ERP Effort Estimation based on Expert Judgments

Izak Pierre Erasmus

University of Twente & SAP B.V.
Netherlands
i.p.erasmus@utwente.nl

Maya Daneva

University of Twente
Netherlands
m.daneva@utwente.nl

Abstract—A new technology shift brings to the ERP domain a change in the industry and a new platform build on in-memory optimized databases, introduced and known as SAP HANA **[1]**. This technology shift in the ERP domain led to SAP's ERP on HANA, the solution where the ERP suite is offered on the same platform as ERP Services such as Business Analytics. The integration of ERP Services and the ERP suite opens up new opportunities to "fine tune" customer and industry specific business processes. This radical shift in innovation brings with it new challenges in terms of ERP effort estimation. No longer can we rely on a single method such as functional size measurement methods, due to the wide range of customization possibilities. This shift from a typical predefined solution scope to a highly customizable landscape poses a challenge to project estimation practitioners as the functional size estimation techniques used in the past for ERP solutions address a fixed scope deployable in multiple landscapes, and hence are no longer suitable for dynamically definable scope. Today's highly volatile and customized ERP landscape demands a new approach to estimate effort by leveraging ERP professionals' tacit knowledge and expert judgments. This paper presents the ERP Service estimation method that leverages the strengths of expert-judgment-based estimation techniques while using a more structured approach to reduce the effects of expert bias and avoid common pitfalls associated with judgment-based estimation.

Keywords—ERP effort estimation, expert judgment, estimation, experts' consciousness, stakeholders' involvement, expert judgment tactics, ERP Services, SAP ERP suite on HANA

I. Introduction

ERP software has come a long way from a pre-packaged "out of the box" software solution to a service driven customizable enterprise tool. The shift in the ERP domain surely shows that no longer is ERP software sold as a standard pre-packaged "all in one solution" with predefined business processes, but rather a service orientated package designed to accommodate customer specific operations (also for unique industries) which enhance and leverage their specialized business processes. One main contributor (in fact, a "game changer") is SAP's ERP on HANA [1], the solution where the ERP suite is offered on the same platform as ERP Services. ERP Services could be defined as the extension of core business processes to realize the execution of specialized processes (often highly customizable). Therefore ERP Services such as Business Analytics can now be integrated as part of the ERP solution to enhance and customize business processes within the ERP suite "core processes" [2]. Organizations adopt ERP Services because this leads to a more flexible ERP landscape composed of less fixed components and allowing for more innovation as part of the core ERP implementations. While launching an ERP Services project has clearly business benefits, from a project management perspective ERP Services projects represent a new context in which almost no research has been done on some important project management issues, most notably the issue of estimating project effort. On one side, ERP Service projects share some common characteristics with ERP package implementation projects (e.g. [3]) as Services projects are exposed to those uncertainties that are specific to large and multi-stakeholders system implementations [4]. On the other side, there are the technological shifts (such the SAP ERP suite on HANA) that enable a customizable landscape which in turn create a high degree of uncertainty prior implementation. For example, highly volatile business processes unique to specific industries and specialized business operations continuously evolve as certain industries mature, and this makes both functional and non-functional requirements extremely unstable. Project planning therefore makes many more assumptions about the business environment and the ERP technology configurations that support the business process flows and the highly customizable business practices.

The presence of these uncertainties and assumptions encourages practitioners to complement the use of functional size estimation techniques with expert based judgments, as one kind of techniques (e.g. counting) might not be enough to blueprint a more complete picture of the situational forces in an ERP Services project that contribute to its effort. Clearly, functional size estimation techniques, e.g. IFPUG FPA or COSMIC EPC [5] could be used in the projects, however, as many configurations and customizations are unknown in advance, there is a consensus in the software measurement community that complementing approaches could help get better estimates [6] [7]. The present research is a step towards this direction. Our research has two main objectives: (a) to determine the needs for effort estimation practices for SAP ERP Services projects and (b) to design a new method to leverage existing effort estimation approaches, while focusing on the strengths of the expert judgment techniques and reducing the pitfalls often associated with these project estimation methods within the ERP domain.

The paper is structured as follows: Sect. II describes the action research method chosen for this research and its application. Sect. III, IV and V present the three (action research) cycles. Sect. VI provides a new ERP Services effort estimation method as a result. Sect. VII is a reflection on the early evaluation of the method, and Sect. VIII concludes.

II. RESEARCH METHOD

The research study in which we used the Action Research method took place at SAP B.V. (Netherlands) and SAP AG (Germany). It consisted in a total of 10 semi-structured interviews and 3 project observations. The participants in the study were SAP professionals who worked on ERP Services projects. The participants were chosen by the first author based on his knowledge of their typicality. Action research was used to investigate the activities, interaction between stakeholders and existing practices used within the effort estimation process, and to use this knowledge in the design of a new method that leverages expert-based judgments for effort estimation purposes. Action research was conducted in three cycles. The first cycle was to determine the problems related to using experts' knowledge for effort estimation purposes, according to the literature. The second cycle was used to determine and investigate how expert judgments have been used as part of effort estimation and where the problems occur, according to published literature. The third cycle was used to validate with practitioners at SAP whether the problems reported in literature were indeed problems they faced in their effort estimation process of ERP Services.

The next three sections (III, IV, V) describe the three cycles.

III. CYCLE 1 – EXPERTS RECONSTRUCTIVE MEMORY

Reconstructive memory refers to the idea that retrieval of memories does not occur in completely accurate form. Memory of past events does not appear like a video might replay a scene, but rather that recollection of memories involve a process of trying to reconstruct (rather than replay) past events." The reconstructive memory is the effect when the mind fills in the gaps of our memory with a reconstructive version of past events, therefore reconstructing the original event or task. The implication for the design of an expert-judgment-based ERP estimation method is that it will need to include a mechanism to reduce imprecisions due to reconstructive memory. Key leanings of expert's tendencies to predict using past memory as anchor include:

The memories of previous task duration are often incorrect, [8] suggests that it is error in memory that causes a corresponding error in prediction.

Second, people show an overall tendency to underestimate task duration in retrospect, remembering tasks they have completed as having taken less time than they actually did [9] [10] [11] [12].

Third, past experience could refer to performing the task directly or observing others. Prediction then could be made by using this general representation as an anchor and adjusting

prediction up or down on the basis of the specific task at hand. In this way, the process of predicting task duration may be similar to that of remembering task duration using reconstructive memory.

IV. CYCLE 2 – EXPERT JUDGMENT

A. Problems associated with using Expert Judgment

Using expert judgments is the preferred method for making effort estimations in the ERP domain [56], despite a dramatic body of evidence suggesting that expert judgment is flawed [13]. In our research, we set out to learn from the challenges and the failures in expert-judgment-based estimation and use this learning to introduce improvements in the form of a more structured approach. Some of the main pain points reported in literature are listed below:

First, expert judgments as a methodology often take for granted the reality of the availability of experts. Experts are often in short supply and tacit knowledge is hard to transfer. Second, experts often focus on a very specific set of topics and rarely consider obtaining knowledge of the bigger picture [14]. Therefore we can differentiate between different types of experts judgments required to derive the complete scope.

Third, just like any occupation, experts make many reasoning mistakes [15]. The quality of professionals' judgment and decision-making is rarely improved through experience, mainly because professionals do not receive accurate and timely feedback [16].

Fourth, some inconsistencies arise when project estimates are done differently by different experts. Lederer and Prasad [17] showed that stakeholders in the estimation process had differing objectives than those objectives affected by their estimates [18].

Fifth, estimators find it difficult to use previously completed projects as analogies [19]. There is little knowledge about how people select and use historical information in the absence of formal estimation tools [20].

B. Expert Judgment Tactics

In this research, our position is to leverage the strength of using expert judgments while reducing the typical weaknesses that comes with it. Counter tactics can be used to decrease the negative effects of expert judgments during the effort estimation process. Literature does suggest a few tactics that could be good candidates to be considered for adoption or adaptation within the ERP domain. Examples include:

(1) Involving expert for further enquiry (use of other techniques/methods) for an 2nd or 3rd opinion where uncertainty is high.

(2) Risk of misleading estimation results from experts can be mitigated or reduced by practices encouraging the self-awareness of an experts own biasness.

(3) Novices can be used where there is a shortage of experts [21]. It has been shown that experts show less overconfidence than novices. By a small amount of training novices could improve their self-insight "calibration" [21].

(4) Due to specialization experts on certain topics they often suffer from having a too narrow scope during estimation, The following counter actions were found: (a) Create a collection of alternative occurrences to widen the scope and keeping an open mind for "extrimistan" (explained as black swans by Nassim Taleb) or things that could go wrong [22]. (b) Generating thoughts about how things can turn out [23]. (c) Creating optimistic and pessimistic estimates. (d) Best guess estimates were more comparable with the optimistic scenarios than with the pessimistic ones [24].

(5) Historical data can be used by generalized formulas or rules-of-thumb, for example, the knowledge that a small software program module with high complexity requires about 30 work-hours [25].

While the above examples include counter-measures applied to the level of a single expert, other solutions focus on grouping experts together for the purpose of effort estimation. Numerous studies emphasize the advantages of group work of experts. For example:

(1) Cross assessment of professionals "experts" was found to reduce the chance of overconfidence [26]. When software professionals assessed the uncertainty of other professionals' estimates, they were better calibrated and showed no systematic tendency toward overconfidence.

(2) Judgment-based (group discussion-based) combination strategies were superior to mechanical combination strategies in a software development context [27]. Estimates produced after the discussions were higher and more realistic than the initial individual estimates [28].

(3) When expert experience some uncertainty, they could use simple cognitive strategies like 'take an outsider's view', and 'consider the opposite' which proof to be efficient in many circumstances. To improve the realism of uncertainty is to first ask for the historical distribution of estimation error and then ask for the minimum and maximum percentage deviation reflecting the confidence level [29].

(4) Clearly, the plethora of counter-measures suggests that there is no one best way to conduct an accurate estimate, therefore making use of a combination of estimation methods [30] [31] helps reduce participation bias and increase estimation accuracy.

V.   Cycle 3 –Effort Estimation at SAP

A. Current estimation practices

Since the introduction of the Accelerated SAP (ASAP) [4] methodology for rapid implementation of the standard SAP application suite in 1997, the SAP organization has been using the estimation approach that belongs to it. As part of the ASAP implementation process, effort estimation usually takes place during the early project stage, when those business processes that should be embedded in the system, are used to determine project scope, together with the discovery/evaluation and project preparation steps which interactively represent the elicitation and prioritization of requirements [4]. The early stage of an SAP project is usually characterized by strong involvement of experts available from

all domains such as development, solution management, sales, presales and consultancy. They are specialists on different topics and work together on creating solution roadmaps, scoping documents, applying rules of thumb and creating an architectural design for integration possibilities. The artefacts that serve as inputs to the effort estimation process are tested during different quality gates. The quality gates represent the different phases of testing the solution in a lab-like scenario. Later on, a first initial implementation at qualified customer's proofs is tested and this is the unique opportunity to create accurate and useful specific effort estimation configurable rules and documentation. Before a new solution is introduced to market, a special project with its own supported processes called Ramp-Up is offered. A ramp-up project is the last quality gate for SAP projects before the release of an ERP service solution is released to the market. These reconfigurable rules-of-thumb and scoping documents are made available for reuse for non-experienced individuals (novices) and project managers upon the launching of specific ERP Services to the wider market. It was at this point of time, when it became clear to many project managers at SAP that within the radical shift in the ERP Service domain, some reliance on expert judgment principles needed to be adopted as part of the SAP effort estimation approach.

VI.   The Proposal for an Improved Method

A. ERP Services Projects: Estimation Method

We designed the following method specifically for facilitating effort estimations of ERP Services. The suggested method includes tactics and lessons learned (addressed in the previous chapter) and designed to decrease participation bias while improving estimation accurateness. The estimation method includes four steps: (1) customer requirements, (2) scope formulation, (2) estimation and (4) validation. Depending on the project's complexity or risk, the cycles could be repeated iteratively to increase the level of detail in the expert knowledge needed to arrive at a project estimate. In the remaining sub-sections, we describe the four steps in terms of work activities they include, pieces of expert knowledge they use (see Section VI.B), and types of experts and stakeholders involved (see Section VI.C).

1. Customer requirements: This involves the elicitation and documentation of customer requirements. It resembles the evaluation phase of the ASAP method. More in detail, as ERP Service projects are often associated as part of a change management initiative, customer requirements also includes the investigation and documentation of refinement of business processes presented as process changes.

2. Scope formulation: This concerns the business blue print phase of the ASAP method [32]. This step takes requirements as input to derive a architecture (list of prioritized requirements), using both functional and quality requirements. The quality requirements are often used as outline for the architecture. The architect can often determine the best fit (high level design) and best choice of technologies based on previous experience. The architecture (now representing

groups of functional requirements) is advanced for further refinement (as per enquiry) to specific solution experts representing specific group of functionalities. Important to good expert judgments estimation in this step is to incorporate different stakeholders during the scoping process and to decompose estimates where uncertainty is high.

3. Estimation: The estimation is initially rolled down with a top down approach which starts with the architecture and design of the project (or refined in the case of a consecutive iteration), The WBS (work breakdown structure) can be defined using the architecture (as breadth) and the functional

(solution specific) abstraction by including specialized experts to determine the depth of the project. The level of abstraction is determined on the level of uncertainty or risk associated to the project. The bottom-up approach is often carried out in this case when a detailed estimation is required of the effort (time) to implement specific solution objects or functions.

4. Validation: The validation phase represents activities associated with the validation of the estimate.

The following figure provides an overview summary of the four steps and their activities suggested by the method.
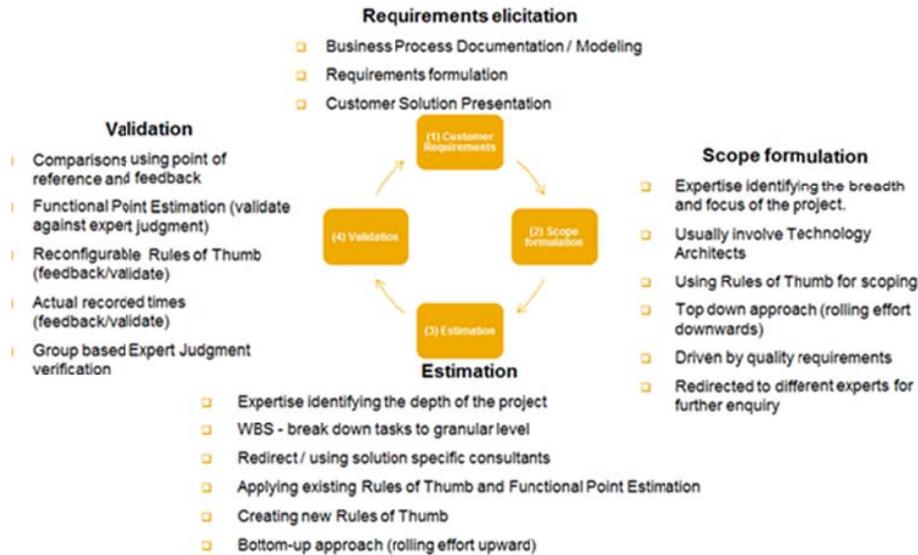

Requirements elicitation
- Business Process Documentation / Modeling
- Requirements formulation
- Customer Solution Presentation

Validation
- Comparisons using point of reference and feedback
- Functional Point Estimation (validate against expert judgment)
- Reconfigurable Rules of Thumb (feedback/validate)
- Actual recorded times (feedback/validate)
- Group based Expert Judgment verification

Scope formulation
- Expertise identifying the breadth and focus of the project.
- Usually involve Technology Architects
- Using Rules of Thumb for scoping
- Top down approach (rolling effort downwards)
- Driven by quality requirements
- Redirected to different experts for further enquiry

Estimation
- Expertise identifying the depth of the project
- WBS - break down tasks to granular level
- Redirect / using solution specific consultants
- Applying existing Rules of Thumb and Functional Point Estimation
- Creating new Rules of Thumb
- Bottom-up approach (rolling effort upward)

Figure.1 Estimation Process – summary

B. ERP Services Estimation process: the knowledge pieces

Various pieces of knowledge are contributed by different experts and at different points in time. More in detail, in step (1), customer specific knowledge is shared such as the organizational structure and their technology landscape. In step (2) domain or field knowledge (industry experience) is required to refine the requirements accordingly. The industry knowledge is often gained via the analysis of current business processes or user stories. Based on the pieces of knowledge collected in step (2), in step (3) a work break down structure is created, which is directly used to get the project estimate. The knowledge applied to such a project estimate could be derived from (a) an architecture focus: based on technology and industry knowledge driven by the quality requirements and/or (b) solution or functional knowledge. The knowledge applied to create an estimate often consists on the combination of both quality (architecture) and functional (design) knowledge and expertise. Last, in step (4), the estimate is validated by using: (a) historical data (explicit knowledge) often associated to a specific solution (group of functionality) or (b) expert

judgment (implicit knowledge) often represented by a technology architect or domain expert.

C. ERP Services Estimation Process: Stakeholder involvement

The estimation method emphasize the flow of expert knowledge across participants, therefore combining knowledge streams between stakeholders are often more realistic than the initial individual estimates [19].

Step1: This phase is represented by a stakeholder involved in sales or pre-sales activities. The focus is to relate the business needs into customer requirements and communicate and facilitate the process of abstraction accordingly. The sales account executive can contribute unique specific customer insights not available to the other stakeholders.

Step2: The role of a project manager predominately facilitates the activities around project scoping. The activities associated to scoping are often shared among project managers, architects and solution experts, but remain the responsibility of the project manager. Technology architects could enquire further insight by including presales and solution consultants.

Step3: The estimations are carried out using the knowledge base of different experts: The WBS (project manager) representing the creation of work packages, the architecture (technology architect) represents the technological outline scope and the solution configuration (solution consultant) represents the functionality and depth.

Step4: Two main approaches for the validation of estimates:

(1) a quantitative validation approach which makes use of historical data to evaluate, compare and validate the suggested effort against explicit values such as functional points or configurable rules of thumb (prerecorded execution times).

(2) a qualitative approach, carried out by a domain/solution expert who predominately rely on past experience and implicit knowledge for comparative evaluations.

VII. First Evaluation and Reflection

The initial evaluation of the proposed method took place at SAP. It included a panel of a group of experts to whom the first author provided a presentation of the method. The goal of this first evaluation was to collect feedback and understand experts' reactions before investing new efforts into the refinement and reformulation of the method. Following the Action Research process, we think such an initial evaluation is instrumental to ensure our method design is industry-relevant and remains focused on solving problems experienced by practitioners in their realities.

The ERP Services Effort Estimation method has been applied within 3 projects at SAP. They were high value projects for an ERP service solution known as SAP DSiM (Demand Signal Management). During this initial evaluation of the method, the group of experts reflected on their experiences in using the method. They provided their reflection points and feedback. The experts mentioned that the method shown reveals important practices towards solving many of the existing problems occurring during ERP effort estimation. Most notably, in the view of the experts, the key value the method provides is formalizing knowledge transfer and validation of estimates by incorporating feedback. This is currently not been practiced beyond the judgment of a single expert.

The experts also provided insights into desired changes of the ERP Service Effort Estimation method. They thought, the method had to be changed in such a way that different experts could influence an estimate during any phase of the estimation process. Topics such as how to apply such a method in reality was an important discussion during the evaluation. Other questions arise like how to provide feedback on specific architectures and how to capture and validate the configurable rules of SAP ERP service projects.

VIII. Conclusion

Effort estimation in the ERP domain can be improved by facilitating a set of appropriate methods and using them accordingly aligned with the needs and pressures within this industry. In this research we highlight the importance to create the conditions most favorable to leverage Expert Judgment tactics. Expert Judgment practices are very useful such as generalizing formulas or rules-of-thumb but could only be verified or improved with proper feedback and assessment from multiple professionals which often reduce overconfidence.

The ERP Service estimation method incorporates the best practice techniques and lessons learned using Expert Judgment as the main method of choice. The ERP Service estimation method is a structured approach required where expert resources are in short supply and can be used by novices. Using Expert Judgments as the key contributor to effort estimations often leads to overconfidence. By using a more structured estimation process one can practice counter tactics to reduce the activities and conditions that cause these unfavorable consciousness of an expert. These counter tactics specifically in the case of Expert Judgment are embedded in the dynamics of the ERP Service estimation method. The processes in this method reduces experts bias by introducing multiple check points of making use of other stakeholders specializing on validating the different levels of the estimation abstraction.

Future work includes piloting the method as part of a functional web tool (or user-interface-integrated within a company's portal) that can be used by a wider audience than those currently using it as part of the research.

IX. References

[1] H. Plattner and A. Zeier, In-Memory Data Management An Inflection Point for Enterprise Applications, Heidelburg: Springer, 2011.

[2] A. Seufert, "Enhanced business intelligence - supporting business processes with real-time business analytics," *Proceedings. Sixteenth International Workshop on Database and Expert Systems Applications,* pp. 919 - 925, 2005.

[3] M. Daneva, "Uncertain Context Factors in ERP Project Estimation are an Asset: Insights from a Semi-Replication Case Study in a Financial Services Firm.," *International Journal of Software Engineering and Knowledge Engineering (IJSEKE),* vol. 21, no. 3, pp. 389-411, 2011.

[4] M. Daneva, "ERP Requirements Engineering Practice: Lessons Learned," *IEEE Software,* Vols. 21(2): 26-33, 2004.

[5] I. P. Erasmus, "The COSMIC EPC method - An ERP functional size measurement method delivering time and cost estimates," Goteborg University/Chalmers University, 2012.

[6] E. R. Stone and R. B. Opel, "Training to improve calibration and discrimination: The effect of performance and environmental feedback," *Organizational Behavior and Human Decision Processes,* vol. 83, p. 282–309, 2000.

[7] P. E. Johnson, "What Kind of Expert Should a System Be?," *Journal of Medical Philosophy,* vol. 8, pp. 77-97, 1983.

[8] R. M. Christenfeld and C. McKenzie, "The broad applicability of memory bias and its coexistence with the planning fallacy: Reply to Griffin and Buehler (2005)," *Psychological Bulletin,* vol. 131, p. 761–762, 2005.

[9] R. A. Block and D. Zakay, "Prospective and retrospective durations judgments: A meta-analytic review," *Psychonomic Bulletin & Review,* vol. 4, p. 184–197, 1997.

[10] P. Fraisse, "On the relationship between time management and time estimation," *British Journal of Psychology,* vol. 90, p. 33–347, 1963.

[11] D. Poynter, "Judging the duration of time intervals: A process of remembering segments of experience," *A life-span perspective,* p. 305–322, 1989.

[12] M. Wallace and A. I. Rabin, "Temporal experience," *Psychological Bulletin,* vol. 57, p. 213–236, 1960.

[13] F. B. a. G. Wright, "Assessing the quality of expert judgment: Issues and Analysis," *Decision Support Systems,* vol. 11, pp. 1-24, 1994.

[14] J. B. J. K. Soll, "Overconfidence in interval estimates. Journal of Experimental," *Journal of Experimental Psychology: Learning, Memory, and Cognition,* p. 299 – 314, 2004.

[15] A. Magazinius, S. Börjessonb and R. Feldta, "Investigating intentional distortions in software cost estimation – An exploratory study," *The Journal of Systems and Software,* 2012.

[16] P. G. Benson, "The Effects of Feedback and Training on the Performance of Probability Forcasters," *International Journal of Forecasting,* vol. 8, pp. 559-573, 1992.

[17] L. A. L. a. P. J, "Causes of inaccurate software development cost," *Systems Software,* vol. 31, pp. 125-134, 1995.

[18] L. A. L. a. P. J, "A causal model for software cost estimating error," *IEEE Transactions on Software Engineering,* vol. 24, pp. 137-148, 1998.

[19] R. Buehler, D. Griffin and M. Ross, "Exploring the "Planning Fallacy": Why people underestimate their task completion times," *Journal of Personality and Social Psychology,* vol. 67, pp. 366-381, 1994.

[20] H. &. H. H. A. J, "Cost Estimation of Software Intensive Projects: A Survey of Current Practices," in *Proceedings of the 13th International Conference on Software Engineering,* Austin, Texas, 1991.

[21] W. M. Goldstein and R. M. Hogarth, Research on Judgment and Decision Making: Currents, Connections, and Controversies, Cambridge University Press, 1997.

[22] P. J. Hinds, "The curse of expertise: The effects of expertise and debiasing methods on predictions of novice performance," *Journal of Experimental Psychology,* p. 205–221, 1999.

[23] L. J. Sanna, C. J. Parks, E. C. Chang and S. E. Carter, "The hourglass is half full or half empty: Temporal framing and the group planning fallacy. Group Dynamics," *Theory, Research, and Practice,* p. 173–188, 2005.

[24] S. J. Byram, "Cognitive and motivational factors influencing time predictions," *Journal of Experimental Psychology,* p. 216–239, 1997.

[25] M. Jørgensen, "Forecasting of software development work effort: Evidence on expert judgement and formal models.," *International Journal of Forecasting,* vol. 23, p. 449–462, 2007.

[26] M. Jorgensen and T. M. Gruschke, "The Impact of Lessons-Learned Sessions on Effort Estimation and Uncertainty Assessments," *IEEE Transactions on Software Engineering,* vol. 35, no. 3, pp. 368 - 383, 2009.

[27] U. Passing and M. Shepperd, "An experiment on software project size and effort estimation," *International Symposium on Empirical Software Engineering,* 2003.

[28] K. Molokken and M. Jorgensen, "A review of surveys on software effort estimation," *International symposium of empirical software engineering,* p. 223–230, 2003.

[29] M. Jørgensen and K. Moløkken, "Eliminating over-confidence in software development effort estimates," *Product focused software process improvement,* vol. 3009, p. 174 –184, 2004.

[30] N. Bajaj, A. Tyagi and R. Agarwal, "Software estimation: A fuzzy approach," *SIGSOFT Software Engineering Notes,* vol. 31, p. 1–5, 2006.

[31] J. Hill, L. C. Thomas and D. E. Allen, "Experts' estimates of task durations in software development projects," *International Journal of Project Management,* vol. 18, p. 13–21, 2000.

[32] G. Keller and T. Teufel, SAP R/3 process Oriented Implementation, Addison-Wesley, 1998.