IS Evolution Benefit Assessment – Challenges with Economic Investment Criteria

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Abstract

In this paper, eight financial investment criteria and their advantages and disadvantages with respect to IS evolution benefit assessment are studied. As a result, it can be suggested that it is unattainable to define one appropriate evaluation method for IS evolution assessment in general. However, NPV and ROI appear to be the most appropriate methods for IS evolution evaluation. Their results can be reinforced with the supporting investment criteria, including AAR, IRR and payback method. The following potential challenges in evolution investment decision making were identified: selection of an appropriate criteria, acquisition of suitable metrics and follow-up data, data conversion, and comparison of different types of evolution options. A preliminary framework, ISEBA, was developed to address these challenges.

1 Introduction

Maintenance and system evolution activities have a significant role in the information system (IS) life cycle. It has been estimated that approximately 80% of the total IT expenses are allocated for maintenance

activities [20]. According to Lehman's first law, maintenance is necessary, because software needs to be continuously improved or it will get out of date and cannot respond to the requirements of its environment [19]. Despite the importance of IS evolution investments, there is a gap between the IT related costs and company profitability [27]. Brynjolfssen [10] described this as a productivity paradox: information technology utilization has increased since the 70's but simultaneously productivity has slowed down.

The work effort of maintenance is generally proportional to the life time of a system. Therefore, it is more dominant in legacy information systems [7]. Besides being old, a legacy system is typically large at size and contains vital information for the user organization, uses out-of-date technology, and is laborious to maintain [3] [4]. There are three strategies to deal with a legacy system: 1) maintaining and using the system as it is, 2) developing or purchasing a new system to replace it, or 3) radically improve, i.e. modernize, the legacy system in order to meet the new business needs [4] [25, p 8-10].

IT investments can be roughly classified in two categories, acquisition projects and development projects [24]. In the context of IS evolution, acquisition project includes purchasing off-the-self software in order to replace the existing legacy system. Development investment refers to a project that aims at developing new or modernizing the existing system. Therefore, replacement can be either an acquisition or development project, while modernization is always a result of development activity. The major difference between acquisition and development projects, in terms of investment evaluation, is the length of time that is required for the benefits to start to appear [24]. In the first, an organization starts to benefit from the investment as soon as the acquisition has been made. In the latter, the benefits start to accumulate only after the project has been completed [24].

Evolution investments are economically significant and, consequently, their justification in financial terms is important. Because a legacy system is closely tied to an organization, a careful consideration of operational environment and organizational context is a prerequisite for its successful migration [5], and should be incorporated in the evaluation process. However, in reality the management often expects plainly financial evidence to support evolution decisions. In this paper, the goal is to study the advantages and disadvantages of financial investment criteria and their suitability in IS evolution benefit assessment. Additionally, a framework for evaluation method selection is presented.

This is a work-in-progress paper that summarizes the preliminary work on IS evolution benefit assessment within an industry co-operation project called ELTIS (Extending the Lifetime of Information Systems) during 2003-2005. The project was carried out in the Information Technology Research Institute (ITRI), University of Jyväskylä, Finland. It focused on prolonging the lifetime of IS in an economically viable manner.

2 Investment criteria

Dehning and Richardson [12] conducted a literature review on studies covering the impacts of IT on firms' performance in 1997-2001. In most of these studies, IT investments had been evaluated with the means of direct performance or accounting measures. That is where the business owner, by tradition, is expecting to see the implications of investments. In case of IS evolution investments, however, the benefits are not necessarily reflected on the firm's performance or accounting figures. The financial investment criteria can only detect tangible benefits while ignoring the intangibles. In the past, several benefit assessment methods have been developed in order to address this problem [15]. In this paper, the focus is on the so called classical financial investment evaluation methods. On the basis of a literature review, the advantages and disadvantages of eight financial investment criteria are presented and their suitability on IS evolution assessment is evaluated.

Classical financial investment criteria can be divided in three categories: 1) discounted cash flow criteria, 2) payback criteria, and 3) accounting criteria. Discounted cash flow criteria include *net present value* (NPV), *internal rate of return* (IRR), and *profitability index*. Payback criteria consist of *payback period* and *discounted payback* period. Accounting criteria consists of *average accounting return* (AAR). [23, p 256]. Other investment criteria include *return on investment* (ROI) method and *real options* approach (option pricing models) [11, p 139]. Investment criteria, their advantages and disadvantages are described in Table 1.

In general, discounted cash flow criteria are considered the most preferred option when evaluating investment proposals [23, p 256]. NPV is in most cases the recommended approach [23, p 256]. On the contrary, investment criteria based on accounting figures are not as useful with respect to investment planning is because they are aggregated and past-oriented [23, p 245]. They can be used, however, as complementary criteria together with other investment criteria.

Table 1. Investment criteria

Criteria and definition	Advantages	Disadvantages
NPV The difference between investment's market value and cost [23, p 233].	Includes time value of money [11, p 73]. No serious flaws [23, p 256].	Unsuitable for analyzing acquisitions because of short-term and user-oriented focus [13]. Unable to deal with uncertainty [24].
IRR The discount rate that makes the NPV of an investment zero [23, p 245].	Includes time value of money [11, p 73]. Results are easy to communicate and understand [23, p 253].	May lead to incorrect decisions if project cash flows are unpredictable, investment options are mutually exclusive, [23, p 253] or level of uncertainty is high [24].
Profitability Index The present value of an in-vestment's future cash flows divided by its initial cost [23, p 253].	Results are easy to communicate and understand. Useful if investment funds are scarce. [23, p 253-254].	May give misleading results when investments options are mutually exclusive [23, p 254].
Payback period A time period from the moment when an investment is made to the moment when the cash flow from the investment equals the original investment cost [23, p 240].	Simple and easy to under-stand. Adjusts for uncertainty of later cash flows. [23, p 240]	Requires an arbitrary cut-off point. Ignores time value of money and cash flows beyond cut-off date. Biased against long-term or new projects, and liquidity. [23, p 240]
Discounted payback period The length of time required for an investment's discounted cash flows to equal its initial cost [23, p 240].	Includes time value of money [23, p 242].	Ignores cash flows beyond cut-off date [23, p 256]. Biased towards liquidity [23, p 242].
AAR An investment's average net income divided by its average book value [23, p 243].	Easy to calculate. Needed information is often available. [23, p 245]	Ignores the opportunity cost [9] and time value of money [23, p 245]. Does not compare to real market returns [9].
ROI The ratio of net benefits plus the original investment divided by the initial investment [11, p 70].	One of the most significant calculation methods for evaluating managerial performance [6, p 207]. Simple and clear [11, p 70].	Ignores the scale of the investment and timing of cash flows. Not useful for planning. [6, p 207]. Insufficient if used alone [11, p 72-73].
Real options An approach used to evaluate alternative management strategies using traditional option pricing theory [2].	Able to deal with uncertainty [24]. Provides managerial flexibility [11, p 146] [24]. Includes timing and risk [11, p 142].	Complex to communicate. Input values are difficult to estimate. Reliance on assumptions. [16]

Traditionally, the financial analysis of IT acquisition projects has been conducted with NPV or discounted cash flow analysis [13]. During the last few decades, also options pricing models have been applied in IT evaluation [24]. ROI has been used to evaluate the benefits of software reuse [20]. However, there are no reports on the use of these investment criteria in IS evolution decision making particularly.

In the context of IS evolution, the best suited financial evaluation methods are simple and require minimum use of resources. After comparing the characteristics of investment criteria, it can be concluded that discounted cash flow criteria and ROI would be appropriate considering those requirements. IRR and profitability index, however, may lead to incorrect results in the case of mutually exclusive investments, i.e. when accepting one investment prevents taking another [23, pp 253-254]. Therefore, they may not be suitable method for IS evolution options evaluation, since they in most cases are mutually exclusive. For instance, acquisition of a new system and modernization of the existing system most likely are investments from which only one is chosen. NPV has been criticized of its inability to deal with project uncertainty [24]. Because of that it may not be a preferred criterion in system modernisation evaluation. Real options approach seems to provide with the most holistic tool to compare (replacement) and development (modernization, replacement) projects. It can cope with the risks and uncertainty related to modernization and provides future oriented results. Also, it provides managerial flexibility allowing decisions about the investment to be changed as new information becomes available [11, p 146] [24]. However, it is mathematically demanding, which sets certain limitations to its use [16]. Also, it requires relatively detailed input data [16] which may cause the estimation method itself become heavy and uneconomical to use. Due to its past-oriented nature, accounting criterion is not useful with respect to IS evolution options evaluation.

In order to avoid one-dimensional view of an IT investment, use of more than one financial criteria is suggested [11, p 73] [23, p 254]. For instance, payback and AAR can be used to reinforce the results of NPV calculation [11, p 73]. The recommended methods for IT investment assessment, in general, are NPV, IRR and payback period [11, p 73]. Additionally, calculation should be conducted before and after the project [11, p 76].

3 Challenges

The main challenge in evaluating IT investments with financial criteria is the selection of a suitable benefit assessment method. As presented above, classical investment criteria are not uniformly suitable for every situation. If a method is selected carelessly, the results may recommend a refusal of a potential investment proposal simply because the selected method ignores a relevant factor [23]. Respectively, an unprofitable investment may seem potential if improper analysis methods are used.

The second challenge is related to existing and available data. In order to conduct a benefit assessment for investment options, a company has to gather IT-related data concerning its own activities to support management decision making [27]. This presumes the existence of a proper metrics program and follow-up. Without systematic data collection there is no accumulated history data on which the investment estimation could be based on. A related risk is that selected metrics do not capture the value of IT [27], i.e. insignificant or false metrics are being monitored.

The third challenge with economic criteria is that the benefits often appear in non-financial form [22, p 7] and the collected data is to be conversed in a commensurable format before benefit assessment can be carried out [14]. Data conversion may be problematic if benefits appear as soft issues, which are difficult to express in terms of money. In order to avoid confusion with data conversion, the expected benefits should be identified before data acquisition.

The fourth challenge, concerning particularly IS evolution evaluation, is in the comparison of different types of investment options. For instance, if all three evolution strategies are possible, there are minimum of three evolution options to be compared. Those can be for instance:

1. replace the existing system with system X (vendor X)
2. replace the existing system with system Y (in-house development)
3. modernize the existing system (in-house modernization)

Or, alternatively, the investment options can be:

1. replace the existing system with system X (vendor X)
2. replace the existing system with system Y (vendor Y)
3. modernize the existing system (vendor Y)

The successful comparison of investment option combinations necessitates that the selected evaluation method(s) are in compliance with the investment options and that the organization has the ability to use them accordingly.

As a conclusion, it can be suggested that it is unattainable to predefine the appropriate evaluation method for IS evolution options assessment.

Some of the investment criteria fit better than the others but in the end the selection should be made on the basis of the investment situation at hand combined with the available resources, skills, and data.

4 ISEBA framework

In the past research, various methods and approaches have been presented in order to merge IT evaluation with financial investment criteria. In 1987, Parker and Benson et al. [21] introduced information economics that seeks to unify financial justification, value, and innovation valuation with decision making. In 1992, Farbey et al. presented a model for matching an IT investment with a suitable evaluation method [15]. More resent models include a manager friendly roadmap for IT investment evaluation [28] and an evaluation method's matrix as a solution for customized IT investment evaluation [18]. A point of consensus for these methodologies is that their focus is on financial benefits of IT in general. Also, there are methods for software modernization cost and work effort estimation, i.e. COCOMO II [8], FPA [1] and Softcalc [26], but it seems that availability of methods for IS evolution evaluation is currently minimal. For this reason, a new framework for this particular purpose was outlined.

ISEBA (Information System Evolution Benefit Assessment) is a framework to support comparison of IS evolution options. Its goal is to provide assistance in the selection of a benefit evaluation method for investment situation at hand. It is based on empirical research consisting of interview study of industrial decision making and industrial co-operation projects, and a comprehensive literature survey. It obliges instructions about the required metrics and follow-up data for both intangible and financial evaluation methods. ISEBA consists of eight phases: 1) identifying the characteristics of investment situation, 2) identifying investment type, 3) defining investment assessment emphasis, 4) estimating organizational capabilities and comparing them to the requirements and labour intensity of potential benefit estimation methods, 5) selecting suitable method(s) and identifying related risks, 6) gathering required follow-up and metrics data for benefit assessment, 7) performing benefit assessment for investment proposals, and 8) interpreting and valuating results.

The implementation of ISEBA follows the form of a decision-tree. Phases 1 to 4 rule out the improper methods and provide a list of potentially suitable methods. In Phase 2, the investment type (acquisition or development project) of investment proposals is defined. This defines

the post-investment measurement timing. The assessment emphasis in Phase 3 refers to financial or non-monetary benefits. It can be decided that either financial or intangible benefits or both are assessed depending on the investment characteristics. In phase 4, it is important to evaluate the resources and skills the organisation is able to allocate for evaluation. Also, the existing metrics and follow-up data are assessed. The final selection of suitable methods is based on the comparison on of the potentially suitable methods and organisation's resources, skills and available data (phase 5). ISEBA supports method selection by providing a description of each method and the required input data per method. In Phase 6, data acquisition (if needed) is carried out. The execution of benefit assessment takes place in phase 7. Finally, in phase 8 the results are examined and valuated in compliance with organization's strategies. If more than one investment proposal is to be evaluated, it is defined in Phase 1. A more detailed description of ISEBA is given in [17].

5 Summary

On the basis of the literature survey, it can be concluded, that the overall benefits of IS evolution have not been studied comprehensively so far. The comparison of the characteristics of investment criteria shows that the best suited criteria for IS evolution evaluation are NPV and ROI. IRR, payback, and AAR can be used as additional criteria in order to verify their results. Accounting criteria tend to be too general and past-oriented while real options rely strongly on assumptions and option prizing methods are demanding to apply. As a summary of the literature survey it can be concluded that there is no straightforward rule for defining the appropriate evaluation method for IS evolution options assessment. The selection should be made on the basis of the investment situation at hand combined with the available resources, skills, and data. Also, it is suggested that none of the investment criteria should be used alone but together with supporting criteria.

Potential challenges related to evolution investment assessment are selecting a proper analysis method, collecting suitable metrics data, data conversion, and comparison of different types of evolution options. Inspired by these challenges ISEBA framework was created. ISEBA has been further developed and validated empirically in real life cases which incorporate evolution benefit assessment. Report of the validated framework and completed two software industry related projects that

ELTIS promoted has been published [17]. Report of the further developed framework, named ISEBA+, will be forthcoming.

References

1. Albrecht A, Gaffney J (1983) Software function, source lines of code, and development effort prediction: a software science validation. IEEE Transactions on Software Engineering 9 (6) pp 639-648
2. Alleman J, Hirofumi S, Rappoport P (2004) An Investment Criterion Incorporating Real Options. In: Real Options – Theory Meets Practice, The 8th Annual International Conference, www.realoptions.org (on-line; read 23.8.2004)
3. Bennett K (1995) Legacy Systems: Coping with Stress. *IEEE Software* 12 (1), pp 19-23
4. Bennett K, Ramage M, Munro M (1999) Decision Model for Legacy Systems. *IEE Proceedings – Software* 146 (3) pp 153-159
5. Bergey JK, Northrop LM, Smith DB (1997) *Enterprise Framework for the Disciplined Evolution of Legacy Systems*. Technical report, CMU/SEI-97
6. Bierman H Jr, Drebin AR (1968) *Managerial Accounting: An Introduction.* The Macmillan Company, New York
7. Bisbal J, Lawless D, Wu B, Grimson J (1999) Legacy Information Systems: Issues and Directions. *IEEE Software* 16 (5) pp 103-111
8. Boehm B, Horowitz E, Madachy R, Reifer R, Clark B, Steece B, Brown A, Chulani S, Abts C (2000) Software Cost Estimation with COCOMO II. Prentice Hall
9. Brealey R, Myers SC (1996) Principles of Corporate Finance. 5th edn, McGraw-Hill, USA
10. Brynjolfssen E (1993) The Productivity Paradox of Information Technology. Communications of the ACM 36 (12) pp 67-77
11. Curley C (2004) Managing Information Technology for Business Value. Intel Press, Hillsboro, OR
12. Dehning B, Richardson VJ (2002) Returns on Investment in Information Technology: A Research Synthesis. Journal of Information Systems 16 (1) pp 7-30
13. Dos Santos BL (1991) Justifying Investments in New Information Technologies. Journal of Management Information Systems 7 (4) pp 71-89
14. Erdogmus H, Favaro J, Strigel W (2004) Return on Investment. IEEE Software 21 (3) pp 18-22
15. Farbey B, Land F, Targett D (1992) Evaluating Investments in IT. Journal of Information Technology 7 pp 109-122
16. de Jong B, Ribbers PMA, van der Zee HTM (1999) Option pricing for IT valuation: a dead end. EJISE Electronic Journal of Information Systems Evaluation, http://www.ejise.com/volume-2/volume2-issue1/issue1-art1.htm

17. Kankaanpää I, Sivula H, Ahonen JJ, Tilus T, Koskinen J, Juutilainen P (2005) ISEBA - A Framework for IS Evolution Benefit Assessment. In: Remenyi D (ed) Proceedings of the 12th European Conference on Information Technology Evaluation, Academic Conferences Ltd, UK, pp 255-264
18. Lech P (2005) Evaluation methods' matrix – A Tool for customized IT investment evaluation. In: Remenyi D (ed) Proceedings of the 12th European Conference on Information Technology Evaluation, Academic Conferences Ltd, UK, pp 297-306
19. Lehman MM, Perry DE, Ramil JF (1998) Implications of Evolution Metrics on Software Maintenance. In: Khoshgoftaar TM, Bennett K (eds) Proceedings of the International Conference on Software Maintenance, IEEE Computer Society, Los Alamitos, California, pp 208-217
20. Lim WC (1996) Reuse Economics: A Comparison of Seventeen Models and Direction for Future Research. In Proceedings of the 4th International Conference on Software Reuse, IEEE Computer Society, pp 41-50
21. Parker MM, Benson RJ, Trainor HE (1988) Information Economics – Linking Business Performance to Information Technology. Prentice-Hall, Singapore
22. Remenyi D, Money A, Sherwood-Smith M with Irani Z (2000) The Effective Measurement and Management of IT Costs and Benefits. 2nd edn, Butterworth-Heinemann, Oxford
23. Ross SA, Westerfield RW, Jordan BD (1998) Fundamentals of Corporate Finance. 4th edn, McGraw-Hill, USA
24. Schwartz ES, Zozoya-Gorostiza C (2000) Valuation of Information Technology Investments as Real Options. In: The 4th Annual Real Options Conference, www.realoptions.org (on-line, read 23.8.2004)
25. Seacord RC, Plakosh D, Lewis GA (2003) Modernizing Legacy Systems – Software Technologies, Engineering Processes, and Business Practices. Addison-Wesley, Boston, MA
26. Sneed HM (1995) Estimating the Costs of Software Maintenance Tasks. In: Proceedings of the 11th International Conference on Software Maintenance, IEEE Computer Society, pp 168-181
27. Verhoef C (2002) Quantitative IT Portfolio Management. Science of Computer Programming 45 pp 1-96
28. Videira A, da Cunha PR (2005) Evaluating IT Investments: A Managerial Friendly Roadmap. In: Remenyi D (ed) Proceedings of the 12th European Conference on Information Technology Evaluation, Academic Conferences Ltd, UK, pp 501-510