



# Comparing Private and Public Sector on Information Systems Development and Maintenance Efficiency

John Krogstie

## ► To cite this version:

John Krogstie. Comparing Private and Public Sector on Information Systems Development and Maintenance Efficiency. 11th International Conference on Electronic Government (EGOV), Sep 2012, Kristiansand, Norway. pp.222-233, 10.1007/978-3-642-33489-4\_19 . hal-01543579

**HAL Id: hal-01543579**

**<https://inria.hal.science/hal-01543579>**

Submitted on 21 Jun 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# Comparing Private and Public Sector on Information Systems Development and Maintenance Efficiency

John Krogstie

IDI, NTNU, Trondheim, Norway  
krogstie@idi.ntnu.no

**Abstract** This paper provides a comparison between public and private organizations on key figures relative to the information systems support activities. Many have claimed that public sector has a less satisfactory conduct of information system support than private sector. In this article we present selected data from survey investigations performed among Norwegian organizations on how they conduct information systems development and maintenance. This investigation has earlier been compared with similar investigations of this sort. A major finding from the previous comparisons is that even if we witness large changes in the underlying implementation technology and approaches used, a number of aspects such as the overall percentage of time used for maintaining and evolving systems in production compared to time used for development is remarkably stable. When we compare public and private organizations in the last survey, we find a small difference on some variables, but these are not statistically significant, thus cannot be used to conclude that IT development and evolutions is conducted more poorly in public sector than in private sector.

**Keywords:** e-government, information systems development and maintenance, public vs. private sector

## 1 Introduction

According to Heeks [13] “Most eGovernment systems fail. They are either total failures, in which the system is never implemented or is implemented, but immediately abandoned; or they are partial failures, in which major goals for the system are not attained and/or there are significant undesirable outcomes”. Also many other authors report on what appears to be more problems in the public than the private sector IT-development. In [24] it is reported that “Public projects had an average effort overrun of 67%, as opposed to the 21% average in private projects. This observed difference appears to be caused by systematic differences between private and public organizations found at 1) the political level, 2) the organizational level, and 3) and the individual level”. A number of reports indicate that this is a challenge experienced internationally [8] in OECD countries, USA and in the UK [30]. A reason these failures get so well-known though, is actually because they are public, thus information about success and failure is also public information, something which is not the case in the private sector. Failure is happening both in public and private sector, and usually, the

failures are only partial; most systems get delivered and are used in some way. Since most work on IT is not on developing new systems, but on maintenance, operation and user-support [6], an alternative way to compare IT efficiency than only looking at the development efficiency, is looking upon how work is distributed in the IT-organization, and the amount being done on value-adding work. Application systems are valuable when they provide information in a manner that enables people to meet their objectives more effectively [2]. An application system is part of an encompassing organizational system, which in turn is part of a broader business environment. This environment of change that an organization must address implies that the supporting information systems also must be easily adaptable. As stated already in [3], it is one of the essential difficulties with application systems that they are under a constant pressure of change. Given the intrinsic evolutionary nature of the sources of system needs as described above, it should come as no surprise that specifications and the related information system must evolve as well [2,26].

The goal of both development activities and maintenance activities is to keep the overall information system support of the organization relevant to the organization, meaning that it supports the fulfillment of organizational goals. A lot of the activities usually labeled 'maintenance', are in this light value-adding activities, enabling the users of the systems to do new task. On the other hand, a large proportion of the 'new' systems being developed are so-called replacement systems, mostly replacing the existing systems without adding much to what end-users can do with the overall application systems portfolio of the organization. Based on this argumentation we have earlier developed the concept application portfolio upkeep as a high-level measure to evaluate important aspects of to what extent an organization is able to evolve their application system portfolio efficiently. How application portfolio upkeep is different from maintenance is described further below.

In this paper, we present results from a survey-investigation performed in Norwegian organizations in this area during the end of 2008. We have earlier compared the overall results with similar investigations done in 2003, 1998 and 1993 [6, 7], finding a stable overall pattern of distribution of work from the last three investigations. We will in this paper look more closely at the results from the last investigation, comparing figures from public and private organizations. Norway has quite a number of companies which are defined as private, but yet having substantial public ownership, the state being a major shareholder. Also, a lot of previous public organizations have recently been transformed to private companies or state owned limited companies or other kinds of organizations with varying degrees of freedom being run more according to private business principles than what was usual some decades ago. On the other hand we find certain important traits among public organizations e.g. that they all have to abide to the same non-optimal rule of procurement and development of IT-solutions when external companies are involved in developing the requirements to a system, they are not allowed to be involved in the implementation of the system [9] making such a dichotomy between private and public companies meaningful. Thus our core research question is: *Is information systems development support conducted in a less optimal way in the public sector, compared to the private sector in Norway.*

We will first give definitions of some of the main terms used within information systems evolution. We describe the research method, including a number of more detailed hypotheses spawned from the field detailing the above research question, before the main results from our investigation are presented. Then a closer investigation on the differences between private and public sector respondents are presented. The last section summarizes our results and presents ideas for further work.

## 2 Definition of Core Concepts

Maintenance has traditionally been divided into three types: corrective, adaptive and perfective [15] inspired by, e.g. Swanson [35]. Maintenance is defined as the process of modifying a software system after delivery to production.

1. Corrective maintenance is performed to correct faults in hardware and software.
2. Adaptive maintenance is performed to make the computer program usable in a changed environment
3. Perfective maintenance is performed to improve the performance, maintainability, or other attributes of a computer program. Perfective maintenance has been divided into enhancive maintenance [4] and non-functional perfective maintenance. Enhancive maintenance implies changes and additions to the functionality offered to the users by the system which is also included as part of perfective maintenance [28]. Non-functional perfective maintenance implies improvements to the quality and other features being important for the developer and maintainer of the system, such as modifiability. Non-functional perfective maintenance thus includes what is often termed preventive maintenance, but also such things as improving the performance and security of the system.

In addition to the temporal distinction between development and maintenance, we have introduced the concepts application portfolio evolution and application portfolio upkeep.

1. Application portfolio evolution: Development or maintenance where changes in the application increase the functionality provided by the total application systems portfolio of the organization. This includes:
  - Development of new systems that support new areas
  - Enhancive maintenance
2. Application portfolio upkeep: Work made to keep up the functionality provided by the information system portfolio of the organization. This includes:
  - Corrective maintenance
  - Adaptive maintenance
  - Non-functional perfective maintenance
  - Development of replacement systems.

Some writers provide more detailed overview of maintenance tasks [5, 16]. Jones [16] has in total 21 categories, also including user-support as part of maintenance; an area looked upon as belonging to 'additional work' in most other investigations.

### 3 Research Method

The investigation was a continuation of a longitudinal study on information systems development and maintenance in Norwegian organizations. The original reason for doing a survey investigation was to get a better overview of the general problems that organizations seemed to face on providing information systems support. Since the situation in individual organizations differs very much from year to year, a survey method was preferred instead of a case study method to get an aggregated view. Such investigations had at that time not been done in Norway, and it was a natural choice to do a survey similar to what had been done in other countries like USA [18, 29, 36].

Our survey form was implemented in the SurveyMonkey web-tool and invitations were distributed by e-mail to 300 Norwegian organizations. The organizations were randomly selected from the list of member organizations of The Norwegian Computer Society – NCS. (NCS has currently around 1000 member organizations).

Some of the selected respondents had marked that they did not want to receive request from SurveyMonkey or had changed their e-mail address. Thus only 278 of the invitations were delivered to the selected organizations (although we do not know if they were submitted further to the appropriate recipient within the organization).

The survey form contained 48 questions including demographic data. The contents of the form were based on previous investigations within this area; especially those described in [14, 19, 22, 27, 29, 36].

According to Galtung [9], the minimum sample size that is meaningful in a survey is 40 units. Earlier survey-investigations in the area of development of application systems toward a comparable population had given a response rate of about 22% [14,19,22] and the response rate of similar surveys has been around 20-25% (e.g., [27,29]). Thus an answer ratio of approximately 20% was expected also in this investigation. 79 responses were returned, giving a response rate of 28%. Out of these, 67 responses could be used for the analysis since the additional 12 responses were incomplete. 20 of these 67 responses were from organizations in the public sector.

The forms were filled in by people with long experience with IT-related work (average 17.5 years), most being the IT director in the organization. Of the respondents, 57 out of 67 (85%) indicated that IT was of extremely (5) to large (4) strategic importance for the organization (on a Likert scale from 5 to 1). This indicates that application systems support including own development and maintenance is an area of importance for the majority of respondents.

#### 3.1 Previous Investigations

We have earlier compared some of the results of the last investigation with the results of similar investigations [6, 7, 23]. A number of later investigations on the distributions of work have been done, but they typically focus on the distribution of maintenance tasks only [12, 25, 33], many only looking on the situation in one organization.

The data was exported from SurveyMonkey as Excel-files, and these were imported into SPSS. Statistical significance of some of the results is determined using the two-tailed Student t-test for normally distributed data and the Mann-Whitney non-

parametric test when the data to be compared were not normally distributed. To decide what type of test to perform the variables used in the comparisons were tested for normality. Where either the Shapiro-Wilks (S-W Sign) and/or the Kolmogorov-Smirnov (Lilliefors-Sign) significance levels were less than 0.05, we used the non-parametric Mann-Whitney test. Statistically significant results are highlighted in the result section using boldface font using a significance level of 0.05.

### 3.2 Potential Threats to Validity

The results of our study should be interpreted cautiously as there are several potential threats to validity. This discussion is based on recommendations given in [17, 18].

**Population.** The sample of our study was initially intended to represent the population of Norwegian organizations with own development and maintenance work. Since a substantial number of the major Norwegian organizations of this type are members of NCS we chose the around 1000 member companies of NCS as our population. This includes in addition to all large organizations in Norway, also organizations within the IT-industry. We emphasized that it was the organizations own IT-activity we were asking about. Some of the responses that we had to dismiss were from IT-companies not having substantial own IT-activities. As described above, we distributed our survey forms to a random selection of 300 NCS member-companies. Other studies also use member lists as a source of subjects, e.g. [28]. In particular, the same source of subjects was used in the Norwegian studies in 2003, 1998 and 1993.

**Respondents** Most of the persons who responded were IT managers. They may have different views of the reality than developers, maintainers and users. For example, [17, 33] found that manager estimates of the proportion of effort spent on corrective maintenance were too high. Since the respondents from both public and private sector were IT managers, we would not expect this to influence the comparisons.

**Response Rate and Number of Respondents.** The response rate of 28% can be argued to be low, although it is higher than in the previous investigations. According to [32], it is common for Internet and e-mail surveys with a response rate of 11 % or lower. Still, a problem with a low response rate is that the respondents may not be representative of the population.

**Quality of Data** On some of the questions, we were particularly interested in the quality of the answers, recognizing that some of the information called for might not be easily obtainable. Answers to the quantitative questions were checked relative to each other for control, and where there were discrepancies the respondents were contacted. The remarks made on the questions gave more insight into the answers. We qualified for instance all data regarding distribution of work both in our study and in the earlier studies without finding significant differences on the variables we have

used in the hypothesis testing between those reporting having good data and those coming with qualified guesses.

**Interpretation of Terms.** Achieving consistent answers requires that the respondents have a common understanding of the terms used in the survey form. This may be difficult to achieve in practice. For example, Jørgensen [17] found that the respondents used their own definition of, for example, “software maintenance”. We conducted a pilot study followed by interviews in a few companies to detect unclear questions. We also got comments from several colleagues including experts in cognitive psychology concerning clarity of questions. In particular the cognitive psychologist was helpful relative to pointing out badly or ambiguously formed questions. For many questions, there was space available to issue comments. This possibility together with the possibility to crosscheck numbers between different questions was the mechanisms used to identify possible misunderstandings among the respondents for follow-up. We also built upon earlier surveys that had undergone similar pilot and full use.

### 3.3 Hypothesis

To detail the main research question presented in the first section the following hypotheses were formulated to investigate the development of the different measures for distribution of work between private and public sector. Since we are looking for differences (and would expect to find something in disfavor of public sector based on earlier reports), we have formulated the hypothesis as if private and public sector are equal (to potentially refute this).

*H1: There is no difference between the breakdown of maintenance work (in corrective, adaptive, enhancive and perfective maintenance) in public and private organizations.* Rationale: Whereas perfective (in particular enhancive maintenance) provides more value than other types of maintenance, it is interesting to look into this breakdown. Investigations reporting on the distribution of time among maintenance tasks [1, 11] report very different numbers. On the other hand these investigations vary greatly. Whereas some look on single systems of numerous organizations and the whole portfolio of numerous organizations, other look only at one or a few (important) applications in one organization. Since this distribution naturally will differ according to where the system is in the lifecycle (development, evolution, servicing, phase-out, closed [31]), this difference between the maintenance work on individual systems should be expected. When averaging across a large number of application portfolios on the other hand, we have found a more stable distribution.

*H2: There is no difference between the percentage of time used for development in private and public sector* Rationale: When comparing the percentage of time used for development activities in organizations earlier, we have found this to be decreasing, but not so much between the three last investigations. Thus is interesting to see if this is equal also between private and public sector.

*H3: There is no difference between the percentage of time used for maintenance in private and public sector* Rationale: When comparing the percentage of time used for maintenance activities in organizations earlier, we have found this to be stable on

around 40 percent of the overall time in investigations both in the seventies, eighties, and nineties in both USA and Norway. It is interesting to see if this is different between private and public sector.

*H4: There is no difference between the distribution of work among maintenance and development between private and public sector when disregarding other work than development and maintenance.* Rationale: Since the amount of other work than development and maintenance is taking up more time now than 10-15 years ago, we found it beneficial also in the surveys in 1993, 1998, and 2003 to look at the proportion between development and maintenance time only. The proportion of time used for maintenance has earlier shown to be stable on around 60% (i.e., 40% for development) in all investigations, across countries. When a larger percentage of maintenance is claimed, this often includes, e.g. user support [16].

*H5: There is no difference between the distribution of application portfolio upkeep in private and public sector.* Rationale: These numbers were on the same level in 2008 and 2003 as in 1998, and it interesting to see if it would be equal also across private and public sector. A high percentage on application portfolio upkeep would in particular signal poor IT support practice cf. the discussion in the introduction.

## 4 Results

42% of the organizations had a yearly data processing budget above 10 mill Nkr (approx. 1.5 mill USD), and the average number of employees among the responding organizations was 1115 (1333 in private, 604 in public). Around a third of the IT-activity was outsourced (32.9% in private, 24.1 in public). Whereas only two of the respondents reported to have outsourced all the IT-activities, as many as 84% of the organizations had outsourced parts of their IT-activity. Whereas the public organizations have outsourced more of the development (40% in public, 29% in private) and maintenance (34% in public, 30% in private) work than the private organizations, they have outsourced less of the operations (31% in public, 41% in private) and user support (21% in public, 29% in private). 94 new systems were currently being developed; 60 of these systems (64 %) were regarded as replacement systems. The average age of systems to be replaced was 7 years (6.35 years private, 8.76 years public).

Work on application systems was in the survey divided into the six categories presented in section 2. We also asked for the time used for user-support and for systems operations which took up the additional time for the work in the IS departments. Basic management activities are kept out.

In earlier investigation of this sort between 50% and 60% of the effort is done to enhance systems in operation (maintenance) when disregarding other work than development and maintenance [6]. An exception from this was our study in 1998 that was influenced particularly by the amount of Y2K-oriented maintenance. Table 1 summarizes the descriptive results on the distribution of work in the categories in our investigation, comparing to our previous investigations.

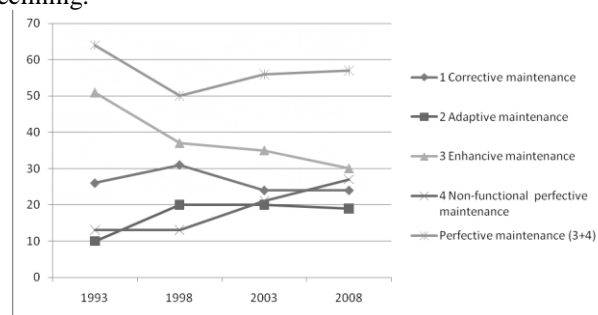


**Table 1.** Distribution of the work done by IS-departments in percentage

Category	2008	2003	1998	1993
Corrective	8.2	8.8	12.7	10.4
Adaptive	6.2	7.3	8.2	4
Enhancive	11.3	12.9	15.2	20.4
Non-functional perfective	9.1	7.6	5.4	5.2
<b>Total maintenance</b>	<b>34.9</b>	<b>36.7</b>	<b>41.4</b>	<b>40</b>
Replacement	9.7	9.9	7.7	11.2
New development	11.4	12.6	9.5	18.4
<b>Total development</b>	<b>21.1</b>	<b>22.5</b>	<b>17.1</b>	<b>29.6</b>
Technical operation	23.7	23.8	23	NA
User support	20.1	17.1	18.6	NA
<b>Total other</b>	<b>44.0</b>	<b>40.8</b>	<b>41.6</b>	<b>30.4</b>

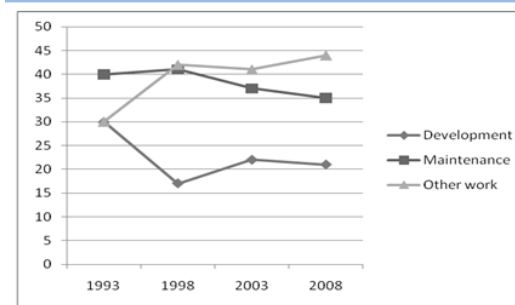
34.9% of the total work among the responding organizations is maintenance activities, and 21.1% is development activities. When disregarding other work than development and maintenance of application systems, the percentages are as follows: maintenance activities: 65.7%, development activities: 34.3%. This is at the same level as in 2003. 63% of development and maintenance work was application portfolio upkeep, and 37% was application portfolio evolution. This is almost the same as in 2003 and 1998, which in turn was significantly different from the situation in 1993 where application portfolio upkeep- and application portfolio evolution respectively amounted to 44% and 56% of the work.

Fig. 1 summarizes the results from our investigations where we look upon the complete portfolio of the responding organizations. Most interesting for comparison with other surveys is looking at corrective, adaptive, and perfective maintenance, which appears to be much more stable than the numbers reported from others above. We do note though that the enhancive maintenance part of perfective maintenance appears to be declining.

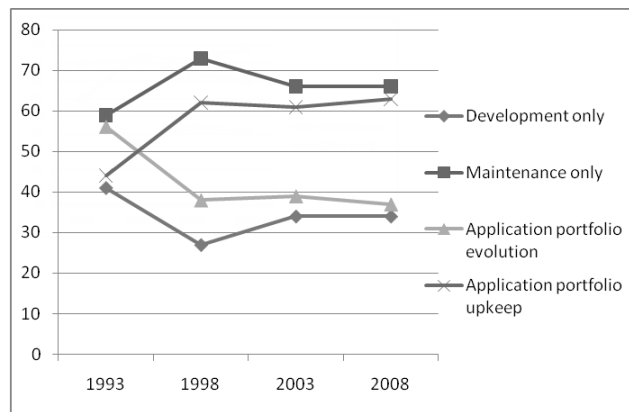


**Fig. 1.** Comparisons of distribution on maintenance tasks, percentage

Further comparisons of descriptive results between different studies are presented in Fig. 2. In Fig. 3 we track the development when disregarding other work, both looking at maintenance and development in the traditional way, and on application portfolio upkeep and evolution



**Fig. 2.** Comparisons of maintenance figures across investigations, percentage



**Fig. 3.** Comparisons of maintenance figures disregarding other work, percentage

In the light of this stability of figures, we have divided the population to test H1-H5 comparing private and public organizations. Before looking for significant relationships, the variables used in the comparisons were tested for normality. A number of variables cannot be investigated as if they were normally distributed. On some variables we could use the assumption of normal distribution, using t-tests. For the others we have used non-parametric tests as described in section 3.

We tested H1-H5 by comparing the numbers from private and public sector as summarized in Table 2. We list the number of cases, the mean and the standard deviation for all relevant figures to test the eight hypotheses (for H1, there are four test, for the difference in corrective, adaptive, perfective and enhance maintenance respectively).  $\Delta$  is the absolute difference in the mean between private and public sector, and  $p$  is the probability for erroneously rejecting the equality of means. None of H1 to H5 are rejected. On the other hand, we do see a slight tendency of worse practice in public sector, i.e. more resources used on application portfolio upkeep, and more resources used for other tasks than development and maintenance, but again, these differences are not statistically significant. Especially taking into account the

pattern of outsourcing reported above, there seems to be small overall differences in these regards.

**Table 2.** Test of hypothesis

	Sector	N	Mean	SD	$\Delta$	P
Corrective maintenance, percentage of all work (vs. H1a)	Private Public	44 19	23.6 24.4	15.5 19.9	-0.8	.314
Adaptive maintenance, percentage of all work (vs. H1b)	Private Public	44 19	17.5 22.8	13.5 15.0	-5,3	.163
Perfective maintenance, percentage of all work (vs. H1c)	Private Public	44 19	58.9 52.8	21.1 16.2	6.1	.163
Enhance maintenance, percentage of all work (vs. H1d)	Private Public	41 18	31,5 26,0	18,5 20.9	5,5	.319
Maintenance, percentage of all work (vs. H2)	Private Public	44 19	37.2 29.8	17.4 17.5	7.4	.130
Development, percentage of all work (vs. H3)	Private Public	44 19	21.9 19.4	16.3 17.1	2.5	.519
Maintenance, disregarding other work (vs. H4)	Private Public	43 18	64.9 67.8	22.2 20.0	-2.9	.621
Application portfolio upkeep (vs. H5)	Private Public	43 18	61.4 66.4	20.8 21.6	-5.0	.411

## 5 Discussion and Conclusion

Overall percentage of time used for evolving systems in production compared to time used for development is remarkably stable over time, and also relatively equal across private and public sector. The small differences found are not statistically significant. The same applies to the rate of replacement, only here it might appear that public sector is better off than private sector. Since more complex infrastructures are supporting the information systems serving a larger number of in particular external users, more and more of the resources are used for other tasks such as operations and user-support, less and less time is available for providing new information systems support in organization, although it seems to have plateau on 20% of the overall time, a level reached already ten years ago in Norway (i.e. even earlier than indicated in [16]). The small differences between private and public sector is contrary to the image often painted on the poor state of public sector IT relative to the private sector. On the other hand, the efficiency of the time used for development and maintenance tasks are not captured in these investigations, i.e. the amount of new functionality provided through the development of new systems or enhance maintenance.

The main investigation aimed at providing a longitudinal study of IT practice in general. In this light the comparison between private and public sector is an exploratory investigation. Several of our results have spurred new areas that could be interesting to follow up on in further investigations, and we have in addition to the survey performed several detailed case studies in different public sector IT-departments. To

come up with more detailed empirical data on to what extent the application systems support in an organization is efficient, demands another type of investigation, surveying the whole portfolio of the individual organizations, and getting more detailed data on the amount of the work that is looked upon as giving the end-user improved support, and how efficient this improved support was provided. This should include the views of the users of the application systems portfolio in addition to those of the IT-managers and developers. It would be hard to get such data through a survey though, thus calling for additional case studies, with the problems of generalization of results.

A long-term plan is to do a similar investigation in 2013 following up the 5 year cycle of investigations, but here also ensure a support for investigating results relative to the private/public sector dichotomy.

## REFERENCES

1. Benestad, H.C., Anda, B. C. D., Arisholm, E.: Understanding software maintenance and evolution by analyzing individual changes: A literature review, *Journal of Software Maintenance and Evolution: Research and Practice* (2009)
2. Boehm, B., Sullivan, K.: Software economics: status and prospect. *Information and Software Technology* 41(14) 937-946 (1999)
3. Brooks, F. P.: No silver bullet. *IEEE Computer* 20 (4) 10-19 (1987)
4. Chapin, N.: Software Maintenance Types – A Fresh View. *Proceedings of the International Conference on Software Maintenance (ICSM'2000)* pp 247-252 (2000)
5. Chapin, N., Hale, J., Khan, K., Ramil, J. Tan, W-T.: Types of Software Evolution and Software Maintenance *Journal of Software Maintenance* Vol 13. 3-30 (2001)
6. Davidsen. M. K., Krogstie, J., A longitudinal study of development and maintenance *Information and Software Technology* Vol. 52, Issue 7, July, Pages 707-719 (2010)
7. Davidsen. M. K., Krogstie, J. *Information Systems Evolution over the Last 15 Years*. Pernici, B. (Ed) *Proceedings of CAiSE'2010, Hammamet Tunisia 9-11 June* (2010)
8. Flak, L.S., Dertz, W., Jansen, A., Krogstie, J., Ølnes, S., Spjelkavik, I.: What is the Value of eGovernment - and How can we actually realize it. *Transforming Government: People, Process and Policy* 3 (3):220-226 (2009)
9. Følstad, A., Jørgensen, H., Krogstie, J.: User Involvement in e-Government Development Projects. Paper presented at the NordiChi'2004 Tampere, Finland (2004)
10. Galtung, J.: *Theory and Method of Social Research*, Universitetsforlaget, Norway (1967)
11. Gupta, A.: *The Profile of Software Changes in Reused vs. Non-reused Industrial Software Systems* Doctoral Thesis 2009:90 NTNU (2009)
12. Gupta, A., Slyngstad, O. P., Conradi, R., Mohagheghi, P., Rønneberg, H., Landre, E.: An Empirical Study of Software Changes in Statoil ASA - Origin, Priority Level and Relation to Component Size. In *Proceedings of ICSEA (October 29 - November 03)*. IEEE Computer Society, Washington, DC, 12 (2006)
13. Heeks, R.: *Implementing and Managing eGovernment*, Sage (2006)
14. Holgeid, K. K., Krogstie, J., Sjøberg, D. I. K.: A study of development and maintenance in Norway: Assessing the efficiency of information systems support using functional maintenance. *Information and Software Technology*. Vol 42: p. 687-700 (2000)
15. IEEE Standard Glossary of Software Engineering Terminology (1991)

16. Jones, C.: The Economics of Software Maintenance in the Twenty First Century <http://www.compaid.com/caiinternet/ezine/capersjones-maintenance.pdf> Last accessed March 2012 (2006)
17. Jørgensen, M.: Empirical Studies of Software Maintenance, PhD Thesis University of Oslo, Research Report 188, ISBN 82-7368-098-3 (1994)
18. Kitchenham, B.A., Pfleeger, S.L., Pickard, L.M., Jones, P.W., Hoaglin D.C., Rosenberg, J.: Preliminary guidelines for empirical research in software engineering, *IEEE Transactions on Software Engineering*, Vol. 28 (8) pp. 721-734 August (2002)
19. Krogstie, J., Sølvberg, A.: Software maintenance in Norway: A survey investigation, in: H. Muller and M. Georges (Eds.) *Proceedings of the International Conference on Software Maintenance (ICSM'94)*, IEEE CS, Victoria, Canada, pp. 304-313 (1994)
20. Krogstie, J.: Use of methods and CASE-tools in Norway: Results from a survey. *Journal of Automated Software Engineering*, 3: p. 347--367 (1996)
21. Krogstie, J.: On the distinction between functional development and functional maintenance, *Journal of Software Maintenance*, 7 383-403 (1995)
22. Krogstie, J., A. Jahr, D. I. K. Sjøberg: A Longitudinal Study of Development and Maintenance in Norway: Report from the 2003 Investigation, *Information and Software Technology* Vol. 48 993-1005 (2006)
23. Krogstie, J.: Work distribution, Methodology, and Technology for ISD and Maintenance: Trends over the last 30 years, in *IFIP WCC TC8*, D. Avison, S. Elliot, J. Krogstie, and J. Pries-Heje, Editors. Springer: Santiago, Chile. p. 131-142 (2006)
24. Moløkken-Østvold, K.: Effort and schedule estimation of software development projects. , PhD thesis, University of Oslo, Norway (2004)
25. Lee, M.-G., Jefferson, T.L.: An Empirical Study of Software Maintenance of a Web-Based Java Application, *Proceedings ICSM'05* (2005)
26. Lehman, M.M.: Laws of Software Evolution Revisited LNCS 1149, EWSPT96, 9-11 Oct., Nancy pp 108-124 (1996)
27. Lientz, B.P., Swanson, E.B., Tompkins G.E. Characteristics of application software maintenance, *Communications of the ACM*, Vol. 21 (6) 466-471 (1978)
28. Lientz, B.P., Swanson, E.B.: *Software Maintenance Management*, Addison Wesley (1980)
29. Nosek, J.T., Palvia, P.: Software maintenance management: Changes in the last decade, *Journal of Software Maintenance*, Vol. 2 157-174 (1990)
30. PASC: Government and IT – “a recipe for rip-offs”: time for a new approach”, Volume I, 28 July (2011) <http://www.publications.parliament.uk/pa/cm201012/cmselect/cmpubadm/715/715i.pdf> (Accessed March 15, 2012).
31. Rajlich, V.T., Bennett, K.H.: A staged Model for the Software Life Cycle, *IEEE Computer*, Vol. 33 66-71 (2000)
32. Saunders, M., Lewis, P., and Thornhill, A.: *Research methods for business students* (5th ed.). London: Pearson Education Limited (2009)
33. Schach, S. R., Jin, B., Yu, L., Heller, G. Z., Offutt, J.: Determining the Distribution of Maintenance Categories: Survey versus Measurement. *Empirical Software Engineering* Vol. 8, 4, 351-365 (2003)
34. Sousa, H., Moreira, H.: A Survey of the Software Maintenance Process. *Proceedings of ICSM'98 IEEE CS Press Bethesda, Maryland*, pp. 268-274 (1998)
35. Swanson, E.B.: The dimensions of maintenance *Proceedings of the Second International Conference on Software Engineering*, San Francisco, USA, August, pp. 492-497 (1976)
36. Swanson, E.B., Beath, C. M.: *Maintaining Information Systems in Organizations*, Wiley Series in Information Systems, John Wiley & Sons (1989)