Linux and Windows in the Web Hosting Industry

An insight in how the operating system affects costs

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Abstract

Several economic studies have attempted to examine which operating system is more cost-efficient, Linux or Windows. However, most of the studies have been criticised for not being fully independent and non-commercial.

This study looks into how the distribution of costs changes within the web hosting industry as a result of changing the operating system. The typical costs for firms in the web hosting industry are briefly discussed. The data retrieved from a questionnaire filled in by a sample of firms is used to analyse how the migration affects costs. Based on this information, an attempt is made to determine which operating system would optimise allocative efficiency in the specific industry.

The conclusion is that both operating systems have their advantages and disadvantages in terms of costs when used on servers. The major changes in the distribution of costs were in licence and labour costs. The results reveal, perhaps surprisingly, that if the firm is large enough, a mixture of servers with both operating systems may be most effective, instead of relying fully on only one system. Running both operating systems simultaneously allows the firms to offer their customers a wider range of software support. However, it is also concluded that for smaller web hosting firms Linux may be a more viable option from the perspective of allocative efficiency as the start-up costs are much lower since there are no licence fees. At the same time, the variable costs of management stay quite low due to the firm's size.

The results may, to some extent, be applicable to other industries as well. However, the main focus of the investigation was on the web hosting industry.

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And lastly I would like to thank Simon Wallen, my supervisor, for all his constructive comments.

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Contents

1. Introduction

The internet plays an increasingly large role in society. Many seem to take it as granted that they can access all websites they wish to use any time of the day. However, in order to access a website, the user's computer connects to another computer somewhere in the network. For the sake of efficiency, these contactable computers have been centralised to web servers, which are computers that are capable of handling many simultaneous website requests. Consequently, instead of computers communicating directly with each other, they communicate via web servers.

In theory, anyone with a broadband connection and the technical knowledge could set up a web server, a normal computer, at home. However, for websites with many frequent visitors, the speed of the broadband might not be sufficient to serve all the users. In addition, home broadband internet connections are not always reliable, and when either the computer is turned off or it cannot access the internet, no one can access the website it hosts.

Thus, as the internet started expanding, a new branch, the web hosting industry, developed. Today there are several firms that offer web hosting services. These firms hire reliable computers with high-speed internet access. The computers, web servers, normally serve many websites each, and are said to be used for shared web hosting.

For running these servers, or any computer, an operating system, which is a program that controls the hardware and allows the user and various applications to use it, is needed. The most commonly used computer operating system today is Microsoft Windows.[1] However, UNIX-based operating systems, such as Linux, are rapidly gaining new users. According to recent statistics, Linux now seems to be even a more common operating system than Windows for web servers.[2]

Lately, there have been discussions about the costs and benefits related to the choice of the operating system. Users of Microsoft Windows and Linux disagree on the value and objectivity of analyses made, and consider them biased because the studies have been financed or done by supporters of either party. In addition, the studies have been blamed for neglecting one or more of the major factors affected by the choice of the operating system, such as labour costs, licence fees,

1 W3schools: acc. 19/6/2006

2 Netcraft: acc. 19/6/2006

life span and customer satisfaction.

By definition, reaching optimal allocative efficiency requires that no possible reallocation of scarce resources could make either the producer or the consumer better off without making at least the other one worse off.[3] The use of the operating system with lowest costs allows for allocative efficiency to be optimised. As the costs reflect the scarce resources used, lower costs indicate greater allocative efficiency. Hence, by choosing the operating system with the lowest costs, a firm can optimise its allocative efficiency through using the minimum amount of resources. If web hosting firms use the operating system with the best allocative efficiency, more of society's scarce resources are used to produce services that consumers value. At the same time, by reaching optimal efficiency, the firm has allocated more of its resources to factors that benefit consumers. For example, instead of fixing operating system-dependent problems, the employed labour may serve consumers in the firm's customer support. Consequently, the consumers get a broader range and better quality of services. As available resources are limited, the optimisation of allocative efficiency will aid in solving the problem of firms having to meet the infinite wants of consumers.

This essay will investigate how the choice of the operating system affects the distribution of costs for firms in the web hosting industry. By asking "**How does the choice of the operating system of servers affect the distribution of costs for firms in the web hosting industry?**", an attempt is made to derive an at least indicative answer to the question of whether it is Microsoft Windows or Linux that should be used on web hosting servers in order to optimise the firm's allocative efficiency. This question is examined primarily by asking management staff of web hosting firms migrating between the operating systems to fill in an online questionnaire. The results are compared to secondary sources, the ones often criticised for bias.

3 McGee: 225

2. Analysis

2.1. The underlying assumptions and the method

The costs of web hosting firms constitute of both fixed and variable costs. Fixed costs are those that are not responsive to the production level, whereas variable costs grow with higher levels of production, proportionally or not.[4] As the web hosting industry is service-oriented, the labour costs tend to be a major factor of the total costs. Labour costs are in most cases variable costs as more personnel is normally needed when the customer base grows, and thus it becomes significant what the labour force spends time on. The operating system of the servers affects the distribution of time between different tasks that need to be completed by the staff, and hence it can also ultimately change the costs of labour. In addition, some operating systems are free whilst some require a licence fee to be paid. Therefore, a cost of forgoing the best alternative, an opportunity cost, is created.[5] According to the profit maximisation theory, firms seek to minimise costs in order to maximise profits.[6] The profit is the total revenue minus total costs, mathematically defined as cost times quantity sold minus the sum of variable and fixed costs.[7] As pointed out earlier, by lowering the costs through choosing the optimal operating system, the resources are allocated more efficiently between the factors of production, i.e. land, labour, capital and entrepreneurship,[8] and thus the opportunity cost disappears and the allocative efficiency is optimised. Therefore, the choice of the operating system can be of high importance for firms. At the same time it may help in meeting the infinite wants of consumers.

In this study, the cost factors assumed to be affected by the change of the operating system are divided into four main categories.

Firstly, maintenance costs could change due to stability of the software and hardware, ease of administration, availability of support and documentation, time spent on upgrades, and finally, the

4 McGee: 185

5 ibid.: 28

6 ibid.: 214

7 ibid.: 211

8 ibid.: 19

possibilities for customising the system. The stability could differ because the software used in the different operating systems have been programmed in a way that allows them to endure different numbers of concurrent users, and have different degrees of fault-tolerance. Most of the software are different and work differently on the operating systems, and thus, migrating from one to another may change the costs. Therefore, also the ease of administration, time spent on upgrades which are a necessity in server administration, and availability of support may differ since the software used is different.

Furthermore, the possibilities for customising the software so that often-repeated tasks can be almost automated could differ. Linux is open source, which means that anyone can freely use, modify and redistribute the code and thus also make small modifications that might decrease the time needed for administrative tasks. On the other hand, Windows offers several ready-made customisations so the administrators do not necessarily need to spend any time on modifying the software. Therefore, it could be argued that also the availability of support and documentation for the administrative staff would differ.

Secondly, the life span of server hardware should theoretically be different, as the operating system affects the way in which the server operates and the extent to which it can use all the available resources. Also the life span of software could be different, as some software can use the available resources more efficiently than others. The life span affects the costs of maintenance and education of labour, as the use of a server with a shorter life span may result in a need of more frequent re-education of the web hosting firm's staff.

Thirdly, the choice of the operating system may affect the overall customer happiness, resulting in either an increase in the customer base due to an improvement of the firm's reputation, or in a decrease due to unhappy customers. Factors affecting customer happiness could be the ease of use of the various services, the down-time caused by hardware or software failures, the loading speed performance of the servers, and the range of support for various programming languages and software used by both current and prospective customers. Although customer happiness does not directly affect the costs, a low level of customer satisfaction may force a firm to invest more into advertising. This would indirectly increase the costs.

Fourthly, supplementary costs such as software licence fees, costs of training labour, and also costs

of third-party administration tasks could be affected by the choice of the operating system. It was assumed that the costs due to third-party administration tasks would differ significantly between the two operating systems as Linux is open source. Thus, the administrators have a possibility of fixing even more complex problems on their own. Microsoft Windows has not made its operating system's source publicly available, thus increasing the demand for commercial technical support. Also, the costs of training the staff were hypothesised to change when choosing another operating system due to the possible differences in the ease of using the different operating systems.

A message (Appendix 1) was sent to an internet forum named Webhostingtalk.com. The forum's members constitute of people related to the web hosting industry. The internet was chosen as the medium as it was considered to be the most powerful way of reaching the target group. The management staff of firms whose representatives read the message were encouraged to fill in an online questionnaire (Appendix 2).

In the questionnaire, the participants were asked whether the change of their server operating system had affected any of the cost factors described above, and whether the change had been an increase or a decrease. The data from the questionnaire were saved into a database. There were 16 valid responses, 11 of which had switched from Windows to Linux, and 5 which had switched from Linux to Windows. Also, rough percentage estimations of the total increase or decrease of the factors were included in the optional part of the questionnaire. Answers were received by 5 firms that had switched from Windows to Linux, and 4 firms that had switched from Linux to Windows.

2.2. Switching from Windows to Linux

The sample gained of firms that switched from Windows to Linux was big enough to allow for satisfactorily reliable conclusions to be drawn. As illustrated in *Figure 1*, the maintenance costs due to complexity of administration increased in 45% of the surveyed firms. At the same time,

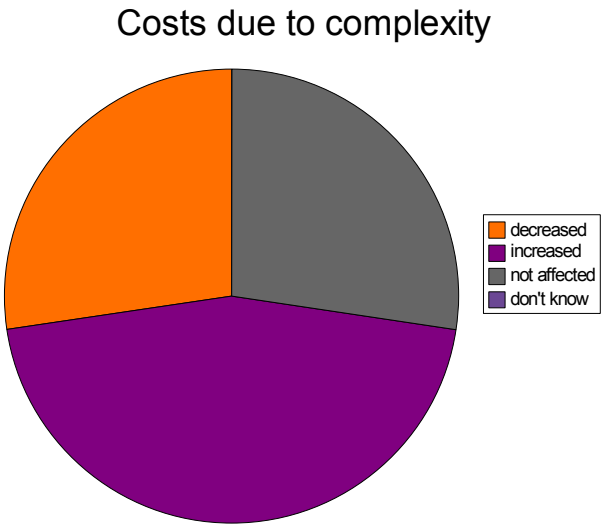

Figure 1. *The figure shows how the change from Windows to Linux affected the maintenance costs due to administration difficulties.*

the maintenance costs caused by frequent upgrading of the software decreased for 45%. In total, half of the firms reported that their maintenance costs increased whilst the other half saw a decrease. At an average, however, the total maintenance costs fell by about 30% as illustrated in *Figure 2*. Thus, in contrast to an earlier report, it is concluded that the maintenance costs do not necessarily grow when switching from Windows to Linux.[9] According to the results of this research, the contradiction is not necessarily caused by a decrease in costs due to stability. Rather, it would be a consequence of controlling upgrades centrally by using advanced scripting. On the other hand, another study reports that Linux administrators spend "15% to 23% longer on patch management", patch management being a significant part of upgrades.[10]

Another major reason for the falling maintenance costs after migrating to Linux seems to be the costs arising from the availability of support and documentation. These costs have, according to three fourths of the surveyed firms, actually decreased. In contrast, 55% of the firms surveyed by Forrester reported that the lack of support was the firms' "primary concern".[11] This difference could partly be explained by the fact that documentation was mentioned in the relevant question of this survey. However, at the same time, it indicates that the web hosting community seems to be able to provide free support for itself, and thus decreasing the need for third-party consultancy. This is supported by the fact that 55% of the firms reported decreased costs as a consequence of a decrease in third-party administration tasks. Furthermore, it indicates that the better web management tools, which were requested in a study sponsored by Microsoft, already seem to be in wide use.[12] As such, the greater maintenance costs of Linux are not considered a main issue anymore by the industry.

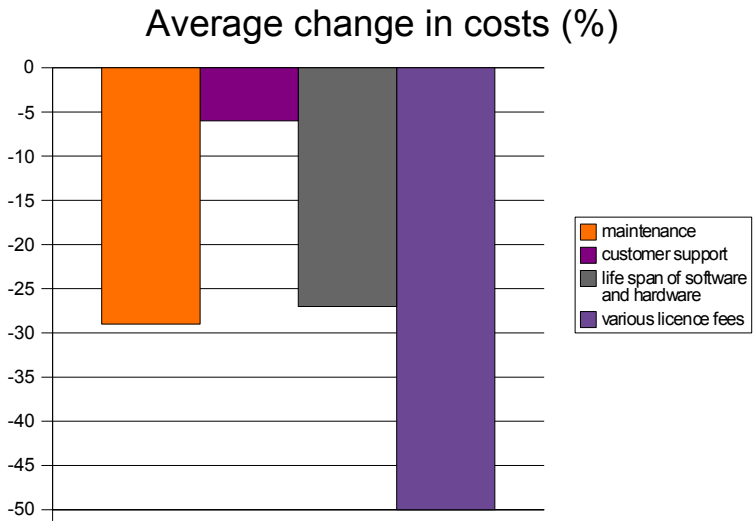

Figure 2. *The figure shows how the costs of maintenance, customer support, life span and licence fees were affected by the change to Linux.*

9 Forrester: 4

10 Yankee Group: 2

11 Forrester: 9

12 Meta Group: 13

Less surprisingly, the switch resulted in a rapid decrease in licence costs for all of the firms, at an average of 50%. This result compares well with the figure from an earlier study which reported a decrease of "at least 60%".[13] The reason for a decrease less than 100% could indicate that firms often run some commercial software on their Linux distributions, such as a non-free Linux distribution or control panel. As can be seen in *Figure 2*, the firms also reported a small decrease of 6% in the customer support costs.

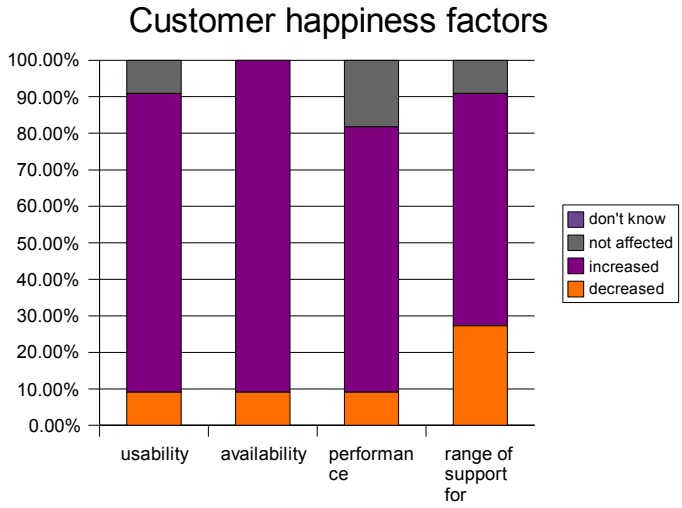

Figure 3. *The figure shows how the customer satisfaction in general increased for the firms that switched to Linux.*

In general, the switch resulted in an increase in customer satisfaction, especially as a consequence of higher availability as illustrated in *Figure 3*. This should theoretically reduce the need for promoting the products and investing in stabler servers, hence decreasing costs. However, some firms reported unhappiness among customers due to lack of diversity in the support for some programming languages or other software. This could be explained by the fact that some programming languages are available only in Windows.

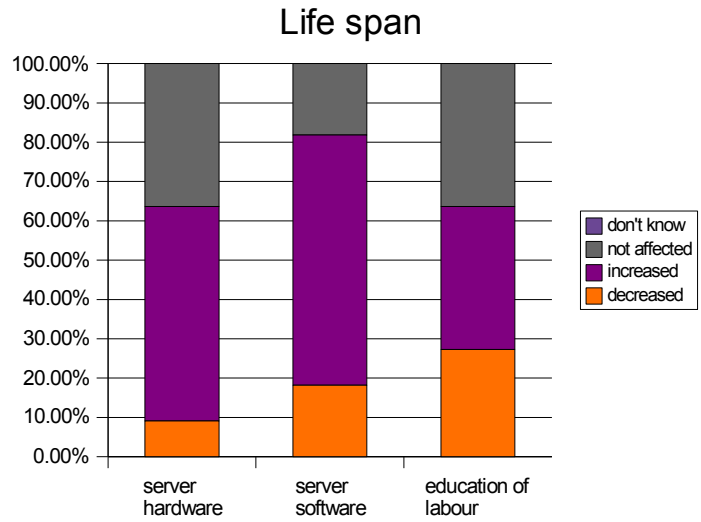

Figure 4. *The figure shows how the life span of hardware, software, and education of the staff in general increased for the firms that switched to Linux.*

The switch has increased the life span of server hardware and software in most of the firms, as illustrated in *Figure 4*. However, the need for re-education of the staff does not seem to have been much affected by the change. Furthermore, as seen in *Figure 2*, the costs due to life span of

13 Forrester: 3

hardware and software seem to have decreased on average by one fourth. As noted in an earlier study, this could indicate that Linux uses the available resources more effectively than Windows,[14] which reduces the need for hardware or software upgrades. However, this decrease may also indicate that the software upgrades are more expensive for Windows servers, partly because the licence has to be renewed.

2.3. Switching from Linux to Windows

Not many reliable conclusions can be drawn from the answers of firms that switched from Linux to Windows as the sample is small. However, indicative conclusions can be retrieved from those questions where clear majorities chose a specific alternative. As illustrated in *Figure 5*, 60% of the firms that switched from Linux to Windows reported that their maintenance costs increased due to the complexity of administration. The explanation could be that it is easier to automatise common tasks in Linux through advanced scripting. Furthermore, even though it is commonly thought that Windows is easier to use because its graphical interface is familiar to most people, it does not automatically mean that it is easier to administrate. For example, by using a commercial web control panel system, one can improve the ease of administration significantly in Linux. Thus, knowledge of the command line, as opposed to the graphical interface where a mouse is generally used, is not anymore a necessity in the web hosting industry if Linux is chosen. If the administrator faces problems requiring knowing how to use the command line, the administrator can, just like in Windows, contact a third-party consultant.

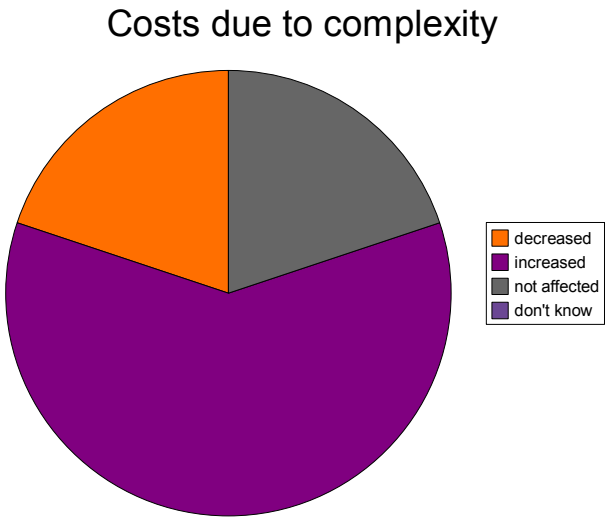

Figure 5. *The figure shows how the change from Linux to Windows affected the maintenance costs due to administration difficulties.*

Additionally, 60% of these firms also reported that their maintenance costs decreased due to

14 EMA: 11

possibilities for customising the software to fit the needs of the customer. A possible explanation for this is that less customisation is needed since Windows gives a high number of ready options. Also, not surprisingly, the licence costs increased for 80% of the surveyed firms, at an average of 10% as can be seen in *Figure 6*. Furthermore, the costs of customer support and maintenance were lower.

Moreover, the costs due to the life span of both software and hardware decreased by an average of 10% according to the surveyed firms. As such, fewer or less expensive investments in new hardware and software were needed after switching to Windows, leading to less costs. Also, the need for re-education of the staff caused by changes in the systems was less in Windows for 60% of the firms. This implies that Windows may be easier to understand and learn. Thus, Windows has an advantage in respect to Linux at least in some parts of the labour costs. In addition, the customer happiness generally increased in 60% of the firms after the switch due to improved usability, availability, performance and support for various programming languages.

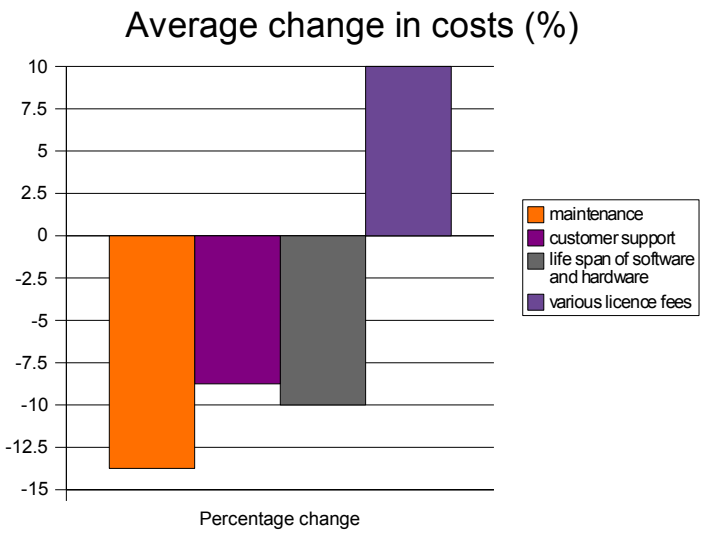

Figure 6. *The figure shows how the costs of maintenance, customer support, life span and licence fees were affected by the change to Windows.*

2.4. Comparison of the migrations

All firms had experienced a change in the maintenance costs due to stability after a switch of the operating system. The opinions were divided almost equally between an increase and a decrease in the costs. There was also an increase in customer happiness due to availability in both categories of migrations. Thus, there seems to be no direct correlation between the choice of operating system and stability of servers within the web hosting industry. Rather, the stability may be affected by other factors such as the experience of the administrators. Therefore, one can conclude that the

conception of Linux and its software being much more stable than Windows and its respective software does not necessarily apply to web hosting servers anymore. Microsoft might have been able to stabilise and eliminate most faults in its server software in the latest versions of its operating system. However, according to an earlier study done by a provider of open source solutions, security problems may continue to be a greater threat to Windows than to Linux mainly because most viruses are designed for Windows. This results, according to the study, in "billions lost by business every year".[15]

Both switches seem to have increased customer happiness and decreased the need for investing in new software and hardware. Additionally, the firms in both groups report that they have experienced a decrease in maintenance and customer support costs. However, the switch to Linux seems to have decreased the maintenance costs over twice as much than the switch to Windows did. Also, as expected, the licence costs are in general much higher in Windows than in Linux, even though web control panels have become increasingly popular in the industry and many enterprise Linux vendors charge money for using their Linux distributions.

15 Cybersource: 8-9

3. Evaluation and conclusion

The theory of allocative efficiency, among other economic theories, assumes that there is perfect knowledge. However, economic knowledge seldom exists in concise or easily-available form. Rather, as in this survey, the data are often incomplete and even contradictory. Even though the presented data allows for drawing some conclusions, no drastic generalisations should be made since the population sample consists only of a reasonably small number of firms, which, in addition, may have been of varying sizes. Also, whilst the investigation is fully non-commercial and independent in contrast to some earlier studies, it is limited by the lack of full authenticity of the results since the participants were allowed anonymity. In addition, the percentages of cost changes are based on the participants' own subjective estimations, and not necessarily on calculations. Moreover, the results do not allow for estimating the extents to which stability and other factors affected the costs. The firms were only asked whether the switch resulted in an increase or a decrease in costs. Furthermore, the sample is not necessarily fully random since it consists only of firms that have been actively reading the internet forum from which they were directed to the questionnaire. However, one strength of the survey is that it got replies from four continents.

Table 1. *The table shows the average changes in costs, inclusive the 95% confidence intervals, for firms that switched from Windows to Linux.*

Windows to Linux	***Average [%]***	***Confidence interval [%]***
maintenance	-29	-108 – 50
customer support	-6	-40 – 28
life span of software and hardware	-27	-74 – 20
licence fees	-50	-124 – 24

Table 2. *The table shows the average changes in costs, inclusive the 95% confidence intervals, for firms that switched from Linux to Windows.*

Linux to Windows	***Average [%]***	***Confidence interval [%]***
maintenance	-14	-136 – 108
customer support	-9	-132 – 115
life span of software and hardware	-10	-159 – 149
licence fees	10	-217 – 237

To evaluate the statistical trustworthiness of the percentage estimations, the confidence intervals which with 0.95 probability contain the true value were calculated (see Appendix 3 for calculations). As can be seen in *Table 1* and *Table 2,* the intervals were considerable. To get more trustworthy results, a greater sample population should have been used.

Due to the lack of perfect knowledge, the data from the survey allows only to make indicative conclusions. The results give an insight in how the distribution of costs in the web hosting firms may change as they migrate from one operating system to another and thus allows the firms to estimate in which areas they should be prepared to invest more if they migrate.

According to the survey, both operating systems have their advantages and disadvantages when used on servers. In general, both variable and fixed costs seem to be affected by the operating system, and, as hypothesised, especially the labour and licence costs were clearly affected. Also, the migrations clearly changed the areas in which firms needed to invest. Even though both groups of firms reported that most of the examined costs decreased, the decrease seems to have been greater when switching to Linux. Firms also reported a decrease in customer happiness due to the support for various software. Thus, in particular for larger web hosting firms, a mixture of servers with both operating systems may be a solution worth consideration. This allows the firms to offer support for most customers as the software used on the servers is not limited by the choice of an operating system. Therefore, they may offer a wider range of services to satisfy the consumers' wants. Hence, the firms will increase the total demand for its products and more consumers will benefit from their services.

However, Linux may still be the better choice for low-budgeted web hosting firms. The start-up costs are much lower due to the lack of licence fees, whilst the variable costs of management stay quite small due to the firm's size and smaller customer base. By utilising only Linux there are less costs and thus fewer resources used, which results in greater allocative efficiency.

The question of whether it really is Linux or Windows that is overall more cost-efficient remains. The results of the survey indicate that there is no simple answer. Rather, the answer depends on what and for whom the firm wants to offer the goods, and on how well the staff is familiar with the different operating systems as the maintenance costs may be significantly affected by possible administration difficulties. Since some services cannot be offered in both operating systems, there is space for both Windows and Linux web hosting firms in the web hosting industry. However, there are unresolved issues that must be answered before it is possible to derive an answer to the question. One such question is the consumer demand for certain types of services from web hosting firms. Without knowing the exact demand for Windows-specific web hosting, for example, it is impossible to determine which operating system one should apply to offer the services. An additional issue is

the optimal size of the web hosting firm for cost-effective running of servers with both operating systems.

In conclusion, the study gives an insight in how the cost distribution of web hosting firms is affected by a migration from Linux to Windows, or vice versa. The results may, to some extent, be applicable to other industries as well. According to the results, the change of the operating system clearly affects the distribution of costs. Most firms report that through changing the operating system, they have successfully minimised their costs, thereby reducing the use of society's scarce resources. Thus, they have succeeded in improving their allocative efficiency and are able to satisfy the consumers' wants to a higher extent. In the end, it all goes back to the basic problem of economics: scarcity. By choosing the optimal operating system or systems in respect of user-friendliness as well as cost-effectiveness, the web hosting firms can attempt to satisfy the infinite wants and desires of people.

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5. Appendices

5.1. Appendix 1

The following message was sent to the www.webhostingtalk.com forum – a forum with a huge community, frequently read by several firms in the web hosting industry.
The message is also available at **http://webhostingtalk.com/showthread.php?t=514913**.

Research Participation Request: Linux and Windows in the Web Hosting Industry

Dear WebHostingTalk members,

In short: I would highly appreciate if any management staff of web hosting companies that have migrated one or more web hosting servers from Linux to Windows or Windows to Linux would fill in this questionnaire: http://tomas.pfister.fi/questionnaire

More details:

I am currently doing a research concerning **the effects of the choice of the operating system for servers on the distribution of costs for firms in the web hosting industry**. In other words, the research investigates how various costs for web hosting firms have changed as companies have changed their operating system from Windows to Linux or Linux to Windows.

I am studying economics in an International Baccalaureate (IB) secondary school in Finland. The research will be completely independent and will not be financed by any third party. The research has been approved by the school's principal and my supervisor *(contact information to be found below)*.

My research is mainly concerned with the benefits and costs of switching servers to Linux from Windows, or vice versa, including, but not limited to, factors such as possible changes in:

a) labour costs: possible changes in time required for maintenance as a result of more/less stable software, complexer/simpler systems, ease/difficulty of administration, more/less documentation, better/worse commercial or free support, and more/less freedom to modify the software according to the needs of the company;

b) licence fees: more/less licence fees required not only for the operating system, but other commercial software necessary to satisfy the customers' diversified software support needs;

c) life span of the servers and software: constant need of expensive, time-consuming upgrades of both hardware and software in order to keep the systems secure and the quality of service high;

d) customer happiness: does the use of a specific operating system enhance the quality of service, including uptime and usability.

I would highly appreciate if any management staff of companies with experience in using both Linux and Windows in the web hosting business would take some time to fill in a questionnaire at **http://tomas.pfister.fi/questionnaire**. I would be very grateful if any changes in costs, and the distribution of costs, related to the use of these two operating systems in companies in this industry could be shared with me. All information will be highly confidential and the participants will stay fully anonymous if not otherwise explicitly requested. The results of the research will made available on the website (link below).

For more secure access, please use this address: **https://tomaspfister.sjr.fi/questionnaire**

Thank you in advance for your input!

Tomas Pfister
tomas@pfister.fi
School: Mattlidens skola, Espoo, Finland
Responsible Supervisor: Simon Wallen, firstname.surname@mattliden.fi
Head of Education Institute: Gun-Maj Roiha, firstname.surname@mattliden.fi, office: +358 9 816 43 050

Espoo, Finland 2006-05-19

5.2. Appendix 2

Below is a copy of the website questionnaire asked to be filled in by web hosting management staff. The document is also available at the original address at **http://tomas.pfister.fi/questionnaire**.

Web Hosting Questionnaire

Note! *This questionnaire is to be filled in only by management staff of web hosting companies that have migrated either from Linux to Windows, or Windows to Linux.*

Please answer every question below until the optional part.
In case you are unable to answer a question, please choose **don't know**.

The *In total*s refer to the total change for the specific collection of questions.
(e.g. the total change of costs of maintenance)

Do you believe that the change of your web hosting server's operating system from

1. ○Windows to Linux
2. ○Linux to Windows

, compared to the previous operating system, *decreased***,** *increased* **or** *not affected* **the**

		decreased	increased	not affected	don't know
***A.* costs of maintenance due to**					
	1. stability of software	○	○	○	○
	2. complexity (i.e. ease of administration)	○	○	○	○
	3. availability of support and documentation	○	○	○	○
	4. possibilities to customise the software to	○	○	○	○

	fit the needs of the firm and the customers				
	5. time spent on upgrades	○	○	○	○
	In total (1-5)	○	○	○	○
***B.* costs of**					
	6. software licences	○	○	○	○
	7. third-party administration tasks (e.g. paying a software firm for fixing problems related to their product)	○	○	○	○
	8. (re)training labour (e.g. for customer support)	○	○	○	○
		decreased	increased	not affected	don't know
***C.* life span of (i.e. the same capital or labour can be used for a longer period of time, with more load, due to the change of the operating system)**					
	9. server hardware	○	○	○	○
	10. server software	○	○	○	○
	11. education of labour (i.e. the necessity of re-educating the technical and customer support staff)	○	○	○	○
	In total (9-11)	○	○	○	○
***D.* customer satisfaction due to**					
	12. usability	○	○	○	○
	13. availability	○	○	○	○
	14. performance (e.g. the speed of services)	○	○	○	○
	15. range of support for various software	○	○	○	○

	(e.g. PHP, ASP, JSP)				
	In total (12-15)	○	○	○	○

Optional part

This optional part involves making **rough percentage estimations of changes in total costs due to the change of the operating system**. If you decide to participate in the optional part, please answer every question.

Otherwise, please just proceed by clicking the Send button.

Please do enter the values with the + / - prefixes.
(e.g. -10, +50 or 0)

The change of the operating system has resulted in a *decrease* or *increase* (in percentage) in costs of

	decrease (-)/increase (+)
16. maintenance	+/- [ ] %
17. customer support	+/- [ ] %
18. life span of software and hardware	+/- [ ] %
19. various licence fees	+/- [ ] %

For **additional comments**, please use the text box below.

Send

5.3. Appendix 3

Confidence interval calculations

By using the *t* distribution and the percentage points of the *t* distribution from a table of values in accordance with Pearson, E. S. and Hartley, H. O. (1966) *Biometrika Tables for Statisticians*, New York: Cambridge University Press, the following formula is derived for 0.95 probability and $n - 1$ degrees of freedom, where n is now 5 (as in the sample that switched from Windows to Linux):

$$P\left(-4.604 \leqslant \frac{\bar{X} - \mu}{\sigma / \sqrt{n}} \leqslant 4.604\right) = 0.95$$

where $\bar{X}$ is the mean, μ is the expectation, σ is the standard deviation and n is the number of samples.

Rearranging the equation:

$$P\left(\bar{X} - \frac{4.604\,\sigma}{\sqrt{n}} \leqslant \mu \leqslant \bar{X} + \frac{4.604\,\sigma}{\sqrt{n}}\right) = 0.95$$

For $n = 4$ as in the sample of firms that switched from Linux to Windows, i.e. 3 degrees of freedom:

$$P\left(\bar{X} - \frac{5.841\,\sigma}{\sqrt{n}} \leqslant \mu \leqslant \bar{X} + \frac{5.841\,\sigma}{\sqrt{n}}\right) = 0.95$$

Table 1. *The table shows the mean, standard deviation and number of samples of the different cost changes for firms that switched from Windows to Linux.*

Windows to Linux	***Mean*** $\bar{X}$ ***[%]***	***Standard deviation*** σ ***[%]***	***Number of samples*** n
maintenance	-29	38.14	5
customer support	-6	16.73	5
life span of software and hardware	-27	22.8	5
licence fees	-50	35.88	5

Table 2. *The table shows the mean, standard deviation and number of samples of the different cost changes for firms that switched from Linux to Windows.*

Linux to Windows	***Mean*** $\bar{X}$ ***[%]***	***Standard deviation*** σ ***[%]***	***Number of samples*** n
maintenance	-14	41.71	4
customer support	-9	42.11	4
life span of software and hardware	-10	50.99	4
licence fees	10	77.89	4

The computed results for the 95% confidence intervals, using the values from the tables above, are found in *Table 1* and *Table 2* (p. 11).

5.4. Appendix 4

Due to the public's interest, the raw data from the survey are given below for further consideration.

ID	*Switched to*	*Question*																		*In total*		
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*1-6*	*9-11*	*12-15*
1	Linux	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	-60	0	-50	-20	1	1	1
2	Linux	0	1	0	0	2	0	0	2	1	2	2	2	1	2	1	-30	-10	-10	-60	0	2	2
3	Linux	1	0	1	1	0	0	0	0	1	1	0	1	1	1	1					1	0	1
4	Linux	0	1	0	0	0	0	1	0	2	1	2	1	1	1	1	-20	-20	-50	-80	0	2	1
5	Linux	1	2	0	1	2	0	2	2	2	0	0	1	1	1	1					2	0	1
6	Linux	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1					0	0	1
7	Linux	1	0	2	1	2	0	0	1	2	1	1	1	1	1	2					1	2	1
8	Linux	0	1	2	2	1	0	1	1	2	2	1	0	0	0	0	30	20	0	-5	1	1	0
9	Linux	1	1	0	2	1	0	0	2	1	1	2	1	1	2	0					1	1	1
10	Linux	0	2	0	0	2	0	0	0	1	1	2	1	1	1	1					0	1	1
11	Linux	0	2	0	0	0	0	2	2	1	1	1	1	1	1	0	-65	-20	-25	-85	0	1	1
12	Windows	1	1	1	0	3	1	3	3	3	3	1	1	1	1	0	-5	0	10	20	1	1	1
13	Windows	0	0	2	0	0	0	0	2	1	1	1	1	1	1	1	-75	-70	-80	-90	0	1	1
14	Windows	0	2	0	2	0	1	0	0	1	2	3	1	1	1	3					0	1	1
15	Windows	0	1	0	0	2	1	1	0	2	2	2	2	2	2	1	10	10	40	10	0	2	2
16	Windows	1	1	2	2	1	1	2	1	1	1	1	0	0	0	1	15	25	-10	100	1	1	0

Codes: *0 = decrease* *2 = not affected* *ID = firm*

1 = increase *3 = don't know*

Comments given by participants:

ID	*Comment*
6	Windows has significantly higher licensing costs.
9	Switching to Linux has given us more power for the dollar over all. We have kept a few Windows servers around due to software availability, but over all our expenses have dropped dramatically to free up our techs and support staff to pursue other projects that had been on hold as well as the monetary savings have allowed us to expand.