is no common accepted definition of an open standards and because standards may in practice encompass both elements. Further, there are multiple dimensions of openness, which may have different impacts on different economic actors in different contexts. The definition of an open standard may also be confused with the consequences of openness (West 2004:3). With this part of the thesis, the aim is to present definitions of open standards, as well as to discuss the openness of standards related to its different stakeholders, in addition to analysing the economic impacts of open standards. This part can therefore facilitate the analysis of whether OOXML can be considered as an open standard, and thereby provide another foundation for the analysis of the economic impacts of this standard.

Krechmer (2005) gives a motivation for open standards by stating that an open society which utilizes communication systems requires open standards. In particular are government agencies increasingly aware of providing all stakeholders with easy access to electronic documents, which does not require the purchase of a particular software program to view or edit the documents. Open standards may hence be a key enabler for interoperability or compatibility since it facilitates transfer of information available to everyone (Ditch 2007).

4.1. Definition

The European Union's Valoris Report gives the following definition of an open standard: "The minimum requirements for an open standard are that the document format is completely described in publicly accessible documents, that this description may be distributed freely and that the document format may be implemented in programs without restrictions, royalty-fees, and with no legal bindings." (Valoris 2003:20). Another definition of open standards is related to intellectual property rights (IPR). West (2004:7) defines "open" for a standard to mean the rights of the standard that are made available to economic actors other than the sponsor. Both specification and implementation of a standard may have associated intellectual property rights. Owners can expect to profit through

licensing or sale of its products if they are subject to strong legal and technical IPRs. It is the standard sponsors' default ownership of such rights that, according to West (2004), enables the distinction between open and closed standards. Hence, if there are no such rights and knowledge is distributed equally to all economic actors, then all standards would be equal and inherently "open".

4.2. Openness of standards related to stakeholders' perspectives

Standardization consists of both the standard creation process, as well as the implementation of the standard by implementers, and the use of the implementations of the standard by users. Hence, it is necessary to consider open standards from the three stakeholders' perspectives; creators', implementers' and users' perspectives, which will be the purpose of this section. The perspectives of implementers and users of open standards are as essential as the perspective of the creators of open standards (Krechmer 2005:29). Further, the economic motivation for each stakeholder will differ. The creation of standards can be motivated by potential market development and control issues, standard implementation can be motivated by production- and distribution-cost efficiencies, whereas the use of implemented standards can be motivated by the consumer's potential efficiency improvement, appropriated by the standard on the user.

To present a complete view of open standards ten specific requirements by creators, implementers and users, according to Krechmer (2005), will be presented. Some requirements will be common for some of the three stakeholders. Creators', i.e. standardization-setting organisations (SSO), view of open standards is a standard development program which amongst others features balance, open meeting (*Open Meeting*), due process (*Due Process*) and consensus (*Consensus*). In contrast from user's and implementer's view, most SSOs do not advocate making standards irrevocably available on a royalty-free basis, which is the highest level of open IPR.

Implementers' view of open standards is a standard which does not impose any costs for them (*Open IPR* and *Open Documents*), serves the market they wish (*Open World*), one which does not make their prior implementations obsolete

(*Open Interface*), does not exclude further innovation (*Open Change*), and lastly is a standard which does not favour a competitor (*Open Use*). These requirements will ensure implementers the ability to compete on an equal basis.

A user of an implementation of a standard would regard a standard as open if the following four aspects related to the standardization process are met. First, when local legal requirements in all necessary locations are met and operated by the standard (*Open World*, *Open Use* and *Open Documents*), and secondly when new implementations considered necessary by the user are compatible with previous implementations (*Open Interface* and *Open Use*). Further, through the availability of multiple interworking implementations of the standard from different sources (*Open Interface* and *Open Use*), and lastly if the implementation is supported over user desired service life (*Ongoing Support*) (Krechmer 2005). When a user purchase a product, the user typically obtains the right to use the standard incorporated in the product and its complements. Rights such as price and terms of usage may be specified by the implementer. Therefore, the openness of the standard itself, related to the development process and formal specification, is relevant mostly if limited competition at the implementation level might reduce consumer benefit (West 2007:105).

The requirements for open standards when considering creators, implementers and users can be summarized in Table 1:

Requirements	Creator	Implementer	User
Open Meetings	X		
Consensus	X		
Due Process	X		
Open World	X	X	X
Open IPRs	X	X	X
Open Change	X	X	X
Open Documents		X	X
Open Interface		X	X
Open Use		X	X
Ongoing Support			X

Table 1: Requirements for open standards related to stakeholders
(Krechmer 2005:33)

Consequently, it is possible to see that the requirements for open standards of the different stakeholders sometimes are similar and sometimes differ. Following, the ten requirements will be described more thoroughly.

Open Meeting implies that the standardization development process is open for all to participate. However, there has been a significant decline in user participation in standard development as technology has become more complex. Economy is a barrier for open meetings, for example when SSOs require membership before attendance. *Consensus* implies that all interests related to the standardization process are discussed, and that an agreement is found without domination from a single stakeholder group. Commonly, consensus translates into no single stakeholder group holding the majority of an SSO membership. If a decision requires consensus or a supermajority, it might increase the influence of a minority of the participants or reduce a powerful vendor's ability to dominate the process (West 2007). *Due Process* involves asking members to vote secretly on an issue, i.e. balloting, and an appeal process which could be used to find resolutions. Generally, it requires that written views and objections of all participants are promptly considered.

Open World implies having the same standard for the same capability worldwide, and is endorsed by the World Trade Organization (WTO) to avoid technical trade barriers. However, this requirement can be politically controversial regarding both religious beliefs and imbalance in costs between countries who implement standards and countries that do not. Consequently, the coordination of standards through world standards is supported, but not considered a requirement, by most acknowledged SSOs. One example is the five different and incompatible wireless technologies of the third-generation (3G) cellular standards, which initially will operate in different geographical areas. Possibly in time, users will request worldwide compatibility of the 3G standards. The open world-requirement is supported by the three recognized worldwide SSOs; ISO, IEC and ITU, however nations are reluctant to giving up their national standardization rights. Worldwide standards are usually created under consortia standardization.

Open IPR is related to how holders of intellectual property rights (IPR) enclosed in standards make the IPR available. Several recognized SSOs and consortia interpret open IPR to mean that IPRs must be made available for implementation on reasonable and non-discriminatory (RAND) terms by the holders of IPRs. *Open Change* implies that all changes done to existing standards will be presented and agreed upon in a forum which supports the previous mentioned requirements. The ability to control changes to standards is an influential and important tool in controlling interfaces when system updates are distributed over the Internet and stored in computer memory. To ensure that interfaces remain open, it is necessary that all changes are presented, evaluated and approved in a committee which supports the first five mentioned requirements for open standards.

The requirement *Open Documents* implies that committee documents and completed standards are readily available. This requirement is necessary for a stakeholder to be able to have access to any documents from an SSO. Standardization documents consist of work-in-progress documents and complete standard documents. It is important for standard implementers to have access to work-in-progress standard documents, so that specific technical decisions are comprehensible, in addition to access to complete standard documents. Most formal SSO's standard documents are available at a cost. *Open Interface* is a

technical concept related to compatibility standards used between programmable systems (Krechmer 2005:40). Compatibility to previous systems, i.e. backward compatibility, and future systems, i.e. forward compatibility, that share the same interface is supported by the open interface requirement. *Open Use* involves the need for users to be assured about the implementation they use, implying known reliable standardized implementations. Open use covers all parameters needed to be identified related to a standard's accuracy, safety and proper use. The last requirement, *Ongoing Support*, involves the support of standards until the interest from users end, rather than when the interest of implementers decline (Krechmer 2005).

As a contrast to the ideal requirements, according to West (2007), real world standards are rarely fully open or completely closed; rather, they consist of some sort of mix of both elements. Two problems related to the open versus closed terminology may therefore be mentioned. The first problem West indicates is that it seems difficult to agree about a consistent classification across all stakeholders. This argument may be supported by the different stakeholders' requirements for open standards presented above. Further, another problem related to the terminology is that openness is represented by more than one dimension. If different stakeholders were to give these dimensions varied importance in rating, and there is perceptual error in rating each standard along a continuum, then attempts to identify the most open standard may produce divergent ratings across a range of stakeholders (West 2007:92).

4.3. Must open be free?

Another discussion related to the openness of standards is whether open standards must be free. The increasing impact of patents and patent royalties is an important issue related to cost, seeing that royalty-based business models for standards such as MP3 and GSM has had great success (West 2007). The impact of IPRs on a standard is to a great extent determined by the IPR policies applied when creating the standard. IPR policies may constrain sponsors and other agents' ability to profit from incorporating their own IPR in a standard.

A possible approach SSOs may take is to disregard potential patent issues when writing the standard, leaving it for the market to handle when implementing the standard. A more aggressive approach is mandatory disclosure, which requires standardization participants to reveal any possibly related IPR during the specification process. The two royalty approaches most commonly used for patents related to standards are reasonable and non-discriminatory (RAND) terms and royalty free. RAND can be royalty free, however in practice it allows standard sponsors, i.e. patent holders, to create an exclusive club whose members through cross-licensing generally have a superior cost structure to non-members. RAND is considered by some to be the minimum acceptable policy for effective open standardization. The other royalty approach, the royalty-free approach, is preferred by Open Source developers who consider patent royalties not to be open enough (West 2007:106).

4.4. Economics of open standards

A model by Grindley (1995) related to the openness of standards will now be presented in order to study the economic impacts of open standards. As mentioned in the definition of standards in section 2.1, standards may be characterised by a firm's control over the standard. It is a firm's control decision that will determine the market control the firm is likely to have over the standard.

Assume that a firm may decide whether to develop a standard or adopt another firm's standard. Further, assume that the firm which holds the technology a standard is based upon may decide whether to keep the standard proprietary or make it open, through standardization in a standardization-setting organisation (SSO). The firm's standardization decision may therefore be characterised as a twofold decision that covers both the leadership of the standard, i.e. whether the firm develops its own standard or adopts another standard, and the access to the standard, i.e. whether the standard the firm supports is proprietary or open.

The firm's standardization decision thereby will yield four options for a firm. The first option is "Sponsor/Defend", which is related to developing a proprietary standard and restricting its use by competitors by charging significant licence fees.

The option "Give Away" concerns encouraging competitors to use an open standard developed by the firm, without imposing any restrictions. "License in" is an option regarding the adoption of a proprietary standard controlled by another competing firm. Finally, "Clone" is the option to adopt an open standard, without restrictions. These options can be presented in the following matrix:

		ACCESS	
		Proprietary	**Open**
LEADERSHIP	**Lead (develop)**	Sponsor/Defend	"Give Away"
	Follow (adopt)	License in	Clone

Figure 7: The firm's standardization decision
(Grindley 1995:30)

Related to the Office Open XML case, it is the two options related to "Leader/Proprietary" and "Leader/Open" that are interesting to study when considering Microsoft's market dominance in the document software market.

4.4.1. "Leader/Proprietary"

Assume that a firm controls the technology the market standard is based upon and that this is a proprietary standard. Likely positive benefits for a firm which holds the proprietary standard is high market share and high profit. This is because if the firm succeeds in establishing a proprietary standard in the market, it can for example charge licence fees from other firms. Furthermore, in the case of network goods, it has previously been shown that the market tends to converge to a single standard, so the firm will hence enjoy a high market share. The firm may thereby obtain monopoly control of the market and obtain monopoly profit (Grindley 1995:36). A firm that controls a technology that becomes established as a standard can obtain a very profitable market position. Examples are IBM's historical dominance of the mainframe computer industry, Microsoft's dominance in operating systems and Intel microprocessors' dominance in the current personal computer industry (Besen and Farrell 1994:119).

4.4.2. "Leader/Open"

Assume that the market standard is based upon the firm's technology, but now this is an open standard. Potential positive benefit for a leader of open standards is greater likelihood of acceptance, since standardization for example by a SSO will lead to broad support from other agents in the market. The standard is usually easier to establish because of wider support from other manufacturers and users. Another positive benefit for a leader of open standards is an increased market. With open standards, firms may create compatible products and hence increase the total output in the market. The result of larger output in the case of achieved compatibility was shown in the model of compatibility standards by Katz and Shapiro (1985). This will benefit the consumers in the market and be socially beneficial.

Network goods may constitute a network of complementary products, for instance a primary and complementary product. It can be advantageous for a producer to make previously proprietary formats open, if the increase in profit from a proprietary complementary product can offset any profit that would have been made from the primary product, had it not been converted to an open standard. Thus, the motivation for opening previously closed formats may be particularly strong if the product is lagging behind another leader and making few profits. Especially if the producer sees a possibility that if the freely available open standard becomes the dominant market standard, the profitability of the complementary segment will increase (Lerner and Tirole 2005).

4.4.3. Static game model of a standard contest

The firm's standardization decision will depend on the firm's chances of winning a standards war against competing standards. The firm's strategy for leading or following will depend on the relation between its own and other firms' payoffs under the different outcomes. This standard contest will now be analysed in a static game model, where each firm's strategic choices will affect the strategic choices of its competitors. Although a common standard is socially beneficial, the differences in firms' payoffs may give rise to a conflict (Grindley 1995:33).

Assume that two firms have to decide whether to stick to their individual technology or switch to the other firm's technology. The two players are Firm A and Firm B. Both firms can choose between leading, and hence setting the market standard, i.e. "Lead", or adopt the other firm's technology and standard, i.e. "Follow". The payoff each firm receives will depend on what choice the rival firm makes, and can be presented in a two-by-two payoff matrix. In each sell the payoff of each firm is indicated as (Firm A payoff , Firm B payoff).

Assume that compatibility is important to achieve through adoption of the same industry standard, for example that there would be little market demand unless firms agree on a common standard or that a standards battle would decrease a large proportion of potential profits. This can be illustrated in a "battle of the sexes" game. Here, the important outcome is that players agree to consistent strategies, i.e. one firm leads and the other follows, rather than fight. The payoffs for two competing firms, Firm A and Firm B, are listed according to whether they try to lead or follow (all payoffs in millions of dollars):

		Firm B	
		LEAD	FOLLOW
Firm A	LEAD	(3 , 3)	**(6 , 4)**
	FOLLOW	**(4 , 6)**	(0 , 0)

Figure 8: Payoffs in "battle of the sexes" game
(Grindley 1995:33)

If the two firms agree to one firm's standard, the total payoff for the industry is $10m. Then the firm that leads will receive $6m and the firm that follows will receive $4. With a leadership contest, i.e. both firms lead, the total payoff is only $6m due to the standard war which reduces the total payoff. Here, each firm will receive $3m. These payoffs indicate that the firms are better off with one prevailing standard.

A Nash equilibrium occurs where neither firm has an incentive to change its strategy. In a one-shot version of this game, if Firm A leads, Firm B's best response is to follow, where Firm A still prefers to lead. Thus, a Nash equilibrium is Firm A leads, Firm B follows, with payoffs (6 , 4). Another Nash equilibrium is Firm A follows, Firm B leads, with payoffs (4 , 6). Thus, both firms do better by agreeing on a single standard than fighting, but the firm that gets its commitment in first does better than the follower.

An interesting case is when the market would benefit from having a single standard, i.e. one firm leads and the other follows, but the distortions in payoffs in favour of the firm that leads is so great that the follower will prefer to risk a standards war. This is a form of the "prisoners' dilemma" game. Here, all players would do better off agreeing, i.e. one lead and the other follows, but when each firm tries to gain an advantage at the expense of the other, they end up disagreeing to their mutual loss. The payoffs in this game can be illustrated in the following figure:

		Firm B	
		LEAD	FOLLOW
Firm A	LEAD	**(3 , 3)**	(8 , 2)
	FOLLOW	(2 , 8)	(0 , 0)

Figure 9: Payoffs in "prisoners' dilemma" game
(Grindley 1995:34)

Compared to "the battle of the sexes" game, the distribution of the payoffs is now more in favour of the leader. The firm that leads will receive $8m, while the follower only receives $2m. If the firms agree on one standard the total industry payoff will be $10m, as before. If both firms lead, this gives each firm a payoff of $3m, resulting in a total market payoff of $6. These payoffs indicate that the players jointly would do better by agreeing instead of fighting, but the follower's payoff is too low for the firm to forego the chance of winning the standards contest.

If Firm B will choose to follow, Firm A will prefer to lead. However, if Firm A leads, then Firm B also will prefer to lead. This will result in the equilibrium outcome (3 , 3) and a standards war. Hence, total payoff in the market will only be $6m, compared to $10m if they would agree to one standard. The outcome will therefore not be socially optimal.

A possible situation that would result in the "prisoners' dilemma" game rather than the "battle of the sexes" game, might for example be in a network market where the market is "tippy". In such a situation the outcome may be large gains for the winning standard. Thereby the firms may be willing to risk a standard battle which reduces their joint profits. The "tippyness" of network markets was illustrated in Figure 1.

However, Firm A (or Firm B) could ensure an agreement by changing the game, through committing to make side payments of $2m to Firm B (or Firm A) if the firm instead follows. In this case, the modified payoffs would be $6m to Firm A that leads and $4m to Firm B that follows, with the outcome (6 , 4) as in "the battle of the sexes" game. Such side payments could for example take the form of reasonable licensing terms of the technology constituting the leader's standard. In the case when payoff differences are low it is less important whose standard is adopted. With no strong gains to be made by leading, the industry may agree on one standard. In such cases *de facto* standards may be established through market forces (Grindley 1995:34).

Open standards are also a way to alter the outcome of this game. An essential part of the logic behind open standards is that they may counteract the distortions in payoffs in favour of the firm that leads. By modifying the payoffs, the payoff of the leader and follower may be made more equal (Grindley 1995:35).

5. The Case: Office Open XML

This part will present the case of Office Open XML (OOXML). This specific standard will be analysed by applying the economic theory of compatibility standards and open standards presented earlier. First, the background of office document formats will introduce the specific type of software that OOXML concerns. Hereunder, the Extensible Markup Language (XML) standard will be presented since this concern the interoperability, i.e. compatibility, aspect of OOXML. Thereafter, the OOXML standard will be presented and analysed. The analysis will focus on the compatibility and the openness of the OOXML standard. Since the analysis concerns the economic impacts of OOXML, the presentation of the technological aspect of OOXML will be basic. Finally, on the basis of these analyses, conclusions about the economic impacts of OOXML based on economic theory will be presented.

5.1. Background Office Document Formats

Document formats are how a computer stores memos or spreadsheets (Shah and Kesan 2008:2). Word processing programs are used for the creation and formation of documents. Word processing tools work on an abstract internal representation of the document, and a document format is used to save and exchange it with other tools. Further, the advance in document formats is strongly linked to the launch of new versions of the corresponding word processor (Valoris 2003:12).

When a program saves a text document into a file, the complex internal representation of the document must be written down from the computer's main memory to the hard drive. Then the document subsequently can be reconstructed from this file. When stored data only is specified to the program that wrote it, the result is a proprietary document format. Some proprietary document formats have implemented a minimum level of functionalities to ensure that the document can be opened on different computers. However, some may remain incompatible between versions, e.g. different Word versions, and platforms, e.g. Mac and PC (Valoris 2003:12).

Import and export filters are provided by word processors. Such filters allow the transference of documents to other formats, thereby solving the issue of compatibility. Newer versions of the software are often backward compatible. For example is Microsoft Office 2007 backward compatible with previous versions of MS Office. However, as technology progresses more functionalities are offered by word processors. A result may be formatting information loss, and consequently format degradation, when converting documents to an older format. An example is that MS Office 2007 converts formulas into pictures when converting the file to an older format. For end-users this may result in increased complexity, and it is not beneficial for the easy exchange of documents. As a result, it is seen as increasingly important that the document format is standardized by publishing and making its specifications available. With standardizing, saving a file will convert the internal representation of the text document to the standard format (Valoris 2003:13).

5.1.1. The XML standard

Extensible Markup Language (XML) is a standard for describing content data. This content is possible to share across different systems and applications (Baker & McKenzie 2008:1). XML was developed by an XML Working Group, formed with the support of the World Wide Web Consortium (W3C) in 1996. A document format based on XML is described by an XML markup language[2] (Valoris 2003:15).

Firstly, one characteristic of XML is that it emphasises descriptive markup instead of procedural markup. The markup codes or tags that are used in a descriptive markup system only define what the element content is, instead of how it can be processed. In XML, there is a clear distinction between the instructions needed to process a document for a particular purpose, e.g. to format the document, and the descriptive markup occurring within the document. There are two key advantages from this separation of description from processing. First, the same document can be processed differently on multiple channels, and for multiple user profiles.

[2] Markup languages are designed for the processing, definition and presentation of text. This language specifies code for formatting, both the layout and style, within a text file. The code used to specify the formatting is called tags. An example of a widely known and used markup language is HTML (Webopedia 2009).

Secondly, the document can be archived without any hindrance of machine-specific processing instructions.

A second characteristic of XML is its document type concept. This makes it possible to process different documents of the same type in an identical manner. The third key characteristic of XML is that it is independent of hardware or software systems. XML is designed with the aim to ensure that documents can be moved from different hardware and software systems without losing information. Whatever language or writing system XML documents use, they all employ an identical underlying character encoding which is defined by an international standard (Valoris 2003:16).

XML should theoretically be platform-neutral. However, in practice vendors who want to protect the market for their platforms may take extensive actions to encode components such that only their own application suites are capable of processing the elements. A counterbalance is to develop open standards that are cross-industrial and widely adopted so that the inclusion of application or platform specific encoding is blocked. Further, documents that act upon different XML based formats are not necessarily compatible, and to convert documents between the two formats could be difficult (Valoris 2003:17).

5.2. The OOXML standard

Office Open XML (OOXML) is "an open standard for word-processing documents, presentations, and spreadsheets. It can be implemented by multiple applications on multiple platforms" (Ngo 2009:1). The standard's intention is to provide its users with the benefit of an XML standard for their documents. This includes stability, preservation, interoperability, i.e. compatibility, and ongoing development.

There are four forces that contributed to the creation of the OOXML standard, namely; the broad adoption of binary formats, technological progress, demand in the market for several applications, and challenges related to long-term preservation of information. The standardization of the OOXML format and

maintenance of the specification over time may ensure a continuous stability and development of the specification for its users. This thesis will not go in depth of OOXML's technical specifications, but rather focus on the economic implications related to its standardization.

In the following sections, first, a timeline of the standardization process of OOXML will be presented. Secondly, the standard's purpose will be explained. Thereafter, the interoperability, i.e. the compatibility of OOXML will be presented. Subsequently, a conclusion about the economic impacts of OOXML related to compatibility standards will be presented. Thereafter, the openness of the OOXML standard will be discussed. Finally, on the basis of these discussions, a conclusion about the economic impacts of OOXML related to open standards will be presented.

5.2.1. Timeline for the standardization

ISO/IEC DIS 29500 was originally developed as the Office Open XML (OOXML) specification by Microsoft Corporation. The standard received in April 2008 the necessary number of votes for approval as an ISO/IEC International Standard (ISO 2008a). A summary over the important events of the OOXML development and standardization will now be given.

During the period from 1998 until 2000 Microsoft used XML to represent some information in MS Office documents. In March 2001 MS Office XP was released with the ability to save spreadsheets in an XML-based format. With the release of MS Office 2003 in April 2003, this Office-version was able to save documents and spreadsheets in an XML-based format. In November 2005 OOXML was submitted by Microsoft to Ecma for standardization. Ecma International is an industry association which standardizes Information and Communication Technology (ICT) and Consumer Electronics (CE) (Ecma 2009). Since OOXML builds on previous XML-based formats used in MS Office, OOXML includes XML representation for presentation. In November 2006 OOXML was used as the primary storage format when MS Office 2007 was released, in addition to supporting previous proprietary formats.

In December 2006 OOXML was approved as the "Standard ECMA-376 Office Open XML File Formats". Thereafter, OOXML was submitted by Ecma International to ISO/IEC JTC 1 for approval for standardization through a fast-track process. In September 2007 the members of ISO voted against the approval of OOXML. Ecma, as the submitter of the standard, thereafter attempted to improve the identified issues in the ISO members' technical comments. In April 2008 the ISO national standard bodies adjusted their initial votes and approved OOXML as the ISO/IEC standard 29500 (Kosek 2008:57).

The ISO/IEC standard of OOXML is assumed to be fully implemented in Microsoft's next major revision of MS Office. This will be Microsoft Office 2010, which is planned to be released in the first half of 2010 (Microsoft 2009a).

5.2.2. The standard's purpose

The aim of creating Office Open XML was to give a complete representation of the already existing written material of word-processing documents, presentations and spreadsheets that are encoded in binary formats defined by Microsoft Corporation. The standardization process linked the following; means of representing and extending existing materials, providing detailed documentation and enabling interoperability to the previously discussed XML format.

An important feature of the OOXML standard is to enable long-term preservation of information. Information has previously been encoded using binary formats that are profoundly attached to the programs that created that same information. The problem that arises when using binary formats is that, after a longer period of time, the information becomes exceedingly difficult to read without significant loss of content. Therefore a main concern for OOXML is to preserve the financial and intellectual investment made in such documents.

5.3. Compatibility of OOXML

Perfect interoperability across different systems implies that a format can be fully implemented in any application, regardless of the platform or system that this application operates on. However, since it is difficult to offer perfect

interoperability, OOXML's approximate interoperability, as well as its potential for complete interoperability will be considered (Hiser 2007:10). In part 3 of this thesis, the economic effects of compatibility standards were analysed. In this section the interoperability, i.e. the economic term compatibility, of OOXML will be studied. Additionally, since the *Open Interface* requirement of open standards is connected to interoperability, the way that OOXML meets this requirement will also be analysed in this section.

5.3.1. Is it possible to achieve compatibility with OOXML?

According to Ecma (Ngo 2009), one of the Office Open XML standard's properties are amongst others interoperability. It can be argued that interoperability is achieved since OOXML is independent of proprietary formats and features. This gives developers the possibility to write applications that use OOXML on multiple platforms. There are specific features in OOXML which seek to make the standard interoperable and hence distinct from binary formats. First is OOXML's independence from some type of source content. Further, is its independence on the run-time environment[3] of the application that produces a document. Furthermore, is the fact that OOXML match some open World Wide Web Consortium (W3C) standards like XML (Ngo 2009:4).

Further, an advantage of OOXML is its backward compatibility with existing Microsoft Office documents. Achieving compatibility with existing documents stored in Microsoft proprietary binary format was a major design goal of OOXML (Ditch 2007:21).

The degree of openness of the standardization setting process of OOXML, with contributions, modifications and review by committee members, contributed to its interoperability. The representation in the Ecma TC45 committee consisted of vendors, such as Microsoft, Apple, Intel and Toshiba, using different operating systems, like Windows, Linux and MacOS. In addition, corporations with financial interests and agents concerned with preservation were also represented (Ngo 2009).

[3] "A runtime environment provides software services for processes or programs while a computer is running" (Wikipedia 2009)

Conversely, supporters for the ODF document standard, i.e. the other ISO XML standard, claim that there are problems for document interoperability across multiple platforms with OOXML. The first claimed shortcoming is the platform dependencies of OOXML. It is claimed that certain platform dependencies of OOXML are features that can only be implemented or optimized for Microsoft's operating system, Windows. Another claimed shortcoming is the possible application dependencies of OOXML. Examples are that OOXML documents' collaborative functionality and integration with e-mail and other applications may depend upon purchase of additional software from Microsoft. Lastly, the ODF alliance claims that there are some elements of inadequate specification in OOXML. If a format feature is incompletely specified, other vendors' products will not be interoperable with it. The ODF alliance concludes that OOXML is dependent or optimized for Microsoft software applications and platforms. Therefore, they claim that it will not function fully for non-Microsoft software (Hiser 2007:14).

5.3.2. Test of compatibility

Following, results from testing the interoperability among different current software implementations of the OOXML document format by Shah and Kesan (2008) will be presented. Shah and Kesan examine whether an implementation faithfully meet the requirement of the standard. Without multiple interoperable implementations, users may be locked-in to the dominant implementation of the standard. Thereby the users may lose some of the benefits resulting from adopting an open standard (Shah and Kesan 2008:2).

A reference implementation is a fully functional implementation of a standard that you can compare and evaluate other implementations against. The test documents used by Shah and Kesan (2008) were developed in "Microsoft Office 2007 for Windows". However, the implementation "Microsoft Office 2007 for Windows" does not perfectly implement the standard, but is the dominant implementation other developers seek compatibility with. Therefore, it currently acts as a *de facto* reference implementation. As mentioned, Microsoft will not support the ISO/IEC

standard of OOXML until their next major revision of Microsoft Office, which is Microsoft Office 2010 (Microsoft 2009a).

The results for OOXML showed that there were no implementations that offered 100% compatibility, other than Microsoft Office for Windows (2003 or 2007). Microsoft Office 2008 for Mac offered 99% compatibility. Further, the implementations "OpenOffice.org" from Novell with a plug-in translator for OOXML and Apple's word processor "Pages" provided good compatibility with 95-96%. However, "Pages" can only read, not write, OOXML documents. The implementations "Wordperfect" and "ThinkFree Office" offered fair compatibility with several problems. "TextEdit" offered low compatibility with 43% (Shah and Kesan 2008:14).

The results show the difficulty in obtaining 100% interoperability for document formats. The only way to avoid interoperability issues may be to only use the leading implementation of the standard. However, there were good results for OOXML implementations. Criticism of OOXML has been that the standard is too complex and difficult to implement, however the results shows that it offers good compatibility.

5.3.3. Economics of OOXML related to compatibility standards

This section aims to link the economic models presented in part three to the OOXML standard, for thereby providing insight to the economic impacts of the OOXML standard. Therefore, some of the points presented in chapter three will be discussed in light of the OOXML case. First, some of the characteristics of the software market will be presented, and thereafter relevant points from part three will be drawn.

Since the software market is characterised by network externalities, the economic models based on network externalities can be considered as relevant. Figure 1 illustrates how a network market is "tippy" as a direct consequence of the positive-feedback effect. Given the network externalities in the document software market, this may be an explanation for why the Microsoft's Office is a

dominant program/network in the market. In the presence of network externalities it is important to obtain a large network size for the network to be sustainable. Likewise, when the OOXML standard will be fully implemented, it might be possible to assume that the same effect will occur for this standard. It can therefore be argued that the market might tip towards the OOXML standard because of the network effect.

Another characteristic of the software market is the usually high fixed sunk cost combined with more or less insignificant marginal costs. This implies that the average cost function declines sharply with the number of products sold to consumers. Being so, such markets will normally be characterised by dominant leader(s) that serve the majority of the market (Shy 2001). In the compatibility model by Katz and Shapiro (1985) in section 3.3, it was shown that given zero marginal costs, achieving compatibility would increase the total output in the market. The level of total output was found to be greater under industry-wide compatibility than in any equilibrium with less than complete compatibility, according to Figure 4. Hence, consumer surplus will increase with the move to complete compatibility. Then, if the sum of the change in industry-wide profits is positive, the change in social welfare is positive. Achieving compatibility was hence found to be socially beneficial.

From the analysis of the compatibility of OOXML, the results indicate good compatibility. However, these results may be somewhat uncertain since the OOXML standard is not yet fully implemented. Given compatibility of OOXML when it is fully implemented, the economic effects from achieving compatibility in the models presented in section 3.2 and 3.3 will be relevant. If the results from Shah and Kesan (2008) remain valid given full implementation, i.e. OOXML achieves compatibility; the economic models might imply that the price of the products/network that implement the OOXML standard will be higher compared to the situation with incompatibility, i.e. no implementation of the standard. It is not the price of the standard itself that might increase through achieving compatibility, rather the products/network that becomes compatible because of the implementation of the standard.

The network model related to compatibility developed by the authors of this thesis and the compatibility model by Katz and Shapiro (1985) show diverging result for compatibility with respect to the effect on consumer surplus. In the network model related to compatibility in section 3.2, it was shown that consumer surplus decreased with compatibility. Here, the result was that the negative effects of increased price dominate. A limitation of this model is that is does not compare output, both under compatibility or incompatibility, as is done in the Katz and Shapiro (1985) model. In the Katz and Shapiro (1985) model in section 3.3 it was shown that consumer surplus would increase with compatibility, as the total output was larger under complete compatibility than under less than complete compatibility, refer Figure 4. The model concluded that the positive effects from the increased network benefits dominated the negative effects of increased price, thus compatibility will increase consumer surplus.

5.3.4. Conclusion

The above sections discussed the compatibility of OOXML and analysed the economic impacts of OOXML related to compatibility standards. The results from the discussion of the compatibility of OOXML can be related to the model of compatibility standards of Katz and Shapiro (1985). The model confirmed that the consumers benefit from achieving compatibility which was illustrated in Figure 4. Findings support the claim that implementations OOXML offers compatibility. Given this is so; it may be possible to conclude that the OOXML standard may lead to increased welfare for consumers in a network market through achieving compatibility. In the model of network externality related to compatibility the prices were increased, even though the market is characterised by network externalities. Here it was illustrated that having compatible programmes would "cancel out" the network externalities, as a firm have no need to reduce its prices to attract consumers to his network. This was in line with the model by Katz and Shapiro. This might imply that the price of the products that implement the OOXML standard will be higher compared to the situation with incompatibility. However, the two models gave somewhat diverging results when it came to consumer surplus. However, due to the fact that OOXML is not yet fully implemented, it is difficult for certain to conclude on the economic effects of OOXML. The conclusions therefore build on assumptions.

5.4. Openness of OOXML

The degree of openness in document formats will influence the possibility for free flow of information across computer systems. Previously, several criteria for openness of standards related to different stakeholders have been presented, and these will now be used to examine the degree of openness of Office Open XML.

5.4.1. Openness of OOXML related to stakeholders' perspectives

In order to answer the first three requirements, *Open Meeting*, *Consensus* and *Due Process*, the standardization procedures in Ecma and ISO need to be examined.

According to the ODF alliance, the standardization process in Ecma International was not so transparent since the voting, balloting and appeals policies are not published. The ODF group also claims that Microsoft's Office software development group pre-developed the formats and had veto power over changes proposed in the technical committee. Further, it is claimed that there were high barriers to participation in the development of OOXML. The Ecma membership requirements are restrictive in that individuals are not allowed to participate except by invitation or through corporate membership. The ODF group concludes that OOXML is a single-vendor specification that was not developed in a manner that was open to public participation. In addition they claim that Microsoft is the single vendor that has control over the development of OOXML (Hiser 2007:4).

ISO standards are developed by national delegations of experts in a committee, who meet to discuss and debate until a consensus is reached on a draft agreement. Since substantial technical development and debate had already occurred in Ecma, resulting in some international recognition, OOXML was submitted for the fast-track processing. The resulting draft agreement was then circulated as a Draft International Standard (DIS) to all ISO's member bodies for voting and comment. The national member bodies should take into account the opinions of all parties that are interested in the standard under its development. Being voluntary agreements, ISO standards need to be based on consensus of international expert opinion, implying that substantial objections are resolved. However, consensus need not imply unanimity. The voting needs approval of minimum two-thirds of

the ISO national members that participate in the standardization, and not be rejected by more than a quarter of all ISO members who vote on the standard. Appeals related to procedural, technical or administrative issues may be put forward (ISO 2008c).

The *Open World* requirement for open standards is supported by ISO. ISO standards are technical agreements which support the realization of worldwide compatible technology. The OOXML standard is therefore designed with the purpose of being globally relevant (ISO 2008 d).

Further, the requirement *Open IPR* for open standards relates to how the intellectual property rights (IPR) enclosed in standards is made available. According to the ISO/IEC patent policy, licenses are required to be made available on reasonable and non-discriminatory (RAND) terms and conditions. This holds for all patents that are needed in the implementation of an ISO/IEC international standard. Therefore, Microsoft, as the holder of the patents related to the implementation of ISO/IEC 29500, has made such a declaration to ISO and IEC (ISO 2008 e). However, only what is explicitly specified in the standard is protected by the patent-protection pledge in "Microsoft Open Specification Promise". Therefore implicit, referenced and undocumented features and behaviours of the OOXML format may risk violating Microsoft's software intellectual property rights (Hiser 2007:9). Microsoft contradicts this, and claim that their commitment go beyond what ISO/IEC requires (Microsoft 2009b). An extreme option is that, after the publication of the standard, ISO has the possibility to withdraw the International Standard if it is determined that licenses to all required patents are not so available (ISO 2008e).

The openness criteria *Open Change* is ensured since ISO reviews all international standards at least three years after the initial publication, and every five years after the first review by all the ISO member bodies. It is the majority of participating members who decide whether an international standard should be confirmed, revised or withdrawn (ISO 2008c).

Moreover, the requirement *Open Documents* for open standards might be said to be met since the OOXML specification is free to download from the Ecma

International website. Additionally, many ISO members have public review procedures for making proposed work-in-progress documents and drafts available for those that are interested. The ISO international standards are also available for purchase through the ISO web store or through ISO's national members (ISO 2008c). However, the OOXML standard may be difficult to access on a practical level since it is very long and complex with its approximately 6000 pages. Another critique from the ODF alliance is claims that it is inconsistent in its terminology and contains deliberate omissions. There may be areas where OOXML have significant challenges related to its full, open availability. For example, OOXML contain undocumented elements which makes it difficult for other implementers than Microsoft to create effective alternative implementations of the standard. Other elements that are designed into, but undefined by the OOXML specification, may possibly make OOXML single-vendor dependent. This might hinder a full implementation by other applications than Microsoft Office (Hiser 2007:7).

Since the *Open Interface* requirement is connected to the compatibility of OOXML, as analysed in a previous section, this requirement will not be further analysed here, and section 5.3 is referred to.

ISO meet the requirement *Open Use* for consumers since its international standards provide assurance about products' quality, safety and reliability. *Open Use* may also be said to be related to the format's availability for implementation, since a standard needs to be implemented in software before consumers may use it. With this in regard, the critique put forward related to the implementation of *Open Documents* may be repeated. Additionally, *Open Use* may require the possibility for multiple implementations. It is possible to say that an open format encompasses characteristics that may attract multiple implementations. However, MS Office 2007 is currently the only application that has partially implemented OOXML, and there exists currently no application which is a complete reference implementation for ISO/IEC 29500 (Hiser 2007:9). Microsoft on the other hand states that the global adoption, support and momentum for OOXML file formats are growing exponentially (Microsoft 2008).

Lastly, *Ongoing Support* will be ensured through the continuous development of OOXML by ISO.

Based on this analysis of how the openness requirements are met by OOXML, it is possible to see that the openness of OOXML is somewhat controversial, although there are several arguments in favour of OOXML as an open standard. This international standard's supporters claim that OOXML is an open standard, whereas its opponents or sceptics are concerned with the standard's actual openness. Microsoft claims that OOXML is an open standard and that it promotes choice in document formats. Further, Microsoft states that they endorse choice and technological neutrality, and that users should consider both OOXML and ODF (Microsoft 2008).

5.4.2. Economics of OOXML related to open standards

When analysing Microsoft's decision to have OOXML standardized by Ecma International and ISO/IEC, it can be argued that Microsoft has moved away from their previously proprietary formats, towards open formats. Therefore, in the terminology from the economics of open standards, they have moved from taking a leading and proprietary position in the market, i.e. "Sponsor/Defend", towards taking a leading and open access position in the market, i.e. "Give Away", refer Figure 7. The presented advantages for a proprietary standard were that the firm may obtain monopoly control of its market, and therefore can keep its market share and margins high. A large market share is the case for Microsoft Office, with a market share of approximately 95%.

Potential positive benefits for a leader of open standards were greater likelihood of acceptance and larger total market. An open standard is usually easier to establish because of wider support from other manufacturers and users. With open standards, firms may create compatible products, and hence increase the total output in the market. It has in fact been claimed that Microsoft submitted OOXML for open standardization in order to expand market opportunities for Microsoft Office (Creese and O'Kelly 2008:22). Hence, the incentive for Microsoft may have been the increasing pressure for open standardization, together with high chance of winning the XML document format standards "war",

the possibility for a expanding the market, as well as broad external support. Negative consideration may have been low license earnings as Microsoft had to make the "Microsoft Open Specification Promise".

The Katz and Shapiro (1985) model considered the possibility for firms to make side payments to one another, combined with having a product standard as the method for achieving compatibility. Then it was argued that the products of a given set of firms will only be made compatible if all of these firms would earn greater profits as a result. Hence, when the compatibility mechanism is a standard, allowing for cost sharing through side payments will increase the possibility for the firms to choose compatibility. The set of cases in which the firms fail to adopt a standard that is socially beneficial is therefore larger when it is not possible to make side payments. If it is not possible to make side payments it is the change in firms' individual level of profit that will motivate the decision to achieve compatibility. This effect may be related to the RAND terms of OOXML, which might allow Microsoft, as a patent holder, to charge reasonable and non-discriminatory licenses fees. If RAND may be seen as cost sharing this will hence be positive for achieving compatibility.

The benefit of cost sharing was also discussed in the in the "prisoners' dilemma" game in section 4.5.3. In the "prisoners' dilemma" game, an outcome of one standard would yield large payoffs for the leader firm and low payoffs for the follower firm. Here, the players would jointly do better by agreeing instead of fighting. Since the follower's payoff was too low for it to forego the chance of winning the standards contest, the firms would be willing to risk a standard battle which would reduce their joint profits. However, one of the firms could ensure an agreement by changing the game, through committing to make side payments to the firm that follows. This would result in modified and a smaller difference in payoffs. Such side payments could for example take the form of reasonable licensing terms of the technology constituting the leader's standard.

Hereunder, it was also proclaimed that the introduction of open standards is a way to alter the outcome of this game. An essential part of the logic behind open standards is that they may counteract the distortions in payoffs in favour of the firm that leads. By modifying the payoffs, the payoff of the leader and follower

may be made more equal. If it can be argued that OOXML is an open standard, this model can illustrate the economic effect on the document format market. The openness of OOXML might hence modify the payoffs of the firms in the document format market, and might result in more equal payoffs.

Comparing the results from the compatibility analysis of OOXML and the openness analysis of OOXML there might be two opposing forces; compatibility might increase the prices in the network that implements OOXML and openness of the OOXML standard might reduce payoffs, i.e. prices. It is difficult to say which force will dominate. However, Microsoft has announced that with the global release of MS Office 2010, a reduced version of MS Office 2010, "Office Web", will be made available on internet for free. It will be possible to use the "Office Web" applications on several platforms (Rossen 2009).

5.4.3. Conclusion

The above sections presented the openness of OOXML related to stakeholders perspectives and discussed the economic impacts of OOXML related to openness of standards. As was observed from the static game models, open standard can help resolve the outcome in the case when the industry would do better off with a single standard. This might be the situation in the document format market, since software markets are characterised by network externalities which might result in the market tipping to one network. In the "prisoners' dilemma" game the players will be better off agreeing, but since each firm tries to gain an advantage at the expense of the other, they end up disagreeing to their mutual loss. Open standards might modify the payoffs, and hence change the combined leadership and access decisions. It is difficult to conclude on whether this simple game model is transferable to the complexity of the real life case of OOXML. If the conclusion is that the international standard OOXML is a relatively open standard, the economic consequences will be positive since an agreement in the game model will yield a higher total payoff in equilibrium. Whether the openness of OOXML will yield lower prices of the software/network that implements the standard and dominate the opposing force of increased prices through compatibility is difficult to conclude on before the standards full implementation.

6. Conclusion

The main research question of this thesis was "What are the economic impacts of compatibility standards?", with the sub-research question "What are the economic impacts of "ISO/IEC 29500:2008 Information technology – Document description and processing languages - Office Open XML file formats?". Because of these two research questions, the focus of this thesis has been twofold; first the focus was on general standardization theory, and thereafter the theory was applied to the OOXML case.

In order to answer the main research question, the thesis discussed theory related to compatibility standards, and showed the economic impacts of achieving compatibility through the derivation of several models. The markets analysed in the models were characterised by network externalities. A focus has also been on comparing the social and private incentives for achieving compatibility, in order to analyse whether private incentives for achieving compatibility are sufficient.

From the network model related to compatibility, derived by the authors of this thesis, the equilibrium result with incompatibility was that the equilibrium prices would decline. The reason was that consumer demand became more price sensitive. When introducing compatibility, the authors of this thesis showed that the consumers' buying decision was not affected by the network externalities. Therefore, the price competition became more relaxed under complete compatibility. The decrease in consumer surplus indicated that the consumers were worse off under complete compatibility. These results for the network model related to compatibility are new and interesting economic implications to the model by Moen (2008) and the Hotelling model, which were proven by the authors of this thesis.

The same result was found in the compatibility model by Katz and Shapiro (1985); achieving complete compatibility would increase the equilibrium prices. However, when calculating the consumer surplus it was found that the negative effects of increased prices were dominated by the positive effects from network benefits. This was illustrated in Figure 4, which showed that total output was

larger under complete compatibility compared to incomplete compatibility. The thesis concluded that compatibility will lead to higher welfare, and if marginal cost remained unchanged, it would also increase firm's total profits due to the expectations formations. The model illustrated the importance of fulfilled consumer expectations in a market characterised with network externalities.

Further, the compatibility model by Katz and Shapiro (1985) showed that the social and private incentives for achieving compatibility may diverge. The oligopoly quality model, derived by the authors of this thesis, drew a parallel from compatibility to quality. When compatibility was interpreted as a quality improvement for the consumers, the model showed that firms have too low incentives for providing compatibility. In equilibrium, the oligopoly firms provided lower quality than the socially optimal level of quality, given the Cournot level of quantity. This was because the firms were not able to extract the full social benefit of the increased quality. The equilibrium result of the oligopolies' choice of quantity and quality, and the results from the welfare analysis of the oligopoly quality model, are new economical findings derived by the authors of this thesis.

Regarding the sub-research question, the thesis discussed the compatibility and openness of the international standard OOXML, and related this discussion to it's the economic implications. The findings in the thesis suggested that OOXML offers compatibility. Given this is so for the future full implementation of OOXML; it may be possible to conclude that the OOXML standard may lead to increased total output in the market, and hence increased welfare for consumers through achieving compatibility. The economic models of compatibility standards might imply that the prices of the software/network that implement the OOXML standard will increase compared to the situation with incompatibility. Based on the analysis of how the openness requirements are met by OOXML, it was possible to see that the openness of OOXML is somewhat controversial. This international standard's supporters claim that OOXML is an open standard, whereas its sceptics are concerned with the standard's actual openness. If the conclusion is that the international standard OOXML is a relatively open standard, the economic consequences will be positive. Whether such positive consequences of openness will yield lower prices of the software/network that implements the

standard, strong enough to dominate the opposing force of increased prices through compatibility, is difficult to conclude on before the standards full implementation.

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Attachment 1: Preliminary thesis

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Table of Content

1. Introduction

1.1 Brief description of the issues and motivation

This thesis will analyse the social impact of ISO/IEC 29500:2008, Information technology – Document description and processing languages - Office Open XML file formats (OOXML). "ISO/IEC 29500 is a standard for word-processing documents, presentations and spreadsheets that is intended to be implemented by multiple applications on multiple platforms." (ISO 2008). The aim of ISO/IEC 29500 is to ensure long-term preservation of documents using programmes that are becoming non-compatible with new improvements in the domain of information technology. ISO/IEC DIS 29500 was originally developed as the Office Open XML specification (OOXML) by Microsoft Corporation, and received in April 2008 the necessary number of votes for approval as an ISO/IEC International Standard (ISO 2008a). The International Organisation for Standardisation, ISO, is the leading organisation of the formal standards bodies. It is a network of national standards institutes of 157 countries with one member per country (ISO 2008b). Membership is a mixture of national partnerships of industry associations and institutions which are a part of the governmental structure or mandated by the governments of their home countries (Ditch 2007:10-11).

Computer software for reading, creating and editing content can be grouped into two categories; software which enables creation and editing of content and software which display or print content. These two software categories manipulate content which is stored as a file and it is the format of this file which is the centre of our analysis. In the beginning of personal computers there was a great amount of different software packages unable to read formats from other vendors. This made it very difficult for users to exchange documents with each others. When the software market matured in the 1980s interoperability was achieved through market consolidation. A few proprietary file formats came to dominate, amongst them WordPerfect, Lotus 1-2-3 and Microsoft's *.doc, .xls* and *.ppt* file types. These are examples of *de facto* standardisation motivated by a network effect

(Ditch 2007:4). The definition of network effects and standards will be further explained and discussed in the literature review.

An ongoing progress of developing a common document format resulted in the new mark-up language XML which is a standard format that enables the storage and organisation of information. Documents stored in this format and plain text files, rather than binary files, will be readable and processable for a long time. This ensures flexibility and potentially interoperability. There is diminishing acceptance for the use of binary file formats, especially those that require the use of proprietary software. Proprietary, *de facto* standards is increasingly viewed as a type of vendor lock-in, which reduces consumer choice and increases cost (Ditch 2007:5).

Due to the move from binary towards XML-based formats, there has been increased pressure to consider formats through a standardisation process involving formal standards organisations. This encourages software producers, such as Microsoft, to "open" previously closed file formats (Ditch 2007:10-11). In addition to the standard OOXML there is another internationally recognised editing office document file formats, namely ISO/IEC 26300:2006 *Open Document Format for Office Applications* which was approved in May 2006. Sun Microsystems released the Open Document Format standard to the public as a response to Microsoft's proprietary formats. Its standardisation was voted unanimous by participating members of the ISO (Mathew 2008:6). For non-revisable office documents, Adobe's Portable Document Format (PDF) has become a *de facto* standard for display and distribution of such documents. ISO/IEC 29500:2008 *Office Open XML file formats* has caused substantial controversies concerning both the need for two co-existing ISO standards for open XML document formats and the OOXML format's supposed lack of openness.

A press release from The Ministry of Government Administration and Reform in Norway published the 21st of December 2007 stated that The Norwegian Government has decided that all information on state-operated web sites should be accessible in the open document formats HTML, PDF or ODF. This mean that public documents no longer only will be published in closed formats. The information and communication technology (ICT) development in the public

sector will hereafter be based on open standards. For the future, it will not be accepted that government bodies are locking users of public information to closed formats. From the 1st of January 2009 when these new demands will take effect, Norwegian citizens can choose themselves which software to use in order to get access to information from public offices. Another effect the Government intends to achieve with this decision is increased competition between suppliers of office programs (Ministry of Government Administration and Reform 2007).

Another motivation for this thesis, besides the controversies of the OOXML standard and how it will affect the market, is our personal experience with the problem of incompatibility between different software program versions. The inability of Microsoft's Word 2003 to open and edit files created in Word 2007 is a source of inspiration for further analyses of these issues.

1.2 The research question

The thesis will aim to analyse the social impact of "ISO/IEC 29500:2008 Information technology – Document description and processing languages - Office Open XML file formats". The primary focus will be on Norway, where we will attempt to describe the effects on the market, in addition to its associated benefits and costs. We anticipate concluding whether it is sensible for Norway to choose this standard by applying economic reasoning. The choice of other countries may in this respect be relevant for Norway's choices.

1.3 Addressing the research question

The research question stated above will be addressed by using applied microeconomics, where the aim is to utilize relevant economic theories to describe and analyse the case. We will assemble further literature in order to perform in-depth study of acknowledged economic theory and material relevant for the case. In addition, we will examine the research question by using analytical models, market analysis, as well as to execute interviews with key agents involved in the standardisation process in Norway. How we will address

the research question will be further described in the methodological approach section presented later in this paper. We emphasise that this thesis will look upon several sides of the OOXML standard in order to make a more comprehensive analysis that highlight the opposing arguments.

2. Literature review

This master thesis will apply theories of network externalities and compatibility standards, and therefore important aspects of these theories will now be presented as an overview.

2.1 Network externalities

2.1.1 Motivation and definition

Network externalities are interesting phenomenon as it will change both characteristics of the market and the nature of the industry competition. A network will exist when the consumer value of a product enhances as the number of users increases. Each additional consumer will obtain private benefits by joining the network, but also provide external benefits on existing consumers. A definition of a network externality can therefore be "a benefit conferred on users of such a product by another's purchase of the product" (Page and Lopatka 1999: 953) which is not taken into consideration. Since the consumers do not take into consideration the network externalities, a network may never reach an optimal size. Another interesting side of this phenomenon is when incompatible standards compete. This may result in "tipping" of the market often towards the standard that obtains an early advantage, even if the standard is inferior (Page and Lopatka 1999). The above will be further discussed in the following part.

Pepall, Richards and Norman (2005) describe network externalities by using a simplified example of Rohlfs analysis (1974) of the telecommunication service, and thereby show how the value of a product to any one consumer will increase due to the additional consumers that buy the product. Through this example one will observe how there exists interdependence between the portion of the market

being served and consumers' willingness to pay that will lead to network externalities. What is also exemplified is how an individual consumer only will take into account one owns value of joining the network. They will, in other words, not take into consideration the external advantages they create when becoming a member of the network nor the impact when leaving it. Becoming a member will improve the value of the network as it will be enlarged, and in contrast, the value will decrease when one leaves the network (Pepall et al. 2005: 616-617). Due to the fact that a network must be large to become feasible, an observed tendency is the outcome of either one (monopoly) or two suppliers (duopoly). A supplier will therefore have strong incentives of reaching the so-called "critical mass" (Rohlfs 1974), which is the lower fraction that must be obtained in order for the network to become sustainable. If the network has not breached this point, customers will then have an interest to wait to join until others do so.

2.1.2 Distinction between direct and indirect network externalities

Economides (1998) explain how network externalities are more distinct in the telecommunication and the computer service industries, and, as many economists before him, describes how one can distinguish between direct and indirect network externalities. Direct network externalities, often found in a physical two-way communications network (Rohlfs 1974) can be exemplified from the telecommunication industry as a positive relationship between the value of the network for a consumer and the number of subscribers of it. In other words, a positive-feedback effect (Katz and Shapiro 1994). Indirect network externalities can be explained from the computer industry, as the value of a product or a system that depend on the complementarity between the different components. The combination of these goods or services will complete some desired task (Page and Lopatka 1999), and this means that the complementarity leads to consumers shopping for systems rather than individual products (Shy 2001).

2.1.3 Relation between network externalities and compatibility

Oz Shy explains how goods and services that ought to be regarded as complements, must be consumed together with other compatible products in order to gain value. It is important to mention that the benefits of complementarity

must be obtained through standardization and interoperability between the components (Economides 1998: 2). This will be addressed in further detail in the standards section of this preliminary thesis, where it amongst other things states that a standard can be regarded as information good. Being so, complementarity will then play a crucial role in the markets for information goods (Shy 2001). Another central aspect of indirect network externalities is the fact that one user's adoption of a certain system will not have a direct impact on the utility of other users. Instead there will be an indirect, lagged effect through for instance the provision of software programming (Katz and Shapiro 1994).

One can study services being shaped in a network through the mixture of different complementary components composing a chain. Economides provides an argument saying that the value a firm may extract will not only depend on the competition in the particular component market the firm operates in, but also depend on the competition in each of the other markets of complementary components in that chain (Economides 1998). Take for instance the classical example of the software/hardware paradigm. One can then observe (being that the components are bought at different periods of time) that the prices and expectations of use of for instance the software, will affect the choice of buying the hardware (Katz and Shapiro 1994). The consumer must therefore anticipate for the second period both its use of the hardware bought in the first period and the future availability of compatible software, as such a choice may lead to the consumer being "locked-in" to the specific hardware/software system. The switching cost to another system can be substantial and therefore not desirable.

2.1.4 Market implications

It should be noted that the type of switching cost will affect the degree of lock-in, and it will also affect the price competition (Shy 2001). As a consequence of the possibility of being locked-in, demand in the first period will depend on the expectations that are formed about the second period (Katz and Shapiro 1994: 98). Being so, consumers' expectations about the network will influence the competitive equilibrium. Due to the presence of expectations, producers will have an incentive to convince their consumers that their network will attract many users. They will strive to shape consumers' expectations to their benefit and

minimizing any uncertainty. Uncertainty may increase the possibility that the market will not develop at all (Lopatka and Page 1999).

As discussed above, due to the lack of consideration of the social benefits a purchaser pose on others, the network may never reach an optimal size. The existence of network externalities may in fact cause a market to fail as there may not be equilibrium, or that multiple equilibria exist. There is also a possibility that the first fundamental theorem of welfare economics may not be valid (Katz and Shapiro 1994: 94). Oz Shy has explained how these networks never will reach a competitive equilibrium. This is due to the high fixed sunk cost combined with more or less insignificant marginal costs, which in turn imply that the average cost function declines at high speed with the number of products sold to consumers. Being so, such markets will normally be characterized by dominant leader(s) that serve the majority of the market (Shy 2001).

Katz and Shapiro have described how for instance adoption externalities can make the equilibrium network size smaller than the socially optimal network size; hence the perfectly competitive equilibrium will not be efficient. This will also be the case even when the adoption externalities at the individual level are small which may lead to sufficient social welfare losses. This is due to the positive-feedback character of networks (Katz and Shapiro 1994: 96). Another significant challenge is the coordination problem among both firms and consumers. Even though such problems occur in most markets, the coordination requirements by the competition of systems is often more pervasive and open, using devices such as long-term contracts, industry-wide standard setting bodies and common ownership of diverse components suppliers (Katz and Shapiro 1994).

2.1.5 Network effects vs. network externalities

Studying the literature of markets of system, a discussion on whether network effects are in fact network externalities should be in place. It seems that the distinction has been taken more into consideration by some authors than others, who might encompass all network effects in the term network externalities. For instance, Liebowitz and Margolis (1994:135) would only use the term network externality to those specific network effects in which "the equilibrium exhibits gains from trade regarding the network participation". By this definition, network

externalities do cause market failure, however it is less frequent than network effects in general (Page and Lopatka 1999). There are scholars who will disagree with Liebowitz and Margolis' suggestions about the amount of network externalities compared to network effects. Katz and Shapiro have approved and used the distinction between network externalities and network effects, but differ on how common these externalities are. Taking the hardware/software paradigm, one must question whether any deviation between the social optimum and market equilibrium stems from externalities or a consumer coordination failure, or if it is in fact due to monopoly power (Katz and Shapiro 1994). As stated earlier, one will often find monopoly or duopoly in network economies due to the requirement of substantial size, or economies of scale, in order to be feasible.

2.2 Compatibility standards

2.2.1 Motivation

Carl Shapiro (2008) presents the motivation behind standards in the article *Setting Compatibility Standards: Cooperation or Collusion?*. Product standards are a key fundament in the world and they drive an extensive part of the information economy. They are a result of systems where complementary products work together to meet the needs of consumers. The importance of standards is also increasing because of its significant influence for a rapidly growing sector of the economy, namely the information, communication and entertainment sector. Standards are required in information systems in order to store, retrieve and manipulate information (Shapiro 2000).

2.2.2 Definition

Standards can be defined as "commonly accepted agreements for doing or making things" (Ditch 2007:39). Most relevant for the information and communication technologies (ICT) is the standardisation which ensures interoperability or compatibility between different parts of a product or between products as part of a system or network (Ditch 2007:39). One may classify standards into product standards, document standards and compatibility standards. Further, there is a distinction between mandatory standards and voluntary standards. The latter can

be divided into *de facto* standards, which result either from the interaction between "clubs" of agents or through a single agent, and *de jure* standards, specified by standards bodies before adoption in the market. *De facto* standards can either be proprietary or non-proprietary. Since the proprietor of a standard controls the licensing of a standard, proprietary standards are excludable. Non-proprietary standards are non-excludable and can therefore be classified as public goods (Mathew 2008:3). Proprietary standards are intended for use within the organisation or by their customers, whereas d*e facto* standards are successful proprietary standards which have developed through the market over time. Collective standards are created in a process where committees of manufacturers, research organisations, government departments and consumers cooperate in drawing up the standard (Ditch 2007:41). Timothy F. Bresnahan at Stanford University divides standards into two concepts; "proprietary" standards implies that each software brand for word processing stores files differently, whereas an "open" standard implies that any program for word processing will be able to read files from other programs (Bresnahan 2001:3).

Standards can be characterised as being information goods. Thereby they are non-rivalry implying that the distribution of a standard will not decrease its availability. Since standards are not necessarily non-excludable, they cannot automatically be considered as public goods. This is because it may be possible to selectively exclude agents from using and adopting a standard through ownership or licensing terms. If only a limited amount of firms cooperate to set standards, the process of standard setting will be excludable. Influential firms in standard setting can therefore gain competitive advantage because they are able to encode the standard based on their own skills and knowledge. Because of this difference in influence, one must separate between adoption costs, which is the cost related to the implementation of a standard, and sponsoring costs, which is costs related to standard setting activities. Markets for compatibility standards which exhibit network effects can tip to one standard becoming the dominant in a market. Therefore firms will compete to set standards, because whoever controls a standard will also control the market structure for its associated products and services (Mathew 2008:2).

2.2.3 Open standards

There are several elements related to the openness of standards; the process and speed in the creation of a standard, the cost of accessing and using of a standard, and copyright or intellectual property barriers when implementing a standard (Ditch 2007:41). In particular government agencies are increasingly aware of providing all stakeholders with easy access to electronic documents which does not require the purchase of a particular software program to view or edit the documents. Open standards are hence a key enabler for interoperability. The European Union's Valoris Report defines an open standard as: "The minimum requirements for an open standard as that the document format is completely described in publicly accessible documents, that this description may be distributed freely and that the document format may be implemented in programs without restrictions, royalty-fees, and with no legal bindings." (Valoris 2003:20 recited in Ditch 2007:9). The openness of OOXML will therefore be further addressed in the thesis.

Open standards may solve the issue of compatibility and thereby enable everyone to benefit from the network effects. Open standards may also lead to competition *in* a market, as oppose to competition *over* a market. This will be further discussed in the section about benefits and costs of compatibility.

Open standards can have both positive and negative effects on the innovation in a market. Open standards may make it easier for other agents to contribute with smaller improvements of a product (Sand 2008). Standards classified as public goods can promote innovation, as this will enable co-production in the public without hindrance. Under such conditions there will be minimal barriers to entry to service systems (Mathew 2008:6). On the other side, standards may lead to the negative effect of lock-in if an old standard is so widely adopted and well-established that sufficiently high switching costs prevent consumers from adopting a new standard (Mathew 2008:2). The success of a public standard may actually contribute to the delay of technological innovation if there are too substantial switching and coordination costs related to a new version of a standard (Mathew 2008:6). In the case of compatibility standards, network effect may cause coordinating problems in the move to a new standard (Mathew 2008:2).

Open standards can contribute to solving this coordination problem since open standards may make the lock-in problem less present (Sand 2008).

2.2.4 Benefits and costs

It is reasonable to question whether cooperative standard setting will lead to efficient standardisation, increased competition and consumer benefits, or rather suppress competition with negative consequences for consumers and firms which are not a part of the standard setting group. In order to answer this question about the impact of standards, one must analyse the competitive effects of such standards (Shapiro 2000:7).

There are both benefits and costs associated with achieving compatibility. A benefit described by Shapiro (2000) is greater realization of network effects when the size of the network is maximised. For communication networks, the benefit is attributed to the fact that users can communicate with any other user. For hardware/software networks the benefit for consumers is attributed to the fact that firms supplying software components gain access to a larger market. This may lead to increased number of entrants, greater variety and increased price and innovation competition for software components. Another benefit is the protection buyers gain of avoiding stranding. Consumers will not fear being stranded when deciding to purchase from a particular supplier if products are compatible (Shapiro 2000:8).

Moreover, Katz and Shapiro (1994) describe the circumstances where two firms are choosing whether to make their competing systems compatible. For hardware/software systems, they state that ultimately the benefits of achieving compatibility are appropriated to lower production costs. With compatible components in different systems there may be increased opportunities of gain through economics of scale, learning effects and technological spillovers in component development and production. For communications networks, in such a case, compatibility may expand the size of each network to the total size of both. This may increase the benefits of gross consumption for a consumer who is part of only one of the networks. It also evades the cost of having to hold duplicate equipment to participate in both the networks in order to reach all consumers

(Katz and Shapiro 1994:109). Page and Lopatka (1999) also proclaim the benefit of expanded network size. Consumers of compatible physical networks may obtain direct external benefits of communicating with more users, in addition to saving the cost of owning two sets of hardware. Consumers of virtual networks may gain indirect benefits of an increased network, hereunder a larger range of mixable components in addition to reduced risk of stranding with outdated technology. The benefits of larger scale may be gained by producers (Page and Lopatka 1999:964).

Contrary, a cost which may be associated with standardisation and compatibility is constraints on variety and innovation. Requirements in standards impose restrictions on firms' product design choices which may cause static losses from the reduction in variety. These restrictions can also lead to dynamic losses when firms are prohibited from some R&D paths, that could potentially lead to innovations not being in accordance with the standards (Shapiro 2000:8).

Shapiro (2000) also states that compatibility in the presence of network effects can fundamentally affect competition. Compatible programs constitute a single network, whereas incompatible programs will constitute several different networks. Increased adoption of one vendors' compatible program will benefit other vendors' programs due to the larger network size, and hence not result in relative competitive advantage. For incompatible programs however, increased adoption of a program would create competitive advantage by increasing its network size and value, leaving the network size of other programs unchanged. With incompatibility firms will compete for the market, making big investments in attempt of becoming the dominant network. Contrary, under compatibility firms will compete within the market along other dimensions like price, product features and service. Cooperative standard setting will hence decrease the intense front-side competition which characterises standard war, at the same time permitting increased competition later in products' life cycle (Shapiro 2000:9). This reduction in intense competition at early stages when incompatible systems are competing to become the *de facto* standard is also stated by Page and Lopatka (1999:964). Moreover, Katz and Shapiro (1994:111) claim the intensified competition later in the product life-cycle as well.

There are two opposing forces related to standardisation which can affect firms. The first is the drive to standardise in order to gain increasing returns due to the network effects. The second is the drive against standardisation because of the fear of price competition (Mathew 2008:3). Network effects can increase consumers' value of a good. Further, compatibility standards can generate additional services and complementary goods in a market. Through the effect of price competition this may reduce costs to consumers. Standards may also benefit firms by reducing transactions costs. Hence, firms will have incentives to make products and services compatible in order to reduce transaction costs and increasing the size of a market through network effects. However, the potential of price competition is an opposing driver which can make firms reluctant to compatibility (Mathew 2008:1).

3. Methodological approach

The methodological approach of this thesis is applied economics where constructed models facilitate the addressing of practical questions (Dow 2002:97). Deductivism is often the approach applied in microeconomics. Axioms, such as rational behaviour of agents, are initially taken to be true, thereafter deductive logic is applied to derive indifference curves, and then downward-sloping demand curves are constructed. A theoretical proposition is then generated, for example the effect on a market of one good by an increase in price of a complementary good, *ceteris paribus*. According to this deductivist approach, assumptions will lack realism as ideal types are referred instead of only being simplifications (Dow 2002:81).

Some of the economic theory that will be presented in the thesis will take the form of models. We hereunder intend to present a model of network externalities which characterises the market for software. Models are intermediate between theory and data, they reconcile between them and models also have their own autonomy (Dow 2002:96). Models will be used as a tool to relate theory to the OOXML case, and also as a mean for communication core economic ideas.

This thesis will analyse and compare various economic theories, models and arguments which have been presented in the standardisation process of OOXML, as well as economic theory related to compatibility standards as such. Our further literature review will consist of in-depth study of acknowledged economic theory, analytical models, market analysis, historical descriptions and material relevant for the case, as well as interviews of key agents related to the standardisation process in Norway. As follows, we aim to draw reasonable economic conclusions for the Norwegian market. It is important to note that the technical aspects of the OOXML will not be analysed in this thesis. We will rather study the economic implications of this document standard.

4. Potential shortcomings

One potential shortcoming is when applying economic theories on real agents in real markets. There are trade-offs from gaining the precision of idealized abstract theory at the expense of direct applicability for the case in the real market, as well as the gain of a case approach at the expense of generality (Dow 2002:163). What in theory may seem obvious and simple may become more complex when involving the real world. We aim to formulate the scope of the thesis in a comprehensible manner. Theory and applied work in microeconomics are based on simplifying assumptions. However, simplifying assumptions are by definition required in theory in order of not simply being descriptions. Simplifying assumptions might sometimes make economic theory unrealistic (Dow 2002:1).

Another potential shortcoming is the vast amount of information available related to the OOXML case, however mostly non-economically founded. Therefore it might be a problem to select the most reliable sources. There are conflicting concerns in the market due to significant economical and political interests. This may motivate the argumentation of all parties in different directions (Hvistendahl 2003).

An additional potential limitation for the thesis is the difficulty of testing our research question empirically because of its complexity. Therefore the final arguments may be difficult to re-test in other cases.

5. Road map

This road map is a tentative plan for how we aspire to organise the thesis study from January till the final deadline the 1st of September 2009. During the entire semester we aim to work thoroughly and on a regular weekly basis with the thesis.

After handing in the preliminary thesis the 15th of January 2009 we plan to meet with our supervisor in February for comments and further guidance. Points of discussion will revolve around the strength and challenges of this preliminary thesis, as well as guidance for the coming study.

The next step will be working on the oral presentation of the preliminary thesis. With the presentation we aim to enlighten the academic staff and our fellow students at the Economic institute at BI The Norwegian School of Management. In February we will also do an extensive literature assessment, including the background literature presented later.

Continuing, the thesis work in March and April will consist of analysing relevant literature. We will emphasise on in-depth study of acknowledged economic theory, analytical models, historical descriptions and material relevant for the case, market analysis, as well as interviews of key agents involved in the standardisation process in Norway, for example Microsoft, "Standard Norge" and "Konkurransetilsynet". During this period we plan to meet with our supervisor to discuss points of interests and potential challenges.

From the result of the in-depth study we aim to have a rough copy ready for supervision within the end of May. Based on the comments from our supervisor we will make additional changes during the summer months. We will also provide copies for revision by external advisors who hold a different academic background than us. In this manner we aspire to have both academic and linguistic comments in order to attain an interesting and accessible thesis for both economists and non-economic readers.

The final thesis will be submitted during the end of August 2009.

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