COMBINING QUANTITATIVE AND QUALITATIVE ASSESSMENT METHODS IN SOFTWARE PROCESS IMPROVEMENT

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ABSTRACT

Since the Software Engineering Institute (SEI) in Pittsburgh developed the Capability Maturity Model for Software (CMM) the idea of using assessments to determine the state of an organisation’s current software processes has gained increasing momentum. However, the assessment process itself has not received nearly the same attention as the maturity models used in the assessments. This paper argues that a useful assessment process is one which combines quantitative and qualitative methods of studying an organisation’s software processes. To demonstrate this an experiment was carried out in a large Danish software organisation. The experiment supports the value of combining quantitative and qualitative assessment methods in software process improvement. Several implications of this are discussed towards the end of the paper.

Keywords: software process improvement, assessment methods, qualitative methods, quantitative methods, CMM, BOOTSTRAP.

1. INTRODUCTION

Since “Managing the Software Process” (Humphrey, 1989) was published, software process improvement (SPI) has received increasing attention both from researchers and practitioners. This growing attention has led to the development of several maturity models that organisations can use to determine their software capability, and establish a maturity baseline which can be used as a basis for implementing and institutionalising software process improvements. These models include The Capability Maturity Model (CMM) (Paulk et. al., 1993) and BOOTSTRAP (Kuvaja et al., 1994), both of which were used in this experiment.

The maturity model that has received the most widespread attention throughout the world is the Capability Maturity Model (CMM) developed by Carnegie Mellon University’s Software Engineering Institute (SEI). This model provides organisations with guidance for measuring software process maturity and establishing process improvement programs (Paulk, 1995).

CMM characterises a software-developing organisation as belonging to one of five levels of increasing maturity. Each maturity level, except the first, is subdivided into Key Process Areas (KPAs) central to the software development process. Each of these KPAs describes the best practice of the process. The phi-
losophy of CMM is that an organisation at a high maturity level will perform better than one at a low maturity level (c.f. Figure 1).

From 1991 to 1993 an Esprit project developed the BOOTSTRAP model (Kuvaja et al., 1994). The BOOTSTRAP model is based on CMM and uses the same 5-level maturity scale. However, the BOOTSTRAP model was extended and adapted to include guidelines both from the ISO 9000 series of standards, and from the European Space Agency’s (ESA) PSS-05 software development standard. See Figure 2.

Software process improvement usually starts with an assessment of the current practice of the organisation’s software development process. This assessment is usually based on a model such as CMM or BOOTSTRAP. Without firmly understanding the current practice it will be difficult to determine what to improve and the selection of software process improvement activities is bound to be arbitrary.

After determining the maturity level an optimal set of process areas to improve is selected. A plan for every improvement area is established to guide in implementing and institutionalising the necessary changes to the organisation’s software development process. Thus, in order to succeed with software process
improvement, the efficiency and efficacy of the applied assessment method is crucial. An assessment method, which is not efficient and efficacious, will reduce the reliability of the assessment results, the confidence the organisation has in the results, and the ability to plan improvement activities, etc.

This paper describes an experiment combining two assessment methods. The first method uses a questionnaire based on CMM Level 2. This method was developed recently at Aalborg University (Arent & Iversen, 1996). The second method is based on the BOOTSTRAP model, and uses both a questionnaire and group interviews. The experiment was established to evaluate the efficiency and efficacy of the combination of the two methods. In more general terms it is an experiment with quantitative and qualitative research methods and their combination and integration in an assessment of a software developing organisation’s strengths and weaknesses. Conclusions may then be drawn on the combination of such research methods and how they can supplement each other in an assessment. More precisely, the research question was:

What are the advantages and disadvantages of combining and integrating quantitative and qualitative methods for assessing software process maturity?

The next two sections of this article (2 and 3) describe the two assessment methods used in the experiment. Section 4 describes the experiment, and Section 5 describes the results that were obtained from the experiment. Section 6 discusses what the implications of the experiment are for software process improvement. Section 7 reports our conclusions about the experiment and its results.
2. QUESTIONNAIRE-BASED ASSESSMENT METHOD

The "Questionnaire-Based Assessment Method" (QBA) is developed at the Department of Computer Science at Aalborg University (Arent & Iversen, 1996).

QBA is based on level 2 of the CMM. The six key practices of CMM level 2 have been turned into questions that are answered by systems developers and project managers from the organisation. Some key practices were augmented with additional questions.

Data collection starts with a meeting with all the respondents and the local sponsor. At this meeting the respondents are briefed about the organisation’s ongoing software process improvement project, the rationale of CMM, and the assessment method. This is done in order to make sure that the respondents understand the questions they will be answering, thus increasing the quality of the answers.

The data collection then proceeds with the questionnaire, which is answered by project managers and systems developers. This is accomplished in a single session with everybody present in the same room, so that the assessors can answer any questions concerning the questionnaire. The aim is to have at least 25% of all software development personnel and for every project at least 3 developers (depending on the size of the project) and the project managers to participate. Answering the questionnaire generally takes between 45 minutes and 2 hours.

QBA has two assessment instruments; the questionnaire and a database for storing and analysing the responses.

The questionnaire is divided into 7 sections. One section contains the introduction to the questionnaire and the 6 remaining sections contain the questions related to the 6 key process areas (KPA) at CMM level 2 (c.f. Figure 1).

Each of the 6 sections containing the 6 KPAs includes a general description of the KPA as well as these subsections:

- **Prerequisites** that should be fulfilled before the activities of the KPA can be performed with satisfactory results.
- **Goals** that at a high level indicate what the KPA should accomplish.
- **Activities** that should be performed to satisfy the KPA.
- **Measurement and Verification** that should be performed to ensure the implementation and institutionalisation of the KPA.

All questions except the goal-questions are answered with *Yes, No, Don’t know* or *Not relevant*. The goal-questions are answered with *Completely, A lot, Not much, Not at all, Don’t know* or *Not relevant*. There is space available to write comments for every question.

At the end of the questionnaire is the question: "If you could change one thing in your organisation, what should it be, and why?" The answers to this question often provide very interesting information about the organisation.
All information on the completed questionnaires are typed into an MS-Access database, enabling the assessors to produce various reports and graphs to facilitate the analysis of the data.

The initial analysis from the assessment includes three types of maturity profiles:

1. Using the responses from all respondents to give an overall picture of the maturity level of the organisation. An example of this profile is shown in Figure 5.

2. Using the responses from all respondents to give a detailed picture of each question.

3. Using the responses from the respondents from each project to give a picture of the maturity of each project. This profile is very similar to Figure 5, but with less data.

These profiles are used to elicit the overall state of the software process, and decide which process areas should be improved to obtain the best results.

The comments to the questions and the improvement suggestions from the last question are studied to give the assessors a better picture of the organisation.

To compensate for the relative lack of qualitative data in this method, a discussion session is conducted with all respondents, management, and other interested persons. This meeting is important as it gives some validation of the results obtained from the questionnaire, but it also provides the assessors with further insight into the organisation, as well as ideas for improving the organisation.

The result of the assessment is an improvement strategy developed in cooperation between the assessors and the local process improvement group. This strategy aims to improve all the process areas of CMM level 2 that were shown by the assessment to be unfulfilled.

Based on the improvement strategy, a number of work groups are formed to decide in detail how to improve a specific improvement area. Each work group usually works on one KPA only, either in the entire organisation or in a smaller part of the organisation. To aid these work groups, the assessment provides them with a report which gives detailed information about every question in the questionnaire. This includes the distribution of answers in the answer categories, fulfilment percentage, and all comments on that question.

QBA is based primarily on the quantitative data obtained from the questionnaire. These data are used to construct various maturity profiles and a detailed report covering every question. The qualitative data (comments on questions, improvement suggestions, and discussion session) is seen as a supplement to the quantitative data.

3. BOOTSTRAP ASSESSMENT METHOD

The “BOOTSTRAP” assessment method was developed in an Esprit project (#5441). The goal of the project that lead to the BOOTSTRAP model was to
fertilise the ground for good software practice in Europe and to analyse the awareness of the European software industry in this area. The BOOTSTRAP model is based on CMM, ISO 9000, and ESAs PSS-05 life cycle model (Kuvaja et. Al, 1994). After the completion of the project, some of the partners established the international organisation, BOOTSTRAP Institute, to promote and to continue improvement of the model.

An assessment using the BOOTSTRAP model consists basically of a number of structured group interviews, conducted by at least two licensed assessors. One interview is always with the management of the software-producing unit in the organisation, and 2-4 interviews are with project groups. Usually a week or two prior to the group interviews there is a pre-assessment meeting. All the group interviews are typically carried out in 3-4 days during the same week, beginning with an opening session. The purpose of the opening session is to give a general introduction to the BOOTSTRAP model and method in order for all participants in the assessments to have the same starting point. There is also a considerable learning effect in this opening session in terms of understanding the concepts of software best practice. A generic assessment plan is shown in Figure 3.

The actual length of the assessment week depends on the number of projects to be assessed. The typical number is four projects, but it may be more or less depending on the nature of the projects the organisation usually undertakes.

The SPU (Software Producing Unit) assessment is conducted with the management at the highest possible level in the software organisation. The project assessments are conducted with the participation of as many of the project team involved in the actual software development projects as possible, though not more than 4-6 people. This will typically be the project manager, the quality responsible person, the test responsible person, and one or two developers.

The actual detailed assessments are based on two questionnaires, one for the organisation as a whole and one for the projects. The questionnaires have two parts, one for general information and one covering the 23 areas in the BOOTSTRAP model, c.f. Figure 2. The latter part contains about 200 detailed questions.

The questions in the questionnaires are used as a structured interview guide. Typically the questions are not asked directly but the issues covered by the questions are taken up as a point for discussion during the group interview. The assessors derive the answers to the questions from the interviews. The answers are given as one of five values: absent, weak, fair, extensive, or not applicable.
A tool with the following functionality supports the BOOTSTRAP assessors:

- A database to store the assessment data
- Generation of the detailed maturity profiles, with a distinct maturity level for each of 23 software processes in the BOOTSTRAP model

The BOOTSTRAP Institute also support the model with a database, in which all conducted assessment data are entered in anonymous form. From this database it is possible to extract mean profiles for the total number of organisations or a selected group. This can be used as a basis for benchmarking.

The BOOTSTRAP methodology includes an algorithm for generating detailed maturity profiles from the completed questionnaires in an objective and valid manner. A tool is provided to support the calculation of the results, both for the SPU, and for each project or for an average of the findings for all the projects. The calculated and quantitative profiles are used in the further analysis work.

The maturity profiles show the maturity level for each of the defined development areas in the BOOTSTRAP model. A corresponding profile for the lower level development areas (the three boxes under Methodology in Figure 2) is also produced. From these maturity profiles, absolute strengths and weaknesses for management and for one specific project or all projects may be derived. From combined maturity profiles it is possible to derive strengths and weaknesses for management relative to a specific project or all projects.

A capability profile may also be presented relative to a mean score profile calculated from relevant data extracted from the BOOTSTRAP database at the BOOTSTRAP Institute, and thereby function as a kind of benchmarking.
An analysis of all the maturity profiles along with additional information about the organisation gathered during the assessment results in an analysis matrix showing selected software development areas sorted according to how well the organisation masters them and how important they are considered to be for the organisation. An example of such a matrix is shown in Table 1.

At the end of the assessment there is a meeting where the preliminary results of the assessment are presented. These results are subsequently analysed further and a final report is produced. The final report includes:

- Maturity profiles
- Analysis of strengths and weaknesses
- Identified key areas for improvement
- Suggestions for specific improvement actions

The maturity profiles show the maturity level for each of the defined development areas in the BOOTSTRAP model individually. An example of a maturity profile for the main development areas for the management interview plus a calculated average for the project interviews are shown in Figure 4.

A corresponding profile for the lower level development areas is also produced. From these maturity profiles, absolute strengths and weaknesses for the management and for specific projects or all projects as a whole may be derived.

### 4. THE EXPERIMENT

In order to test the combination of the two assessment methods, an experiment was set up in a major Danish Software House (DSH) which develops software for administrative purposes. DSH has 4 divisions, three of which were assessed. The assessed divisions employ a total of approximately 300 developers.
4.1. The Combined Assessment Process

The aim of the assessment was to try a combination of quantitative and qualitative assessment methods on the same organisation and projects. The local sponsor of the assessments was interested in making the two assessments appear as two aspects of the same assessment. It was thus necessary to closely coordinate the activities of the two assessment methods.

DSH had the following goals for the assessment:

- An evaluation of the status of current practices in software development.
- An identification of strengths and weaknesses in the software development.
- Suggestions for improvement actions which meet the needs of DSH.

The assessment was performed on the following organisational units:

- Top level management from DSH (president and three vice-presidents)
- Eight selected projects representing different kinds of development projects and different development phases within DSH.

The questionnaire was answered by 30 respondents (8 project leaders and 22 developers). The group interviews were performed on 4 of the 8 projects.

### Assessment timetable

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 20-22</td>
<td>Group interviews in four projects. BOOTSTRAP questionnaire filled out by assessors</td>
</tr>
<tr>
<td></td>
<td>Questionnaire-Based Assessment (QBA) in eight projects (4 were the same as above)</td>
</tr>
<tr>
<td>May 26</td>
<td>Consolidation of preliminary results</td>
</tr>
<tr>
<td>May 27</td>
<td>Presentation and discussion of consolidated results</td>
</tr>
<tr>
<td>June 12</td>
<td>1st draft of BOOTSTRAP report</td>
</tr>
<tr>
<td>July 3</td>
<td>Final BOOTSTRAP report including recommended improvement plan</td>
</tr>
<tr>
<td>August 8</td>
<td>QBA data report and 1st draft of recommendations for improvements based on QBA</td>
</tr>
</tbody>
</table>

Two days after the data collection phase ended, all assessors and the local software engineering process group (SEPG) met to consolidate the preliminary results. This consolidation resulted in a list of 7 process areas that should be improved. The consolidated results were subsequently presented at a seminar with all respondents, senior management, and other interested persons. At this meeting the results were discussed, and the general feeling seemed to be that the
detected improvement areas were in need of improvement. The initial reaction from everybody involved was that the assessment had been a relative success.

4.2. Assessment Results

The preliminary results were obtained by using the two methods without any attempt to integrate them. However, the results pointed in the same direction, but were slightly different at a detailed level.

The initial results from using the QBA-method included a graph showing the responses of all respondents (c.f. Figure 5). As can be seen in Figure 5, the strongest areas are requirements management (RM), software project planning (SPP), and software project tracking and oversight (SPTO). The weakest areas are software quality assurance (SQA) and software configuration management (SCM). Of the four categories of questions, measurement and verification are the weakest.

The preliminary result from the BOOTSTRAP group interviews was the maturity matrix shown in Table 1.
<table>
<thead>
<tr>
<th>Importance for company</th>
<th>Current Status of Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Crucial</strong></td>
<td><strong>User requirements (workshop)</strong></td>
</tr>
<tr>
<td>High</td>
<td><strong>Resource management</strong></td>
</tr>
<tr>
<td>Medium</td>
<td><strong>Subcontractor management Configuration Management</strong></td>
</tr>
</tbody>
</table>

**Table 1:** Preliminary maturity matrix (BOOTSTRAP results)

<table>
<thead>
<tr>
<th>Importance for company</th>
<th>Current Status of Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Crucial</strong></td>
<td><strong>Acceptance testing Operations User requirements (workshop)</strong></td>
</tr>
<tr>
<td>High</td>
<td><strong>Resource management</strong></td>
</tr>
<tr>
<td>Medium</td>
<td><strong>Subcontractor management (external)</strong></td>
</tr>
</tbody>
</table>

**Table 2:** Consolidated maturity matrix. Differences from Table 1 shown in italics.
The first activity in the consolidation phase was to incorporate the QBA results into the maturity matrix, in order to develop a list of software process areas that should be targeted for improvements.

Both the QBA and the BOOTSTRAP methods gave profiles of the current development practices in DSH. The two types of profiles were consolidated using an integrated maturity matrix as shown in Table 2. The areas that were moved or changed are shown in italic.

To address the weaknesses shown in Table 2, the assessors and the SEPG concluded that the following areas should be targeted for improvement actions:

1. Strengthening testing of software, especially application and integration testing.
2. Improving the design phase from architectural design to detailed design. This includes design methods, procedures, templates and guidelines for carrying out software design.
3. Strengthening quality management within projects
4. Modification of development model already developed in the organisational unit called Architecture.
5. Improving diffusion and ensuring adoption throughout the organisation of new and existing methods, techniques and tools (typically developed within the Architecture unit).
6. Improving project management – especially estimation.
7. Strengthening of configuration management including requirements management.

5. EVALUATION OF THE EXPERIMENT

The experiment has been evaluated by having the assessors discussing their experience and by interviewing each member of the SEPG individually.

5.1. Assessors’ Experience

The assessors’ experienced that the combined assessment process had several advantages and a few disadvantages, but altogether it was both efficient and efficacious.

Advantages:

The BOOTSTRAP group interview was a useful technique for obtaining in-depth knowledge and much relevant insight into software processes as viewed by both management and projects. Such knowledge was crucial for the assessors to gain confidence in their assessment results and to be able to argue for the improvement areas they identified.

- The QBA questionnaire was a useful technique to gain representative primary data of (a few) important software processes.
• Quantitative data were necessary for the assessors to be able to rely on their assessment and to increase the reliability of the results.

Disadvantages:
• The two methods were combined but they were not integrated to the full possible extent. A full integration would have been better: This is illustrated by the following:
  • There were two separate reports.
  • The reports were not delivered to DSH at the same time.
  • The primary data from the group interviews were only accessible to the BOOTSTRAP assessors.
• The involved managers and systems developers never understood the purpose of the combined assessment and were confused by the difference in the two techniques.

5.2. Interviews with the SEPG
Qualitative interviews as proposed by Patton (1984) were subsequently conducted to find out how the SEPG perceived the experiment. Four SEPG members were interviewed using an interview guide and a tape recorder. The duration of each interview was from 25 minutes to 70 minutes.

From these interviews the following citations illustrate the main advantages:
• “The major advantage was that management was involved in a group-interview. You cannot ask management to fill out a questionnaire, but it was very important for their understanding that they are involved.”
• “The major advantage for the QBA-questionnaire was that you can send it out to many people.”
• “I like the BOOTSTRAP report.... It is very good that they dare to come up with an improvement plan and some estimates for the activities in the plan.... It has been a valuable tool. I would not have been without it.”
• “The closing session was very important. It is a major strength that you are able to present preliminary results so fast.”

From the interviews the following citations illustrate the main disadvantages:
• “The adaptation of the QBA-questionnaire to our organisation took a lot of effort. And still there is a lot interpretation involved in every question. And there are still interpretations where you are left in doubt whether the people answering understood the question.”
• “It took nearly 2.5 months from the assessment to the report .... We haven’t used the QBA-report due to the timing.”
“If management hadn’t been at the closing session I believe more detailed issues would have been raised.”

“The distinction between internal and external subcontractors did not work. Nobody understood it.”

“The QBA questionnaire is focused on large development projects. It did not work well for the maintenance projects.”

This further validates the assessors’ experience with the combination of the two assessment methods.

6. DISCUSSION

The experiment has implications for how future assessments in software process improvement should be carried out. This discussion also relates to similar discussions in research in general.

6.1. The Mix of Quantitative and Qualitative Methods

In software process improvement in general we can see the experiment as a first ground for the following conjectures:

- Qualitative data collection is crucial for the assessors to gain confidence in their assessment results and to be able to argue for the improvement areas they identify.

- Quantitative data collection is necessary for the assessors to be able to rely on their assessment and to increase the reliability of the results across the organisation.

At at more detailed level the following should be observed of each of the two methods, BOOTSTRAP and QBA (summarised in Table 3):

- The BOOTSTRAP method is primarily based on qualitative data collection techniques through the group interviews with open-ended questions. This means that the number of groups interviewed is small and have to be selected carefully to represent the whole organisation.

- The interpretation of the qualitative data in the BOOTSTRAP method is done by the assessors. The qualitative data is turned into quantitative data when the assessors answer the BOOTSTRAP questionnaire. The quantitative data is documented by the maturity profiles. The analysis of which process areas are immature is done by the assessors based on the quantitative profile data supplemented with the original primary qualitative data.

- The QBA method is based on a quantitative data collection technique through having software developers answering a questionnaire. Secondly, the questionnaire is used for collecting some qualitative data as a supplement to qualify the primary quantitative data. The
questions for the qualitative data are connected to the quantitative questions and are thereby fixed in structure. The number of respondents can be large to ensure that the sample is representative. It also means that the primary data will reflect perceptions of individuals.

- In the QBA method the documentation contains the primary quantitative data. The analysis of which processes are immature is done by the assessors in cooperation with the SEPG and the analysis is validated in cooperation with the respondents.

<table>
<thead>
<tr>
<th></th>
<th>QBA</th>
<th>BOOTSTRAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary data collection</td>
<td>Quantitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Respondents</td>
<td>Assessors</td>
</tr>
<tr>
<td>Documentation</td>
<td>Quantitative</td>
<td>Quantitative</td>
</tr>
<tr>
<td>Sample size</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Unit of analysis</td>
<td>Individuals</td>
<td>Project groups</td>
</tr>
<tr>
<td>Primary analysis</td>
<td>Quantitative</td>
<td>Quantitative</td>
</tr>
<tr>
<td>Secondary analysis</td>
<td>Qualitative, fixed</td>
<td>Qualitative, open-ended</td>
</tr>
<tr>
<td>Report (supplement)</td>
<td>Quantitative</td>
<td>Qualitative (quantitative)</td>
</tr>
</tbody>
</table>

Table 3: Summary of mixes

The combined approach to software process assessment may be evaluated based on three criteria: (1) how reliable is the analysis? (2) what confidence has the organisation in the analysis results? (3) how is the ability to plan improvement actions supported? The following characteristics appear:

- **Reliability**: Because the BOOTSTRAP method is directed at a fairly small sample size it is useful to supplement it with QBA. The combined approach is then more reliable. In the DSH experiment it is, however, likely that it would have been more efficient to extend the BOOTSTRAP sample to all 8 project groups. On the other hand, QBA could without much effort have been extended to a sample of 100 or more respondents and thereby added considerably to the reliability. The combined approach is also more reliable because QBA and BOOTSTRAP provides independent sources and they reach similar conclusions.

- **Confidence**: Because the insight gained through the QBA method is representative but tends to be rather abstract and hard for the organisation to grasp it is necessary to supplement it with an assessment method like BOOTSTRAP. The qualitative insight gained through BOOTSTRAP is much more accessible and it therefore adds to the confidence that actors in the organisation puts on the results of the analysis. It is likely that the level of confidence connected to the
QBA results may be raised if the questions are simplified and more questions turned into open-ended questions.

- **Ability to plan:** The BOOTSTRAP results were useful for the SEPG in planning the improvement actions because the report was formed as a constructive instrument for much of the detailed planning. The QBA report did not have a useful format. It is however likely that a much more useful QBA report may be compiled.

### 6.2. Relationship to Similar Results

It is an old struggle whether a quantitative or a qualitative research method is best. Nothing final can be concluded as it usually depends on the research setting and the research question. However, there seems to a growing awareness that a combination of qualitative and quantitative research methods in assessments seems to be a promising way to go. The two main arguments have been:

- By combining multiple methods (triangulation) it is possible to cope with the limitations that any single research method has (Campbell & Stanley, 1966).

- The combination of qualitative and quantitative methods has value in itself. Two plus two equals five when combining the two disparate research methods (Jick, 1979).

Patton (1990) discusses this in considerable detail. As a starting point he notes that:

> “qualitative and quantitative methods involve differing strengths and weaknesses, they constitute alternative, but not mutually exclusive, strategies for research” (Patton, 1990, p. 14)

For research as for software process assessment there is no ideal way of performing it. The usefulness of an applied strategy can only be discussed in terms of its appropriateness for the specific situation and the particular assessment context. With this in mind there is still room for a general discussion of the mixing of qualitative and quantitative methods. Patton cautions the designers of research, evaluations and assessments that while triangulation of methods usually is concerned with applying both types of methods it is not a straightforward process. This is because the two types of methods in general addresses different questions (Patton, 1990, p. 464–465).

This means that it is in general a useful idea to combine qualitative and quantitative methods. This, of course, applies to software process assessment, too. Though, at a more detailed level assessment designers have to design the combined approach with the above in mind. As a consequence:

- The combination will only add to the reliability of the results if the qualitative and the quantitative methods address the same questions.
The combination may add to the confidence the organisation puts on the results if different but related questions are addressed.

The discussion of these issues and design of the combination can be based on the model of assessment. QBA is based on CMM (Figure 1), and the BOOTSTRAP methods is based on the BOOTSTRAP model (Figure 2). Though different concepts are used in these two models they basically are models of the same software processes. Thus, the underlying models then become instruments in forming the combined assessment.

7. CONCLUSION
An experiment with the combination of quantitative and qualitative assessment methods has been established as reported in Section 4. An extensive evaluation of the experiment has been conducted as reported in Section 5 and the implications of this have been discussed in Section 6.

The main results are:

- It is both efficient and efficacious to combine quantitative and qualitative research methods in assessments, thus the combination of questionnaires and group interviews works very well.
- Special attention must however be put on how well the specific methods integrate in terms of time schedules and time span, accessibility to primary data, and easiness of presentation of results.

Thus, the combination is useful, but further research is needed to integrate them more.

8. ACKNOWLEDGEMENTS
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9. REFERENCES