Systematic Mapping of Value-based Software Engineering - A Systematic Review of Value-based Requirements Engineering

Naseer Jan and Muhammad Ibrar
This thesis is submitted to the School of Engineering at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 40 weeks of full time studies.

Contact Information:
Authors:
Naseer Jan
Address: Folkparksvägen 16 LGH: 10, 37240, Ronneby, Sweden
E-mail: naseer.jan1@gmail.com

Muhammad Ibrar
Address: Folkparksvägen 16 LGH: 10, 37240, Ronneby, Sweden
E-mail: ibrarckd@yahoo.com

University advisor(s):
Mahvish Khurrum
Department of System and Software Engineering, Blekinge Institute of Technology

School of Computing
Blekinge Institute of Technology
SE-371 79 Karlskrona
Sweden

Internet : www.bth.se/com
Phone : +46 455 38 50 00
Fax : +46 455 38 50 57
Abstract

**Context:** In many organizations, practices and processes of software engineering are carried out in a value-neutral setting. These value-neutral settings within software development are responsible for project failures. Value-based software engineering (VBSE) manages these value neutral settings by integrating value-oriented perspectives into software engineering. The fundamental factors that differentiate VBSE from value-neutral software engineering are value dimensions that play a crucial role in companies’ success by managing customer needs, demands, and expectations

**Objectives:** The aims of this master thesis are to 1) systematically classify the contributions within VBSE and 2) investigate practical application and validation of solutions in industry to determine their practical usability and usefulness.

**Methods:** In this study, systematic mapping, followed by systematic review were used as research methods.

**Results:** The findings of systematic mapping show that a clear majority of value-based research has been conducted within requirements engineering, and verification and validation. Whereas, there were not many studies discussing value-based design. In terms of research types used, evaluation research and solution proposal were the most dominant contributions. While experience reports and philosophical research were less emphasized. In general, value-based contributions such as recommendations and processes were highly reported in VBSE studies. In addition, the finding of systematic review indicates that although many solutions were proposed for value-based requirements engineering but in the absence of qualitative and quantitative results from usability and usefulness perspectives make it hard for practitioners to adopt for industrial practices.

**Conclusion:** The systematic classification of studies and resulting maps not only give an overview of existing work on VBSE but also identifies interesting research gaps which can be used by researchers to plan and carry out future work. The findings of systematic review can be used by industry practitioners to assess the level of applicability of the proposed value-based requirements engineering solutions with respect to their application/validation context and usability and usefulness.

**Keywords:** Value-based Software Engineering, (VBSE), Value, Systematic Map, Systematic Review.
ACKNOWLEDGEMENT

First of all, we are thankful to Almighty Allah who blessed us to contribute in the knowledge of world. We would like to express our gratitude to our supervisor Mahvish Khurrum for support, guidance and motivation throughout this thesis project. Her ideas and directions were of great value since we had no prior knowledge of value-based software engineering. We are also thankful to Dr. Tony Gorschek for helping us in improving our analytical skills. We are also thankful to Mrs. Eva Norling and Mr. Kent Pettersson for guidelines in searching relevant literature. We are also grateful to all students at BTH who participated in discussions during this thesis. It seemed like a long journey but eventually we have gone through this by grace of Allah Almighty. Lastly we cannot express our gratitude enough to our family and friends for their patience, support and understanding throughout this thesis.
Contents

ABSTRACT ................................................................................................................................................. 3
ACKNOWLEDGEMENT ................................................................................................................................. 4
1 INTRODUCTION .......................................................................................................................................... 10
2 BACKGROUND AND RELATED WORK ..................................................................................................... 11
  2.1 VALUE DEFINITIONS ............................................................................................................................ 11
  2.2 VBSE AGENDA ..................................................................................................................................... 12
  2.3 SYSTEMATIC MAPPING ......................................................................................................................... 13
  2.4 SYSTEMATIC REVIEW .......................................................................................................................... 14
  2.5 KAPPA ANALYSIS ............................................................................................................................... 15
3 DESIGN ...................................................................................................................................................... 16
  3.1 AIM, OBJECTIVES AND OUTCOMES .................................................................................................. 16
  3.2 SYSTEMATIC MAPPING DESIGN ......................................................................................................... 18
  3.2.1 Sys-Map Step 1: Definition of research questions (Research Scope) ........................................... 18
  3.2.2 Sys-Map Step 2: Formulation and execution of search queries (All studies) ............................... 19
  3.2.3 Sys-Map Step 3: Pilot selection ......................................................................................................... 22
  3.2.4 Sys-Map Step 4: Screening of VBSE studies (Relevant VBSE studies) ....................................... 22
  3.2.5 Sys-Map Step 5: Developing classification scheme (Key wording using title, abstract and index terms) .......................................................................................................................................................................................... 24
  3.2.6 Sys-Map Step 6: Data extraction process and mapping of studies (Systematic map) ............ 25
  3.3 SYSTEMATIC REVIEW DESIGN ........................................................................................................... 26
  3.3.1 Sys-Rev Step 1: Research questions ................................................................................................. 26
  3.3.2 Sys-Rev Step 2: Search strategy ........................................................................................................ 27
  3.3.3 Sys-Rev Step 3: Study selection criteria and procedure ................................................................. 27
  3.3.4 Sys-Rev Step 4: Pilot selection .......................................................................................................... 27
  3.3.5 Sys-Rev Step 5: Study quality assessment ....................................................................................... 28
  3.3.6 Sys-Rev Step 6: Data extraction strategy ......................................................................................... 28
  3.3.7 Sys-Rev Step 7: Data Synthesis Strategy ......................................................................................... 34
  3.4 VALIDITY THREATS .............................................................................................................................. 34
  3.4.1 Internal validity threats ....................................................................................................................... 34
  3.4.2 Conclusion validity ............................................................................................................................. 35
  3.4.3 Construct validity ............................................................................................................................... 35
  3.4.4 External validity ................................................................................................................................. 35
4 RESULTS ................................................................................................................................................... 36
  4.1 SYSTEMATIC MAPPING ......................................................................................................................... 36
  4.1.1 Execution of search queries and primary study selection ............................................................... 36
  4.1.2 Value-based Requirement Engineering (Vbre) ............................................................................... 39
  4.1.3 Value-based Architecture (VBA) ..................................................................................................... 42
  4.1.4 Value-based Design (VBD) .............................................................................................................. 44
  4.1.5 Value-based Development (VBDev) ................................................................................................. 46
  4.1.6 Value-based verification and validation (VBV&V) ......................................................................... 50
  4.1.7 Value-based Quality Management (VBQM) ................................................................................... 55
  4.1.8 Value-based Project Management (VBPM) ..................................................................................... 57
  4.1.9 Value-based Risk Management (VBRM) ......................................................................................... 60
  4.1.10 Value-based People Management (VBPPM) ............................................................................... 63
5 ANALYSIS AND DISCUSSION .................................................................................................................. 66
  5.1 SYSTEMATIC MAPPING ....................................................................................................................... 66
5.1.1 Value-based Requirements Engineering ................................................. 66
5.1.2 Value-based Architecture .......................................................................... 67
5.1.3 Value-based Design .................................................................................... 69
5.1.4 Value-based Development ........................................................................... 70
5.1.5 Value-based Verification and Validation ..................................................... 71
5.1.6 Value-based quality management ............................................................... 73
5.1.7 Value-based Project Management ............................................................... 74
5.1.8 Value-based Risk Management .................................................................. 77
5.1.9 Value-based people management ............................................................... 78
5.1.10 Research type .......................................................................................... 79
5.2 SYSTEMATIC REVIEW .................................................................................. 80
5.2.1 Results overview ...................................................................................... 80
5.2.2 Results and Analysis ................................................................................ 81

6 CONCLUSION .................................................................................................. 114
7 FUTURE WORK .............................................................................................. 118
8 REFERENCES .................................................................................................. 119
9 APPENDIX ..................................................................................................... 146
List of Figures

Figure 1: Design of systematic mapping and systematic review ........................................... 17
Figure 2: Manual and automated search process .................................................................... 21
Figure 3: Inclusion and exclusion process ............................................................................. 23
Figure 4: Developing classification scheme .......................................................................... 25
Figure 5: Primary study selection results ............................................................................... 27
Figure 6: Bubble plot of Overall VBSE ................................................................................ 28
Figure 7: Bubble plot of Value-based requirement engineering ............................................. 30
Figure 8: Focused value dimensions in value-based requirements engineering .................... 32
Figure 9: Bubble plot of value-based architecture ................................................................ 32
Figure 10: Focused value dimensions in value-based architecture ....................................... 36
Figure 11: Bubble plot of Value-based Design ...................................................................... 39
Figure 12: Focused value dimensions in value-based Design ................................................ 42
Figure 13: Bubble plot of Value-based development ............................................................. 47
Figure 14: Focused value dimensions in value-based development ....................................... 49
Figure 15: Bubble plot of Value-based verification and validation ......................................... 50
Figure 16: Bubble plot of value-based software testing levels ............................................... 52
Figure 17: Bubble plot of value-based software testing techniques ....................................... 53
Figure 18: Focused value dimensions in value-based verification and validation .................... 54
Figure 19: Bubble plot of value-based quality management ................................................ 55
Figure 20: Focused value dimensions in value-based quality management ........................... 57
Figure 21: Bubble plot of value-based project management .................................................. 58
Figure 22: Focused value dimensions in value-based project management ............................ 60
Figure 23: Bubble plot of Value-based risk management ....................................................... 61
Figure 24: Focused value dimensions drivers in value-based risk management .................. 62
Figure 25: Bubble plot of value-based people management .................................................. 63
Figure 26: Focused value dimensions in value-based people management ........................... 64
Figure 27: Focused value dimensions in overall VBSE ........................................................... 65
Figure 28: Overview of included studies ................................................................................ 80
Figure 29: Empirical basis of needs identified ...................................................................... 81
Figure 30: Application/validation Method ............................................................................. 83
Figure 31: Application/validation designed explained ............................................................. 84
Figure 32: Application/validation Results presented as ......................................................... 84
Figure 33: Scale of Application/validation ............................................................................. 85
Figure 34: “Usability” Scalability of introduction .................................................................... 86
Figure 35: “Usability” Scalability of Use ................................................................................. 87
Figure 36: “Usefulness” Better Alternative Investment ............................................................. 88
Figure 37: “Usefulness” Effectiveness .................................................................................. 89
Figure 38: Metrics for proposed solutions ............................................................................. 90
Figure 39: Overview of value dimensions definitions/descriptions ...................................... 97
Figure 40: Value dimensions definitions/descriptions ........................................................... 98
Figure 41: Overview of value dimensions components ........................................................ 103
Figure 42: Reporting of value dimensions’ components ....................................................... 110
Figure 43: Overview of value dimensions perspectives ...................................................... 111
Figure 44: Value dimensions perspectives .......................................................................... 112
List of Tables

Table 1: Systematic mapping sub-research questions ............................................ 18
Table 2: Systematic mapping search strategy .......................................................... 19
Table 3: Study selection criteria .............................................................................. 24
Table 4: Systematic review sub-research questions .................................................. 26
Table 5: Data Extraction Strategy and category definition ...................................... 29
Table 6: Metrics reported for proposed solutions ...................................................... 90
Table 7: Challenges categorization .......................................................................... 94
Table 8: Value dimensions definitions ................................................................... 98
Table 9: Value dimensions evaluation/estimation/determining ................................. 100
Table 10: Value dimensions components ................................................................. 104
Table 11: Coefficient correlations ............................................................................ 113
List of Appendices

Appendix A: Value, development and management process areas and sub-process areas keywords .......................................................... 146
Appendix B: Classification and definitions of research types and value-based contributions .......................................................... 150
Appendix C: Search queries .......................................................................................................................... 150
Appendix D: Definitions of development and management process areas and sub-process areas .......................................................... 152
Appendix E: Value map of value-based requirements engineering .......................................................... 152
Appendix F: Value map of value-based architecture ...................................................................................... 154
Appendix G: Value map of value-based design ................................................................................................. 158
Appendix H: Value map of value-based development ....................................................................................... 161
Appendix I: Value map of value-based verification and validation ................................................................. 162
Appendix J: Value map of value-based quality management ........................................................................... 163
Appendix K: Value map of value-based project management ............................................................................ 166
Appendix L: Value map of value-based risk management ............................................................................... 168
Appendix M: Value map of value-based people management .......................................................................... 169
Appendix N: Value map of value-based software engineering ....................................................................... 170
Appendix O: Definitions of value dimensions ................................................................................................. 171
Appendix P: Kappa Statistics - Research Type ................................................................................................. 171
Appendix Q: Kappa statistics - Value-based contribution (disagreements) ......................................................... 173
Appendix R: Kappa statistics - Value-based contribution (agreements) ......................................................... 173
Appendix S: Kappa statistics - VBSE process areas ............................................................................................ 173
Appendix T: Kappa statistics - empirical basis of need (disagreements) ......................................................... 173
Appendix U: Kappa statistics - Empirical basis of need (agreements) ............................................................. 173
Appendix V: Kappa statistics - Application validation method ............................................................................. 173
Appendix W: Kappa statistics - Application validation Design .......................................................................... 173
Appendix X: Kappa statistics - Application validation Results ............................................................................. 173
Appendix Y: Kappa statistics - Usability ............................................................................................................ 173
Appendix Z: Kappa statistics - Usefulness (disagreements) ............................................................................. 173
Appendix AA: Kappa statistics - Usefulness (agreements) ............................................................................... 173
Appendix BB: Kappa statistics - systematic map pilot selection (disagreement) ............................................. 173
Appendix CC: Kappa statistics - systematic map pilot selection (agreement) ............................................... 173
Appendix DD: Missing value dimensions .......................................................................................................... 173
Appendix EE: Value dimensions perspectives ................................................................................................. 173
1 INTRODUCTION

Value-based software engineering (VBSE) is an emerging field, which integrates value-oriented perspectives into software engineering. Value can be defined as “relative worth, utility or importance” [51]. Here relative worth means to compare something against the other.

In many organizations, practices and processes of software engineering, for example requirements traceability, inspection process, testing and configuration management etc, are carried out in a value-neutral setting [25]. Seminal studies about VBSE hold this value-neutral setting within software development responsible for project failures [1, 2, 3, 4, 86, 123]. The characteristics of value-neutral settings include ignorance of stakeholders’ interests, neutral value assignment to every requirement; use case, object and defect, separation of concerns within the development organization [1, 2]. In such a setting, for example, critical requirements and defects may not get required attention. Moreover, isolating people by restricting them to perform specific tasks and not providing them with a broader picture of the product/project reduces their ability to generate more value out of their work [2]. Value-based software engineering addresses both the technical and economic aspects within software development lifecycle [1, 2].

The concept of VBSE started gaining popularity in mid 90s and since then several studies have been presented in academia and as industry experiences [1, 15, 16, 68, 74, 88, 105, 108, 111, 114, 151]. However, in order to summarize and provide an overview of the research done in VBSE, it is required to classify and map the studies with respect to the research types and value-based contributions. Moreover, in order to gauge the usability and usefulness of value-based contributions proposed in the field of VBSE, it is important to review the empirical evidence of their application and/or validation, for example in industry or through experiments or tests. To achieve this, systematic mapping and systematic review can be used as research methodologies.

To the best of our knowledge, no systematic mapping and review in this field has been conducted so far. Thus, the aims of this master thesis are to 1) systematically classify the contributions within VBSE and 2) investigate practical application and validation of value-based requirements engineering (VBRE) solutions in industry to determine their practical usability and usefulness.

The remainder of thesis is structured as follows. In Section 2, background and related work is explained. Section 3 contains design of this study. Results are presented in Section 4, and analysis and discussion are given in Section 5. Conclusions are presented in Section 6 and limitations and future work are covered in Section 7.
2 BACKGROUND AND RELATED WORK

In this Section, value definitions (see Section 2.1) and VBSE agenda (see Section 2.2) are introduced. The purpose of this is twofold, one, to provide a background to the concepts relevant for systematic mapping and systematic review, and, two, to describe the scope of the study. Section 2.3 and Section 2.4 provide an introduction to the systematic mapping and systematic review methodologies.

ISO defines software engineering as “the systematic application of scientific and technological knowledge, methods, and experience to the design, implementation, testing, and documentation of software to optimize its production, support, and quality” [1, 7]. There are three shortcomings in this definition from VBSE perspective [1].

First, value-neutral software engineering exclude management science, economics, humanities, and cognitive sciences from the body of knowledge required to develop successful software systems. However, VBSE cannot ignore this body of knowledge because it considers software development as a meaningful activity carried out by people for people [1].

Second, value-neutral software engineering only emphasizes on technical activities (i.e. design, implementation and testing) [1]. In contrast, VBSE consider management-oriented activities as part of the software lifecycle. These management-oriented activities include business case development, project planning, project evaluation, process selection, project management, risk management, process measurement and monitoring [1, 86].

Finally, there is lack of recognizing ultimate goal that is value of software systems gradually evolves with organizational and human needs [1, 2, 25, 47]. According to VBSE, it is not enough for software projects to meet unilaterally planned schedule, budget and quality objectives. But it is also necessary that the product being developed increases the wealth of the stakeholders and improves the image of the organization [1].

The fundamental factor that differentiates VBSE from software engineering is value [1, 2]. It is central for companies’ success is to deliver products that fulfill customer needs, demands, and expectations, which result into high value creation [1, 9, 86].

Adding value is an economic activity that has to be taken into account from a software business perspective. Value is created when a company makes a profit. The critical success factor for software companies is their ability to develop a product that meets customer requirements while offering high value that provides increased reassurance of market success [2, 4].

2.1 Value definitions

Value is the relative worth, utility, or importance of an object (i.e. artifact, software, product, process, idea, or outcome) compared to other objects [40]. In business, value is considered as an economic activity that can be generated for an object when it makes a profit [86]. There exist many value dimensions such as:

Use value of a product is the customer willing to pay for it and exchange value is the product market value [11]. Value creation is an iterative process, supported by aligning project, product and business level decisions throughout the software development [12, 86]. There are many internal and external stakeholders involved in the development of software product. Each stakeholder has his/her own value considerations [92]. For instance, within a company higher management perceives value as profit, development organization measures value in terms of less number of defects, quality and robustness,
technology whereas customers perceive product value in terms of the benefits versus its price [92].

Product value can be defined as market value of the product (i.e. exchange value). It is related to product price and is greatly influenced by the non-functional requirements of the software product [81, 86, 94, 95, 117]. The value of the product is directly proportional to its advantages over competitor’s products and vice versa [81, 86, 94, 95, 117].

Whereas, business value is created from product sales [137, 86, 108], marketing [137], customer orientation [137], strategic alliance [137], integrity [137], sustaining competitive advantage [137], managing requirement process [108], requirements agility [108], contractual innovation [108] and controlling project risk (i.e. development cost and task schedule overruns [328], not meeting user requirements [328], and system development that is not concerned with business value). It is directly proportional to the product sales.

The customer perceived value can be calculated by perceived benefits relative to competitive product/perceived price relative to competitive product. The drivers for the creation of the customer’s perceives value are product benefit, price, and fulfillment of needs, expectations and demands [49, 50, 86]. Relationship value can be created through the social relationships between the customer and the software company [86]. The drivers for customer-company relationship value are time, effort, product development cost, price, time-to-market, differential advantage and customer satisfaction [48, 49, 50, 86]. It is directly proportional to the product sales, whereas, the project value is created from budget, scheduling and delivery [86]. In next Section 2.2, VBSE agenda is given that emphasizes the importance for integration of these value dimensions into the full range of current and emerging software engineering principles and practices.

### 2.2 VBSE agenda

The objective of this agenda is to take considerations of value into existing and evolving principles and practices of software engineering, and establishing an overall framework in which they support each other [1, 25, 123]. In order to realize this VBSE agenda, seven key elements/principles need to be taken into considerations during all activities of the project/product and these are given below:

1) To establish and understand the goals and initiatives for the realization of overall benefits [1, 25, 26, 123].
2) To identify and understand the success critical stakeholders involvement, their needs and expectations, conflicts among them, and how they interact with each other [1, 5, 25, 123].
3) To determine the relative benefits, development costs and return on investment [5] throughout the life cycle of product [1, 25, 27, 123].
4) To monitor and mitigate the risks during activities and the potential realization of them as an opportunity of value creation [1, 25, 123].
5) To understand and adopt such type of methodology (i.e. Agile approach, Evolutionary Spiral Process [18], Rational Unified Process [19], and the MBASE/CeBASE models [20, 21]), which bring stakeholders closer, mitigate risks, and ensures the concurrent activities to be performed [1, 25, 123].
To establish a mechanism, which determines the actual activities against the planned in terms of value creation progress and to make correction when necessary [1, 25, 123].

To understand the rapid changes that emerge in market place, technologies, companies, stakeholder’s value and priorities, and these can be utilized as an opportunity for value creation [1, 25, 123].

Value-based approach can be used in different process areas of software engineering such as requirements engineering [14, 33, 130, 135], architecture [144, 148], design & implementation [37, 38, 39], verification and validation [40, 41], quality management [44, 276, 285], risk management [381] and people management [1]. Moreover, VBSE makes it possible to establish an early necessary communication between different stakeholders during the software development process. This process reduces the risk of mismatch between business objectives, product design and overall market expectations [151]. In addition, through the use of value-based software development methods, tools and techniques software product flexibility and quality are improved because of reduced risk, time to market and multiple product development cost [151, 281, 288, 302, 304, 307].

2.3 **Systematic Mapping**

Systematic mapping study is used to provide a broader overview of the research area, to investigate the existence of research in the field of interest and to show frequency of studies in that field [22, 23, 52, 58]. The results of systematic mapping reveal research areas appropriate for performing systematic review.

Systematic mapping is extensively used in the field of medical research, but its importance has been lately recognized in the field of software engineering [60]. A limited number of systematic mapping studies have been performed in software engineering field such as Bailey et al. [58] performed systematic mapping for determining the extent to which the empirical evidence supports the software design methods. Mujtaba et al. [23] conducted systematic mapping to develop map and classify the relevant studies for Software product line variability. David et al. [63] conducted an informal review of the mapping studies to assess effectiveness of the mapping studies in software engineering and specify the challenges while conducting mapping studies. Nelly et al. [60] conducted mapping study to classify studies on the basis of empirical evidence in relation to the different aspects of the software requirements specification. Furthermore, Wasif et al. [59], performed systematic mapping to present a broad review of studies on the basis of application of search-based optimization techniques and non-functional testing.

Systematic mapping process as proposed by [22, 23] consists of the following steps

1) **Sys-Map Step 1: Definition of Research Questions (Research Scope)**
   The research questions are formulated in such a way that they reflect the main and secondary goals of the systematic mapping of the study [22, 23, 59].

2) **Sys-Map Step2: Formulation and execution of search queries (All studies)**
   The main purpose of search strategy is to identify and formulate search terms, define search process and resources to be searched [22, 23]. Accurate and precise search strings can be formulated with the help of population, and intervention [22, 23, 59].
3) **Sys-Map Step 3: Pilot selection**
   Pilot selection helps the individual researchers to develop a common understanding of the study selection criteria [53]. During this step, researchers individually apply the inclusion/exclusion criteria on the same set of studies prior to the actual selection of studies.

4) **Sys-Map Step 4: Screening of VBSE studies (Relevant VBSE studies)**
   Defining inclusion and exclusion criteria helps to include or exclude the studies to answer the systematic map research questions [22, 23]. Research questions have an impact on the inclusion and exclusion criteria [22, 23, 53].

5) **Sys-Map Step 5: Developing classification scheme (Key wording using title, abstract and index terms)**
   Key wording is used to minimize the time needed for development of classification scheme [22]. It is done in two steps.
   a) Reading abstract, looking for concepts and identification of context of the research (defining set of categories by combining set of keywords) [22].
   b) Reading introduction or conclusion if abstract is poor and clustering a final set of keywords to create categories for the map [22, 23].

6) **Sys-Map Step 6: Data Extraction process and mapping of Studies (Systematic Map)**
   After development of classification scheme, all relevant studies are classified according to the classification scheme [22, 23]. Bubble plot (visual graph) is used to show the mapping of studies [22, 23, 59].

2.4 **Systematic Review**

The motivation for conducting a systematic review is to summarize the existing research in a particular area in a thorough and unbiased manner [53]. Systematic review also helps in finding the research gaps in the existing research or to present a framework for accommodating the new research activities [53]. The results of systematic review can be used for drawing more general conclusions than the individual studies and can be used as a prelude for further research [52]. It presents a clear picture of a specified area by identifying, interpreting and evaluating all the available studies [53]. The systematic review consists of the following steps [52, 53]:

1) **Sys-Rev Step 1: Research Questions**
   The first step in systematic review is to state the research questions [53] reflecting the primary and secondary goals of the review. They bind the scope of the review [52].

2) **Sys-Rev Step 2: Search Strategy**
   Search strategy identifies and formulates the search terms, defines search process and resources to be searched [22, 23]. Accurate and precise search string can be formulated with the help of population, and intervention.
3) **Sys-Rev Step 3: Study selection criteria and procedure**

Study selection criteria and procedure determines the studies to be included or excluded from a systematic review [53].

4) **Sys-Rev Step 4: Pilot selection**

Pilot selection helps the individual researchers to develop a common understanding of the study selection criteria [53]. During this step, researchers individually apply the inclusion/exclusion criteria on the same set of studies prior to the actual selection of studies.

5) **Sys-Rev Step 5: Study Quality Assessment**

Study quality assessment is a way of judging the quality of the individual study when results are being synthesized [53].

6) **Sys-Rev Step 6: Data Extraction Strategy**

Data extraction strategy defines information that will be extracted from the studies included to be reviewed systematically [53]. For systematic review, data extraction strategy is developed in such a way that it collects relevant information from the selected studies to answer research questions.

7) **Sys-Rev Step 7: Data Synthesis Strategy**

Data synthesis gathers and summarizes the results of selected studies with the help of extracted data. Data synthesis is of two types: qualitative (descriptive synthesis) and quantitative (meta-analysis) [53]. In this systematic review descriptive analysis will be performed.

2.5 **Kappa Analysis**

Kappa statistics are used to measure the agreement level between two researchers who rate each sample of subjects on different types of scale [460]. Kappa is useful when all disagreements are considered equally important in nominal data and weighted kappa is useful in specifying disagreements with respect to ordinal data [460, 461]. Weighted kappa is very effective for measurement of inter observer bias and agreement of raters in categorical ordered data because this type of data lead to high Inter observer bias [460, 461]. For example, a scale may contain attributes such as worst, bad, average, good, best, and excellent or very sad, sad, neutral, happy, and very happy etc. however, inter observer bias in nominal data also known as categorical data is minimum.
3 Design

In this Section, the aims, objectives and outcomes (see Section 3.1) of this thesis are stated. In order to achieve the desired aims and objectives, this thesis is divided in two parts: systematic mapping of VBSE and systematic review of VBRE as shown in Figure 1. Design of systematic mapping and systematic review are presented in Section 3.2 and Section 3.3 respectively.

3.1 Aim, Objectives and Outcomes

The aims of this master thesis are to 1) systematically classify the contributions within VBSE and 2) investigate practical application and validation of solutions in industry to determine their practical usability and usefulness. These aims will be accomplished through following objectives:

- To classify the contributions in VBSE with respect to software management and development process areas
- To identify the process areas, for which VBSE contributions are lacking and/or missing
- To investigate the research type of studies [22, 23, 46]
- To systematically classify the proposed VBRE solutions in the selected process area with respect to empirical basis, application/validation, usability and usefulness [6]

The following are the outcomes of this study

- Systematic classification and mapping of the studies in the context of VBSE
- Research gaps in different areas of VBSE, both in terms of missing research contributions in different areas and missing connections between proposed solutions
- Systematic review and detailed analysis of the VBRE studies in the selected process area

Table 1 and Table 4 present an overview of the research questions, with motivations, that will be answered in this thesis. Systematic mapping was conducted to answer Sys-Map_RQ1 (see Figure 1) that was intended to systematically classify and map VBSE existing literature based on process areas and sub-process areas, value-based contributions, and research types. Whereas, systematic literature review was used to answer Sys-Rev_RQ2 (see Figure 1) by classifying, examining and aggregating the empirical evidence of application and validation of proposed solutions in VBRE.
Figure 1: Design of systematic mapping and systematic review
3.2 Systematic Mapping Design

In this section, a detailed description of systematic mapping design is shown. Section 3.2.1 represents research questions of this study. Section 3.2.2 describes formulation and execution of search queries. Section 3.2.3 contains pilot selection and the screening of VBSE studies is given in section 3.2.4. Development of classification scheme is shown in Section 3.2.5, and data extraction process and mapping of studies are given in Section 3.2.6.

3.2.1 Sys-Map Step 1: Definition of research questions (Research Scope)

The main research question for the systematic map is given below.

*Sys-Map RQ1:* What is the classification of VBSE literature with respect to software management and development process areas?

The sub-research questions with motivations are given in the following Table 1.

**Table 1: Systematic mapping sub-research questions**

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Systematic Mapping research questions</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sys-Map RQ1.1</td>
<td>What are the software development process areas and sub-process areas addressed in the selected studies?</td>
<td>To identify and classify software development process areas and sub-process areas (see Appendix D) for which solutions are proposed in VBSE literature.</td>
</tr>
<tr>
<td>Sys-Map RQ1.2</td>
<td>What types of contributions are presented in the selected studies?</td>
<td>To identify and classify contributions (such as process, methods, tools, techniques, frameworks, methodology and recommendations) reported in VBSE literature (see Appendix B).</td>
</tr>
<tr>
<td>Sys-Map RQ1.3</td>
<td>Which research types are used in the selected studies?</td>
<td>To identify and classify research type (such as evaluation research, validation research, philosophical research, solution proposal, opinion report, and experience report) of each VBSE study (see Appendix B).</td>
</tr>
<tr>
<td>Sys-Map RQ1.4</td>
<td>Are there any gaps with respect to the context, contribution and research type in the field of VBSE?</td>
<td>To identify, which software development process areas and sub–process areas need more attention with respect to the value-based contributions and research types in VBSE.</td>
</tr>
<tr>
<td>Sys-Map RQ1.5</td>
<td>Which value dimensions are considered in the selected studies?</td>
<td>To identify and present value dimensions (such as business value, project value, product value, customer perceived value, intrinsic value etc.) considered in each process areas and sub-process areas.</td>
</tr>
</tbody>
</table>
3.2.2 Sys-Map Step2: Formulation and execution of search queries (All studies)

The search strings were formulated based on populations and interventions. As two researchers were involved in this study, therefore, all possible keywords were divided among them and each researcher conducted search for primary studies. Following search strategy was used during systematic mapping.

**Search strategy:**

VBSE is based on the concept of value and value exists in multiple dimensions. It was found that some of the studies that discuss value or present value-based solutions have not explicitly stated “value-based” keyword anywhere in the study. Therefore, snowballing approach [61] was used to identify all possible value related keywords. The keywords and search strings were refined in consultation with the supervisor and a senior librarian. Search strings were formulated through following steps.

- All possible value-based keywords were identified by scanning title, abstract, and index terms of the studies.
- Main terms were identified by determining population and intervention in terms of research question.
- Synonyms of the keywords were identified by using thesaurus.
- At last, search strings were formulated by using Boolean operators such as AND, OR, PRE, ONEAR etc.

All possible value-based and software engineering discipline keywords are listed in Appendix A and search strings are given in the Appendix C. Table 2 explains query formulation in more detail.

**Table 2: Systematic mapping search strategy**

<table>
<thead>
<tr>
<th>Data Items</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Databases searched</td>
<td>IEEE Xplore, ACM Digital Library, Inspec and Compendex (through Engineering Village), Scopus, and SpringerLink</td>
</tr>
<tr>
<td>Population</td>
<td>Management and development process and sub process areas: Requirements engineering, software architecture, software design and development, verification and validation, software quality, risk management, planning and control, and people management and their sub process areas. For detailed list of search terms (see Appendix A).</td>
</tr>
<tr>
<td>Intervention</td>
<td>Value keywords (see Appendix A).</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Followings are the outcomes of systematic mapping study: Systematic classification and mapping of the studies in the context of VBSE Research gaps in different areas of VBSE, both in terms of missing research contributions in different areas and missing connections between proposed solutions</td>
</tr>
</tbody>
</table>
Search queries formulation

To make the search exhaustive, electronic databases were searched using the following strategy
- Boolean OR was used in between the interventions.
- Boolean AND was used in between the population and intervention.
- In order to restrict our search to studies that contains only value keyword and software. Boolean AND was also used in between them.

An example is given below, while detailed queries are provided in Appendix C.

| Software AND Population AND Intervention |

Out of scope

Fields such as enterprise resource planning, computer aided software engineering, component based software engineering and web services etc; were out of scope. Similarly, editorials, prefaces, summaries, news, reviews, correspondence, discussions, comments, reader’s letters and summaries of tutorials, workshops, symposium, panels, and poster sessions were also excluded.

Reference management system

Zotero for reference management, and Endnote (for removal of duplicated studies).

Year

The studies are selected from the year 1990 to 2010.

Studies Targeted

Journals and conference studies

Refinement of manual and automated search strategy

Selection of appropriate data sources, deriving proper search terms, and developing precise search queries are essential in systematic mapping and systematic review studies [464, 465]. In this study, a systematic approach was adopted for designing, executing, and evaluating a suitable search strategy that optimally retrieved the targeted literature from electronic databases. This approach consists of main three steps and sub steps which are shown in Figure 2.

Step 1 is related to the identification of relevant sources and databases [465]. In manual search (also called snowballing), we considered all important databases such as IEEE, ACM, Scopus, Inpsec, SpingerLink, google scholar and science direct. Based on search evidences, it was noticed that the databases (IEEE, ACM, Scopus, Inpsec, SpingerLink) were extracting all the relevant studies therefore they were further considered in automated search. The concept of ‘quasi-gold standard’ (QGS) was introduced for the collection of important studies in the field of value-based software engineering (shown in Figure 2 - step 2.1). Through QGS, the “title, abstract, and keywords” fields of a study/book were scanned and important keywords were obtained regarding VBSE process and sub-process areas that were further included in search queries for automated search (see Figure 2 - step 3.1). The performance of the automated search queries were checked against the ‘quasi-sensitivity’ [465]. Continuous amendments and updation were carried out in search query until it could not retrieved more than 90% studies contained in the QGS (see Figure 2 – step 3.3).
The documentation strategy of search was implemented in following steps.

a) Each researcher created an account in above-mentioned databases for saving all possible records along with executed queries.

b) Both researchers shared an excel sheet named “Systematic-map-search log-history” for maintenance of records. Studies were selected or rejected according to the inclusion and exclusion criteria and a record of selected and rejected studies was maintained. The excel sheet composed of the following attributes: reference no., process areas and sub-process areas, research type, value-based contributions, value dimensions and comments.
3.2.3 Sys-Map Step 3: Pilot selection

Prior to the start of actual inclusion/exclusion procedure, a pilot selection was performed where both researchers applied the designed inclusion/exclusion criteria on a set of 30 studies, individually. During pilot selection some conflicts were identified regarding development and management process areas, research types, value-based contributions, and value dimensions. Both researchers conducted postmortem analysis, and found the imprecise definitions of the above terms as root causes. After refinement of these definitions (see Appendix B, Appendix D, Appendix O), then again we conducted pilot selection on 30 randomly selected studies. In addition, we found that both the researchers had a coherent understanding of the inclusion/exclusion criteria.

During pilot selection, conflicts among researchers were identified regarding the inclusion and exclusion of some fields such as enterprise resource planning, computer aided software engineering, component based software engineering and web services etc. These conflicts were resolved during discussion and then verified from the supervisor in order to ensure common understanding. Afterwards the selected studies were divided equally among the researchers and each researcher did selections independently.

Based on previous records of conflicts related to inclusion/exclusion criteria, we applied Fleiss’ kappa [461] statistic in order to find out the inter-rater agreement and validate the previous manual reported agreements/disagreements. The statistics show a very low agreement value (0.4) between two researchers during first pilot selection (see Appendix BB) that is a fair level according to Landis and Koch [461]. Fair value tells us to find out root causes of disagreements, address these root causes and conduct second pilot selection that we also performed manually. During second pilot selection, this value is improved to (0.720) (see Appendix CC), that is a substantial level according to Landis and Koch [461]. This seemed to be a good starting point for applying inclusion/exclusion procedure.

3.2.4 Sys-Map Step 4: Screening of VBSE studies (Relevant VBSE studies)

All potential primary studies were reviewed that fulfill the following selection criteria shown in Figure 3.

Step 1: It was checked that potential primary studies were written in English, not duplicated and peer reviewed.

Step 2: The relevance of the primary studies was checked with respect to VBSE. The relevance of the studies was decided after reading the title and the abstract. If after
Figure 3: Inclusion and exclusion process

reading the title and abstract sections a decision could not be made, then the introduction and conclusion sections were considered. If there was still an uncertainty about the study then it was tagged as “left for discussion”. The tagged studies were then discussed with the other researcher for final judgment.

Step 3: The primary studies that were available in full text were included in the systematic mapping. However, the primary studies, which we could not get (either in digital or printed format) until the end of systematic mapping process, were rejected.

Step 4: The potential primary studies were checked for any type of evidence or evaluation related to VBSE and included. Table 3 presents the detailed inclusion/exclusion criteria.
Table 3: Study selection criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion</strong></td>
<td></td>
</tr>
<tr>
<td>● As the central concept in our studies is “Value”. Whereas, multiple dimensions of value exists (briefly explained in Section 2.1), therefore if an abstract clearly mentions any value-based keywords, listed in (Appendix A), in the context of software engineering then that study will be selected. From title, abstract, and index terms, researcher is able to determine that whether the study lies in the domain of software engineering or not</td>
<td></td>
</tr>
<tr>
<td>● Studies must be available in full text</td>
<td></td>
</tr>
<tr>
<td>● Studies must be in English language</td>
<td></td>
</tr>
<tr>
<td>● The studies should be peer reviewed (published in a journal, conference or workshop)</td>
<td></td>
</tr>
<tr>
<td>● Studies should contain any one of the research type (i.e. validation research, evaluation research, solution proposal, philosophical research, experience report or opinion report)</td>
<td></td>
</tr>
<tr>
<td>● Studies that present any type of evidence or evaluation related to VBSE should be included</td>
<td></td>
</tr>
<tr>
<td><strong>Exclusion</strong></td>
<td></td>
</tr>
<tr>
<td>● The studies containing value-based keywords but are not in the domain of software engineering, will be excluded</td>
<td></td>
</tr>
<tr>
<td>● Any value-based study available in language other than English will be excluded</td>
<td></td>
</tr>
<tr>
<td>● Any value-based study that does not reflect any research type will be excluded</td>
<td></td>
</tr>
<tr>
<td>● Editorials, prefaces, paper summaries, news, reviews, correspondence, discussions, comments, reader’s letters and summaries of tutorials, workshops, symposium, panels, slides, and poster sessions will be excluded</td>
<td></td>
</tr>
<tr>
<td>● Studies not available in full text will be excluded</td>
<td></td>
</tr>
<tr>
<td>● Any value-based study that doesn’t reflect any research type will be excluded</td>
<td></td>
</tr>
<tr>
<td>● It is not necessary that the studies should be available in digital format, because we had collaborated with a librarian to retrieve the studies in the printed form. However, the primary studies, which we could not get until the end of systematic mapping and systematic review, will be rejected.</td>
<td></td>
</tr>
</tbody>
</table>

3.2.5 Sys-Map Step 5: Developing classification scheme (Key wording using title, abstract and index terms)

The process of creating classification scheme was tailored to meet the aims and objectives of our study [22, 23]. It was followed in two phases as shown in Figure 4.

**Phase 1**: Initially some keywords from seminal research literature [1, 2, 5, 10, 14, 15, 17, 28, 29, 30, 31, 34, 37, 38, 41, 48] were taken to create basic structure of the classification scheme. It was useful to reduce time and effort.
**Phase 2:** Each researcher read title, abstract and index terms to select keywords and understand the concepts that reflected the value-based contribution in studies. If an abstract did not give a clear image of the whole study and keywords, then each researcher read introduction and conclusion. The classification scheme was updated in order to improve the categories and sub-categories with set of all possible relevant keywords from VBSE studies.

![Diagram](image)

**Figure 4:** Developing classification scheme

### 3.2.6 Sys-Map Step 6: Data extraction process and mapping of studies (Systematic map)

After the development of classification scheme, the selected value-based studies were mapped according to the classification scheme. Data was extracted based on: value-based process areas and sub-process areas (see Appendix D), value-based contributions (see Appendix D) and research types (see Appendix B). First pilot data extraction was performed individually on a set of 20 studies and some conflicts were identified regarding value-based contributions especially recommendations and frameworks because of their imprecise definitions. We properly defined value-based contributions and then conducted another pilot selection on 20 randomly selected studies. The results of the second pilot data extraction showed that both the researchers had a common understanding of the data extraction procedure.

Based on previous records of conflicts related to data extraction categories, we applied Fleiss kappa [461] statistic in order to find out the inter-rater agreement and validate the previous manually reported agreements/disagreements. The statistics show a very low agreement value (-0.318) between two researchers during first pilot data extraction (see Appendix Q), that is a poor level according to Landis and Koch [461]. Poor value compels us to find out root causes of disagreements, address these root causes and conduct second pilot data extraction that we also performed manually. During second pilot data extraction, this poor value is improved to a substantial level (0.8) [460, 461] (see Appendix R).

Moreover, we conducted reverse engineering in order to find out inter-rater agreement regarding data extraction categories reported in Appendix P and Appendix S.
Fleiss’ kappa statistics showed inter-rater agreement value (0.79) that is considered substantial according to Landis and Koch [461].

We show the results of mapping as bubble plot diagrams because of its simplicity and effective presentation of results, frequencies of value-based studies and research gaps. Bubble plot consists of two dimensional x-y scatter plots. Bubbles lie on the intersection of each category or sub-category. The size of bubble is directly proportional to the number of studies for each pair of category or sub category (e.g., pair contains requirements engineering and methods).

3.3 Systematic Review Design

In this section, a detailed description of the review design is presented. Section 3.3.1 contains research questions of the review. Section 3.3.2 explains the search strategy of this review. Primary study selection criteria and pilot selection is presented in Section 3.3.3 and Section 3.3.4 respectively. Section 3.3.5 explains the quality assessment procedure. Strategy for the extraction of data from the selected studies is presented in Section 3.3.6. Data synthesis strategy is explained in Section 3.3.7.

3.3.1 Sys-Rev Step 1: Research questions

For this systematic review, the main research question is given below.

Sys-Rev RQ2: What is the level of empirical application/validation of value-based contributions in the selected process area?

The selected process area is requirements engineering (RE). The sub-research questions with motivations are given in the following Table 4.

Table 4: Systematic review sub-research questions

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Research Questions</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sys-Rev_ RQ2.1</td>
<td>Are value-based contributions based on needs identified in industry?</td>
<td>The identification of needs in industry is the initial step in the research agenda formulation and development of a solution [64]. Therefore, it is necessary to investigate that the value-based contribution developed based on any need identified in industry through process assessment or surveys or participation knowledge or observation etc.</td>
</tr>
<tr>
<td>Sys-Rev_ RQ2.2</td>
<td>Are value-based contributions, proposed for the selected process area, applied and/or validated in a laboratory setting or in industry?</td>
<td>There are certain ways to validate the solution such as conduction of lab validation (i.e. Laboratory experiment), conduction of static validation (i.e. interviews or seminars etc.), conduction of dynamic validation (i.e. controlled small test, pilot projects etc.) [64]. Therefore, it is necessary to investigate the applicability/validity of value-based contributions in the selected process area.</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.3</td>
<td>Are the value-based contributions, proposed for the selected process area, usable?</td>
<td>If the value-based contribution is applied/validated in industry/ laboratory experiment then what is the level of usability of value-based contribution [6]?</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.4</td>
<td>Are the value-based contributions, proposed for the selected process area, useful?</td>
<td>If the value-based contribution is applied/validated in industry/ laboratory experiment then what is the level of usefulness of value-based contribution?[6]</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.5</td>
<td>Which of the following factors that challenge or impair the project are considered in studies?</td>
<td>Mapping of Standish group challenges and challenges that are reported in VBRE studies</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.6</td>
<td>Are value dimensions clearly defined in VBRE studies?</td>
<td>In order to find out that whether value dimensions have been defined/described in VBRE studies</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.7</td>
<td>Which methods (tools, techniques etc.) are used to elicit given value consideration or how the value consideration is assigned a value?</td>
<td>In order to find out the conceptual background of value dimensions, empirical investigation/assessment of value dimensions and also the methods, tools, and techniques used to determine value dimensions.</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.8</td>
<td>Which type of value and their components are considered in the study?</td>
<td>As value exist in multiple dimensions, so it has to be answered that what kind of value dimensions are reported and not reported in VBRE studies and to find out the components of value dimensions.</td>
</tr>
<tr>
<td>Sys-Rev_RQ2.9</td>
<td>In which perspective (project, product organization), authors discuss value dimensions?</td>
<td>The main motivation to answer this question is based on onion model[459] to see value dimensions from different perspectives</td>
</tr>
</tbody>
</table>

### 3.3.2 Sys-Rev Step 2: Search strategy
Since the VBRE studies were already identified during the searches for systematic mapping, therefore this step was not repeated.

### 3.3.3 Sys-Rev Step 3: Study selection criteria and procedure
Potential primary studies of VBRE were already reviewed based on the selection criteria during systematic mapping. Therefore, this step was not repeated.

### 3.3.4 Sys-Rev Step 4: Pilot selection
Since pilot selection was already done during systematic mapping therefore this step was not repeated.
3.3.5 **Sys-Rev Step 5: Study quality assessment**
In this systematic review, the study quality assessment covered both quantitative and qualitative studies because the aim was to assess levels of empirical evidence and not to force any restriction in terms of any specific experimental design or research method.

3.3.6 **Sys-Rev Step 6: Data extraction strategy**
Following extraction categories were used to extract data (see Table 5).
Table 5: Data Extraction Strategy and category definition

<table>
<thead>
<tr>
<th>Extraction category</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Type</td>
<td>For description of the research types see Appendix B.</td>
</tr>
</tbody>
</table>
| Empirical basis of needs / problems | **Empirical:** It may be validation research, evaluation research or solution proposal. Is value-based contribution developed on the basis of empirically identified need/problem/issue? [6]  
  **Empirical rationale reported as:** If yes, then the rationale for empirically identified need can be categorized as  
  **VBSE agenda(survey, interviews and focus group):**  
  Those studies that refer VBSE agenda means that their empirical basis of need reported as “survey, interviews and focus group” and will be considered as strong empirical basis of need in those studies.  
  **VBSE agenda motivation:** Standish group [3, 4] conducted surveys, personal interviews with IT executives, and focus groups in small, medium and large organizations in order to find out the most critical factors for project success and failures. Value-oriented shortfalls responsible for projects failures are incomplete requirements, lack of user involvement, lack of resources, unrealistic expectations, lack of executive supports, changing requirements and specifications, lack of planning, lack of IT management, technology illiteracy, and unrealistic time frames etc [1, 3, 4]. However, value neutral software engineering principles and practices do not deal with the value oriented shortfalls. Besides the concepts from other fields [1], value oriented shortfalls identified by Standish group [3, 4] has major contribution in the development of VBSE agenda [1].  
  **Process assessment:** The author reveal the need for value-based contribution by conducting formal process assessment such as PARSEQ, REPEAT, RAM, and RDEM etc.  
  **Interview:** the need for value-based contribution resulted by conducting interviews with experts.  
  **Participation knowledge:** The identification of need resulted with the help of participation knowledge.  
  **Statement only:** The author claims in written statement that the need for value-based contribution is identified without conducting interview, process assessment, and participation knowledge.  
  **Non-empirical:** It may be philosophical, opinion or experience report. |
| Application/ validation method | Application/validation research method: If a study contains empirical application/validation then what research method is used such as experiment, survey, case studies, interview, observation, prototyping etc [6]. |
**Application/validation research design:** If a study contains empirical application/validation then we analyze that how the design of the application/validation method is explained. The possible levels of design are statements, summary and detail [6], which are explained as follow.

1. **Statement only:** If the author reports the empirical application/validation of the proposed solution without providing any summary/detail [6].
2. **Summary:** The author describes the design of the application/validation method in a brief manner (i.e. in some sentences without providing any details about the research questions, sampling of population, study’s context and execution, validity threats etc.) [6].
3. **Detail:** when the author reports in detail about the application/validation method including research questions, sampling of population, study’s context and execution, validity threats etc. [6].

**Application/validation result explained:** If a study contains empirical application/validation then how the results are explained such as nothing, statements only, qualitative results, quantitative results, and qualitative in combination with quantitative results[6] [57]. The above terms are explained as follows:

1. **Nothing:** The results of the application/validation are not provided in the study.
2. **Statement only:** The results are given in the form of statements without any clarification of how these were obtained, for example; “The benefits of getting the quality requirements “right” can be substantive …” [124].
3. **Qualitative results:** It refers to the subjective interpretation of words, pictures or objects [463], meanings rather than numbers [462] through participant observation, or in-depth interviews with expert [6].
4. **Quantitative results:** The results of the application / validation of the proposed solution are presented in the form of numbers and statistics [462, 463], precise measurement (metrics) [6].
5. **Qualitative + Quantitative results:** It refers to the combination of both qualitative and quantitative results.

| Usability and usefulness | Usable and useful: It can be YES or NO |
Usability and usefulness stated in study: If study contains usability and/or usefulness of value-based contributions then it can be reported as statement only, qualitative data, quantitative data or qualitative plus quantitative data [6].

Usability and usefulness can be defined in terms of the following attributes.

Usability:

1). Scalability of introduction: This attribute shows that how scalable is the proposed solution in terms of introduction cost such as manuals, training, labor, cost of adopting the proposed solution etc. [6].

2). Scalability of use: This attribute shows that how scalable is the proposed solution in terms of input, output and processing time. For example if a solution is proposed then does it solve the problems in industry? [6]

Usefulness:

Better Alternative investment: This attribute shows that how much better is the proposed solution than an existing or previous proposed solution in terms of usability, availability, reliability, return on investment etc. [6]

Effectiveness: This attribute shows that how effective is the proposed solution in terms of achieving the proposed goals or solved the company problems. [6].

Example usefulness is as follows:

**Usefulness**

**Statement only:** The authors have been written statements that show the usefulness of the proposed solution like “The knapsack approach presented here provides an easier, more reliable way to find an optimal solution than plotting cost-value points on an xy-plane” [111].

**Qualitative data:** This data can be obtained through expert opinions. For example, during the interview some experts claim that the proposed solution will be useful than the existing solution for requirements prioritization.

**Quantitative data:** The quantitative data that shows the usefulness of the proposed solution as compared to the existing solution. For example in [120], the proposed approach for requirements change management is compared to other approaches, that produced better results in terms of handling requirements change request, reduces effort and cost to analyze change scope and to maintain requirements traceability links.

**Qualitative plus quantitative data:** both qualitative and quantitative data proving effectiveness of proposed solution
| **Metrics** | It can be Yes or No  
| Metrics are used to capture information about attributes/components/determinants of value dimensions. You cannot control value dimensions if you cannot measure it. In order to see that how better alternative investment and effectiveness of proposed solutions are measured.  
| If a study report a metric then it will be Yes otherwise No |
| **Challenges addressed** | It can be challenges that are reported in Standish group studies and can be other challenges. |
| **Value dimensions definitions/ descriptions** | It can be yes or No  
| If a study define/describe value dimension in some form then it will be yes otherwise No. |
| **Elicitation of value dimensions** | It consist of three attributes that are as follows  
| **Conceptual background of value dimensions:** As VBSE borrows the concepts and ideas from various disciplines, for example, finance, economics, marketing strategies, business administration, innovation and entrepreneurship, management science, economics, humanities, and cognitive sciences. In order to find out that how many VBRE studies presents conceptual analysis of value dimensions.  
| **Empirical investigations of value dimensions:** To find out number of studies that report empirical investigation of value dimensions.  
| **Methods/Process/scales to determine value dimensions:** different types of methods/tools/process are used to determine value dimensions. Such as Gap analysis [466], CVA analysis [467], Kano model and Kano questionnaires and Internal value analysis (IVA)[459]. |
Type of value and components

**Type of value** can be different types of value dimensions such as product value, customer value, business value or stakeholder value. For example, [81, 86, 94, 95, 117] reported different types of value with main emphasis on product value.

**Components of value dimensions** are those attributes that constitute value dimension. For example: the possible important drivers of business value are product sales[81, 86, 110], stakeholder savings[119], increase in sales revenue[119], sales value[137], marketing value [137], competitiveness[137], strategic alliance[137], customer retention[137], customer satisfaction[137], integrity[137], product Diversification[92], improving process [92], product or new business opportunities [92], meeting business goals and customer needs [92], reduced time-to-market [92, 101], revenue generation[92, 101, 110], value of technology[101], return on investment[101, 103], usefulness[101], market shares[101], project completion time[103], robust requirements process[108], measurable requirements[108], reusable requirement[108], embrace change[108], and contractual innovation[108].

Value dimension perspectives

Five level perspectives are described in [459] such as requirement phase, project level, product level, company level and society level [459]. Value dimensions are mapped on different levels of onion model. Value dimensions are viewed from different level perspectives. For example, [89, 117, 133] reported product value from product perspective.

Prior to the actual data extraction, both researchers performed a pilot extraction in order to ensure that each member has the same interpretation of the form and data to be extracted. The pilot data extraction was performed on a set of 20 selected studies. During pilot data extraction, conflicts among researchers were identified on empirical investigation of needs/problems, and usefulness of proposed solutions reported in studies. These conflicts were resolved through discussion and additionally the extracted data was verified from the supervisor in order to ensure homogenous understanding of data extraction categories. After refinements, we conducted a second pilot on 20 randomly selected studies and the results were quite satisfactory.

Based on previous records of conflicts related to data extraction categories for systematic review, we applied Fleiss kappa [461] statistic in order to find out the inter-rater agreement and validate the previous manually reported agreements/disagreements. The results show that the inter-rater agreement (i.e. 0.3) was very low between the researchers during first pilot extraction (see Appendix T, and Appendix Z), that is a fair level according to Landis and Koch [461]. Fair value demands to find out root causes of disagreements, address these root causes and conduct second pilot data extraction that we also performed manually. During second pilot data extraction, this fair value is increased to a substantial level (0.8) [261] (see Appendix U, and Appendix AA).

Moreover, we conducted reverse engineering in order to find out inter-rater agreement regarding systematic review data extraction categories reported in Appendix V, Appendix W, Appendix X and Appendix Y. Fleiss’ kappa statistics showed inter-rater agreement value (0.73) that is considered substantial according to Landis and Koch [461].
3.3.7 Sys-Rev Step 7: Data Synthesis Strategy

For the systematic review data synthesis was carried out in descriptive form [52]. The extracted data from the studies were gathered in tabular form to answer review questions. Then after summarizing the results of selected studies, they will be presented in the form of graphs.

3.4 Validity Threats

Threats to validity of systematic mapping and systematic review have been identified and discussed in sections below.

3.4.1 Internal validity threats

Internal validity threats are concerned with the issues of design and its execution in order to prevent systematic errors [52, 67]. The potential internal validity threats for this study are as follows:

One of the great challenge in doing systematic map and systematic review of VBSE topic, was that most of the studies that deals with VBSE concept do not mention “value-based” keyword anywhere within the study. Overall, the threat was in the form of existence of multiple dimensions of value that needs to be properly identified and defined. To minimize this threat (see Section 3.2.3), keywords were selected with extreme caution from seminal literature in VBSE [1, 2, 5, 14, 15, 17, 28, 29, 30, 31, 34, 37, 38, 48] through snowballing approach. Moreover, selected keywords were verified from the supervisor and a senior librarian in order to carry out the work within the domain of VBSE. Set of keywords used are listed in (see Appendix A).

The set of value and value dimension keywords are very general and have been discussed in many fields including software engineering. We found that value dimensions studies were not only published in software engineering but also in many relevant fields i.e. business, finance, economics and management. To overcome the threat of missing relevant studies, we adopted some precautionary measures that are as follows:

1) VBSE studies that lie in the domain of business, economics, management, finance, and marketing and that have clear connection with software engineering, were selected. We did not include any study from other domains like medical, physics, chemistry, mathematics, manufacturing etc. the excluded field have been clearly mentioned in database searching queries.

2) We also did not include any studies from enterprise resource planning, component based software engineering, computer aided software engineering, web services, electronic commerce, information system and service oriented architecture in order to keep our work within the boundaries of value-based software engineering.

3) We had some interesting sessions with students that have business, economics, management and finance academic background in order to setup our mind regarding different concepts and terminologies.

4) The inclusion and exclusion of studies, placing them in proper process areas and sub process areas could be biased. To minimize this threat (see Section 3.2.3), we developed systematic mapping and systematic review protocols, verified it
from supervisor and then followed these protocols in a systematic way. Both researchers selected the studies individually based on criteria. If one researcher could not decide about study, regarding acceptance or rejection then both take decision based on mutual agreement after discussion. In cases where both could not reach an agreement, the conflicts were resolved after discussing with the supervisor.

3.4.2 Conclusion validity

Conclusion validity threats are concerned with the relationship between the data extraction process and outcome of the study [52, 67]. The potential conclusion validity threat in this study is related to the reliability of the data extraction categories. In order to overcome this threat (see Section 3.2.3 & Section 3.3.6), the researchers identified the data extraction categories based on research questions of systematic mapping and systematic review. These data extraction categories were further refined in meetings with the supervisor. The studies were scanned thoroughly and any claim made by the researchers was considered as evidence. However, the claims were further analyzed that are evident from each step of systematic mapping and systematic review carried out in this thesis.

3.4.3 Construct validity

Construct validity is concerned with relationship between the theory and the application [67]. The potential construct validity threat is related to keywords and concepts used in this study; it is quite possible that the concepts used in one construct could be misinterpreted by the researchers. But we believe that this risk is quite minimal because of the careful evaluation of the context of value.

3.4.4 External validity

External validity threats are concerned with the generalization of results [52, 67]. The potential external validity threat for this study is related to the generalization of results of this study. The researchers believe that the results of the study could be more generalizable if they have been validated with empirical means or interviews with experts. The main challenge with systematic mapping and systematic review is the reliability. Reliability of the study has been ensured by involving two researchers in the study and by piloting review protocol.
4 RESULTS

4.1 Systematic Mapping

The following sections describe the results of primary study selection and its characteristics.

4.1.1 Execution of search queries and primary study selection

We executed different search strings in different databases meeting their particular format requirements. All the search strings are given in Appendix C. Selection of primary studies for development and management process areas are shown in the following Figure 5.
We retrieved a total of 27,404 studies by using the search strings devised for systematic mapping study. We found 4,741 studies as duplicates and 976 studies as proceedings, and therefore these were excluded. Furthermore, based on title, abstract, and introduction/conclusion 14,146, 6,805 and 371 studies were excluded from the remaining pool of studies respectively. The remaining 364 studies were selected as primary studies.

The results of systematic mapping are presented process area-wise as answers to the sub-research questions posed. Answer to sub-research question: Sys-Map RQ1.4 (Are there any gaps with respect to the context, contribution and research type in the field of VBSE?), would be presented in detail in Section 5 where answers of Sys-Map RQ1.1, Sys-Map RQ1.2 and Sys-Map RQ1.3 are analyzed and discussed.
Overall VBSE Map

Mapping of selected studies to the process areas in Figure 6 clearly shows that a clear majority of value-based research is concerned with requirements engineering (70 studies), verification and validation (59 studies), quality management (54 studies) and project management (48 studies). Whereas, there were not many studies discussing architecture, design, development and people management from value-based perspective. Complete map is given in Figure 6.

In terms of research types used, evaluation research\textsuperscript{314} and solution proposal\textsuperscript{315} were the most dominant research types in general. In addition, some studies also used validation research\textsuperscript{316} but such studies are relatively fewer in number. Since VBSE is a relatively new field, it is important that experience reports are written to ascertain if value-based solutions address challenges faced in industry. However, experience\textsuperscript{317} and philosophical research\textsuperscript{318} were fewer in number. Moreover, only two opinion reports\textsuperscript{319} were identified in whole systematic mapping process.

Processes\textsuperscript{320} and recommendations\textsuperscript{321} as value-based contributions were highest in number. Moreover, methods\textsuperscript{322} and models\textsuperscript{323} were also proposed, whereas, frameworks\textsuperscript{324} and tools\textsuperscript{325} were comparatively fewer in numbers.

\begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{Overall VBSE.png}
  \caption{Bubble plot of Overall VBSE}
\end{figure}
4.1.2 Value-based Requirement Engineering (VBRE)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

Within value-based requirements engineering (VBRE), largest numbers of studies were found in sub-process areas: release planning, requirements prioritization and traceability. 25 studies\(^1\) in requirements engineering process area focused on release planning, 12 studies\(^2\) on requirements prioritization and eight studies\(^3\) on traceability of requirements. In addition, nine studies\(^4\) focused on product line engineering for business value. However, value-based contributions in other sub-process areas (for example, requirements elicitation, validation, and roadmapping) were not that many; the mapping details are given in Figure 7.

Figure 7: Bubble plot of Value-based requirement engineering
Sys-Map RQ1.2: What types of contributions are presented in the selected studies?

In general, contributions as methods\(^5\), processes\(^6\) and recommendations\(^7\) were proposed in large number. Whereas, not many models\(^8\), tools\(^9\), and frameworks\(^10\) have been proposed within VBRE.

Within release planning, largest number of studies suggested new methods/techniques\(^11\) for release planning. For example, [139] proposed a systematic method EVOLVE+ for release planning. Similarly, [129] proposed H2W method to re-plan an existing product release strategy in order to manage the volatility of features and dynamic changes in stakeholders needs. [131] proposed quantitative Win-Win method to manage the conflicting priorities of different stakeholders regarding requirements selection for a release plan. In order to estimate different aspects of product value in release planning, a value estimation (VP) method [133] was proposed. Six studies provided recommendations\(^12\) and three studies proposed tools\(^13\). Few studies\(^14\) proposed criteria for requirements selection in release planning process to create product value. For detailed visual results see Figure 7.

In requirements prioritization, five studies\(^15\) out of 10 proposed new process/approach, four suggested methods/techniques\(^16\) and four proposed frameworks\(^17\). For example, cost-value approach [78] (here cost refers to implementation cost, and value refers to customer or user's value) was proposed for requirements prioritization. [137] proposed a framework VOP that was used to manage requirements selection and prioritization issues in order to produce business value.

Whereas, studies about requirements traceability have either mostly reported recommendations or practices\(^18\) or have proposed a process or an approach\(^19\). For example, it is quite expensive, complex and erroneous to establish traceability links among different software artifacts such as requirements, architecture and source code. In order to overcome these issues, a value-based traceability approach [85] was proposed.

Moreover; two studies\(^20\) proposed processes/approaches, two studies proposed methods\(^21\); one study proposed model\(^22\) and four studies suggested recommendations\(^23\) in product line engineering.

In less focused areas like requirements elicitation, authors have presented/proposed recommendation/practice\(^24\), method\(^25\), process/approach\(^26\) or models\(^27\). The details and visual results of research type and value-based contributions in value-based requirements engineering are presented in Figure 7.

Sys-Map RQ1.3: Which research types are used in the selected studies?

The visual map in Figure 7 shows that in general evaluation research\(^28\) and solution proposal\(^29\) are the most dominant research types in VBRE. Whereas, validation research\(^30\), experience report\(^31\) and philosophical research\(^32\) are fewer in numbers.

Within release planning, the most dominant type of research is evaluation research\(^33\). In addition, studies about release planning have used validation research\(^34\) (four studies) and solution proposal\(^35\) (two studies).

The studies about prioritization used following research types: evaluation research\(^36\) (seven studies), solution proposal\(^37\) (four studies), experience\(^38\) (one study) and philosophical\(^39\) (one study). Whereas, traceability related studies\(^40\) used evaluation research (five studies) and solution proposals\(^41\) (three studies).
Studies about product line engineering used evaluation research \(^{42}\) (six studies), experience report \(^{43}\) (two studies), validation research \(^{44}\) (one study), and philosophical \(^{45}\) (one study).

There are very few studies using validation research and experience report types. There could be several possible reasons for this. For example, in order to perform validation research of a proposed requirements prioritization solution, it is difficult to create/simulate industrial requirements prioritization challenges like conflicting interests of multiple stakeholders, fixed deadlines, large number of requirements to prioritize, fewer resources etc in a controlled environment. When it comes to experience reports, it could be the case that industry practitioners are not keen on writing research results of the solutions they apply to solve requirements engineering challenges.

**Figure 8:** Focused value dimensions in value-based requirements engineering

**Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?**

From 70 selected value-based requirements engineering primary studies, value dimensions like **business value** (16 studies), **value** (16 studies), and **others** (24 studies) were emphasized more (as shown in Figure 8). Here **others** contain methods such as cost-benefit analysis, cost-value, and return-on-investment that calculate some aspects of value dimensions. Whereas, **product value** (nine studies), **customer value** (eight studies), **stakeholder value** (six studies), and **system value** (six studies). Some of the studies (see Appendix E) reported **value** however; it is not clear what type of value it is.

For bespoke projects, cost-benefit based value analysis makes sense however, in market driven context **customer value, product value** and return-on-investment need to be evaluated than simple cost-benefit analysis. But it was observed that even for market-driven requirements engineering, more focused value estimation method is cost-benefit analysis whereas, rest of value dimensions are either less emphasized or ignored in studies. Detailed value dimensions along with value-based contributions in value-based requirements engineering are presented in Appendix E and Appendix N.
4.1.3 Value-based Architecture (VBA)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

As can be seen from Figure 9, within value-based architecture process area, studies about architecture design decision (12 studies) and architecture evaluation (nine studies) were larger in number. Whereas, value-based contributions in other sub-process areas (for example, architecture structure and viewpoint, and linking RE activities with architecture) were not emphasized; their mapping details can be seen in Figure 9.

Sys-Map RQ1.2: What types of contributions are presented in the selected studies?

In general, contributions as processes, and methods were dominant whereas, recommendations, models, tools, and frameworks were given less attention in value-based software architecture. The visual details of research types and value-based contributions are presented in Figure 9.

Within architecture design decision and practices, four studies out of 12 proposed new process/approaches, four presented frameworks, and another three proposed some methods or techniques. For example, a number of processes/approaches were proposed for adaptation of ATAM, value assessment and considerations and value-based rational documentation in software architecture design practices. Furthermore, a number of frameworks were proposed to reflect and manage issues (economical and technical), explicit requirements negotiations component and architectural choices from the perspective of end-users in the process of architecture design. Methods/techniques proposed mainly focused on the economic criteria and cost-benefit analysis (here cost refers to architecture strategies implementation cost and benefits refer to value of architecture strategies with respect to ROI) to support architecture design decisions.

Within architecture evaluation sub-process area, three studies presented new processes/approaches and three other studies proposed methods/techniques (one study i.e. 161 proposed two methods). For example, processes/approaches were presented for value assessment, customer value analysis in terms of quality requirements and economic benefits analysis in architecture. Whereas, methods or techniques were proposed to support a multi-criteria decision-making process in architecture evaluation. Detail mapping can be seen in Figure 9.

Sub-process areas like architecture structure and viewpoints are important areas within VBA. However, value-based frameworks, models, approaches, and methods are missing in these areas.

Sys-Map RQ1.3: Which research types are used in the selected studies?

Similar to VBRE, evaluation research and solution proposal are the most dominant types of research in VBA. Whereas, studies using validation research, experience report and philosophical research are fewer in numbers.

Studies about architecture design decisions and practices used evaluation research (10 studies), solution proposal (four studies), experience report (three studies), validation research (two studies), and philosophical research (one study), whereas studies about architecture evaluation used evaluation research (six studies), solution
proposal\textsuperscript{75} (two studies), experience report\textsuperscript{76} (two studies) and validation research\textsuperscript{77} (one study).

\begin{figure}
\centering
\includegraphics[width=\textwidth]{value_based_architecture.png}
\caption{Bubble plot of value-based architecture}
\end{figure}

**Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?**

From 25 value-based architecture studies, value dimensions like value (10 studies) and others (16 studies) were highly emphasized as shown in Figure 10. Whereas, rest of the value dimensions were either less emphasized or completely ignored. Details of value-based contributions reported for value dimensions in value-based architecture are presented in Appendix F and Appendix N.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{focused_value_dimensions.png}
\caption{Focused value dimensions in value-based architecture}
\end{figure}
4.1.4 Value-based Design (VBD)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

Within value-based design (VBD), a number of studies were found in sub process areas: modularity, and design decisions. As evident from Figure 11, four studies in value-based design focused on modularity, and three studies focused on design decision. Value-based contributions in sub-process areas (for example, design issues, modeling language, design strategies and methods, design maintainability, design evaluation and design review) was not that many however; their mapping details can be seen in Figure 11.

Sys-Map RQ1.2: What types of contributions are presented in the selected studies?

When it comes to contributions, processes and recommendations have been proposed in large number. Whereas, in addition, few methods are also proposed but models, tools, and frameworks have not been proposed for value-based software design. The visual details of research types and value-based contributions in value-based software design are presented in Figure 11.

Within modularity, few studies suggested recommendations, processes/approaches and frameworks. Only two studies suggested recommendations/practices for the analysis and assessment of aspect modularization. For example, [4] proposed the analysis of modularity in aspect oriented design by using the three major elements such as Design Structure Matrix (DSM), Modular Operators, and Net Options Value (NOV). Similarly, [171] proposed that how aspects modularizations could be beneficial as well as detrimental while using DSM and NOV. Furthermore, only one study proposed an approach for modeling software designs that incorporate information hiding and value considerations. Moreover, one study proposed a framework to assist software designers in making reliable design decisions with respect to engineering cost and time to market. Detail mapping can be seen in Figure 11.

Besides modularity, within design decision processes/approaches and recommendations/practices were focused in research. For example, [176] proposed an approach that helps designers to take decisions about software future design. Similarly, in [178] a real-options-based approach was proposed that evaluate, improve, and generate softwarc design decision-making heuristics. Furthermore, recommendations/practices [175] were proposed for commercial software design decisions in order to cope with marketplace issues related to ROI, cost (here cost refers to development, maintenance, upgrades, and customer support cost) and risk (here risk refers to project failure, budget overrun, and revenue shortfall). Similarly, in [179] proposed recommendations for making investments of irreversible capitals in the face of uncertainty. Detail mapping can be seen in Figure 11.

For less focused areas like design evaluation, authors have reported process/approach. The details and visual results of research type and value-based contributions in value-based design are presented in Figure 11.
### Research type

<table>
<thead>
<tr>
<th>Value-based design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value-based contributions</td>
</tr>
<tr>
<td>Value-based design</td>
</tr>
<tr>
<td>Design issues</td>
</tr>
<tr>
<td>Modelling languages</td>
</tr>
<tr>
<td>Modularity</td>
</tr>
<tr>
<td>Design documentation</td>
</tr>
<tr>
<td>Design decision</td>
</tr>
<tr>
<td>Design review</td>
</tr>
<tr>
<td>Design strategies and methods</td>
</tr>
<tr>
<td>Design maintainability</td>
</tr>
<tr>
<td>Design evaluation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value-based contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>Method/technique</td>
</tr>
<tr>
<td>Tool</td>
</tr>
<tr>
<td>Framework</td>
</tr>
<tr>
<td>Process/approach</td>
</tr>
<tr>
<td>Metric</td>
</tr>
<tr>
<td>Evaluation research</td>
</tr>
<tr>
<td>Opinion report</td>
</tr>
<tr>
<td>Solution research</td>
</tr>
<tr>
<td>Experience report</td>
</tr>
<tr>
<td>Validation/philosophical research</td>
</tr>
</tbody>
</table>

### Figure 11: Bubble plot of Value-based Design

**Sys-Map RQ1.3: Which research types are used in the selected studies?**

The visual map in Figure 11 shows that evaluation research\(^9\), experience report\(^3\) and philosophical research\(^4\) are the most used research types within value-based design. Whereas, solution proposal\(^5\), validation research\(^6\) are few in numbers. It is important to note that there is no opinion research carried out in value-based design and the reasons for it will be discussed in Section 5.

Studies about modularity used evaluation research\(^7\) (two studies) and philosophical\(^8\) (two studies), whereas studies about design decisions used experience report\(^9\) (two studies), solution proposal\(^10\) (one study) and philosophical research\(^11\) (one study).

**Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?**

From 13 value-based design studies, main emphasis were given to value dimensions like **others** (10 studies) as shown in Figure 12. While **economic value** (two studies) and **intellectual capital** (two studies) were also considered. Other of the value dimensions were either given less attention or completely ignored as shown in Figure 12. Detailed value dimensions along with value-based contributions in value-based design are presented in Appendix \(G\) and Appendix \(N\).
4.1.5 Value-based Development (VBDev)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

Within value-based development, a number of studies were found in sub-process areas: reusability and programming paradigm. As can be seen from Figure 13, 10 studies\textsuperscript{102} particularly have focused on reusability, and four studies\textsuperscript{103} focused on programming paradigm. Value-based contributions in sub-process areas (for example, development models, integration and anticipating change) were not that many however; their mapping details can be seen in Figure 13.

Sys-Map RQ1.2: What types of contributions are presented in the selected studies?

A number of recommendations\textsuperscript{104} and models\textsuperscript{105} have been proposed. Whereas, few methods\textsuperscript{106}, tools\textsuperscript{107}, processes\textsuperscript{108} and frameworks\textsuperscript{109} have been developed/proposed in value-based software development. Complete visual results of research type and value-based contributions in value-based development are presented in Figure 13.

Within reusability, 10 studies particularly focused on recommendations, models, metrics and frameworks. Out of 10, six studies\textsuperscript{110} suggested recommendations. For example, [194] suggested recommendations for code reusability in order to improve software productivity and quality of individual components. Similarly, [195] have suggested recommendations for the selection of methods regarding business case for software reuse. Furthermore, three studies\textsuperscript{111} proposed models for reusability of coding that calculate cost, benefits and return-on-investment. Here cost refers to reuse cost with respect to % efforts, development error detection and repair rate cost, reuse cost avoidance, and maintenance cost avoidance.

One study\textsuperscript{112} developed software reuse metrics for measurement of code that help in calculating return on investment for a software project. Furthermore, one study\textsuperscript{113}
proposed value-based process-decision framework for the development of COTS-based applications. For complete results see Figure 13.

Within programming paradigm, three studies\textsuperscript{114} suggested recommendations/practices. For example, [191] proposed recommendations for how to reduce costs (here cost refers to total time required to accomplish tasks, warranting, training and support) and increase benefits (it refers to time saving at each phase of the life cycle) in object oriented analysis for system modeling (i.e. design and coding). Similarly, the system’s value increases when it is modular, the easier it is to produce and extend. Recommendations \textsuperscript{188} about aspect-oriented programming technologies were proposed in order to improve system modularity by modularizing crosscutting concerns. Moreover, one study proposed model\textsuperscript{115} and one study proposed method/technique\textsuperscript{116} for programming paradigm as shown in Figure 13.

For less focused areas like development models, authors have reported either recommendations\textsuperscript{117} or models\textsuperscript{118}. Complete results of research type and value-based contributions in value-based development are presented in Figure 13.
Figure 13: Bubble plot of Value-based development
Sys-Map RQ1.3: Which research types are used in the selected studies?

Experience reports\textsuperscript{119}, solution proposals\textsuperscript{120} and evaluation research\textsuperscript{121} are the most dominant types of research in value-based development. Whereas, studies using philosophical research\textsuperscript{122} and validation research\textsuperscript{123} are relatively fewer in number. Moreover, no opinion report is found during the study of value-based development.

Studies about reusability used experience\textsuperscript{124} (five studies), solution proposal\textsuperscript{125} (three studies), and evaluation research\textsuperscript{126} (one study), philosophical\textsuperscript{127} (one study), whereas studies about programming paradigms used experience report\textsuperscript{128} (two studies), evaluation research\textsuperscript{129} (one studies), solution proposal\textsuperscript{130} (one study), validation research\textsuperscript{131} (one studies) and philosophical research\textsuperscript{132} (one study).

![Figure 14: Focused value dimensions in value-based development](image)

Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?

In 30 studies, value dimensions like \textit{business value} (nine studies) and \textit{others} (17 studies) were highly focused. While value dimensions such as \textit{project value} (six studies), \textit{system value} (four studies), and \textit{stakeholder value} (four studies) were also focused as shown in Figure 14. Whereas, rest of value dimensions were ignored in the literature. Detailed value dimensions along with value-based contributions in value-based development are presented in Appendix H and Appendix N.
4.1.6 Value-based verification and validation (VBV&V)

**Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?**

Within value-based verification and validation studies, largest numbers of studies were found in sub-process areas: software testing (41 studies\(^\text{133}\)) and inspection process (17 studies\(^\text{134}\)).

Within software testing, it was found that 21 studies\(^\text{135}\) focused on testing levels. Whereas, value-based contributions in other sub-process areas (for example, software testing fundamentals, software testing techniques, software testing related measures and software testing process) were not that many however; the mapping details can be seen in Figure 15.

Within testing levels, nine studies\(^\text{136}\) focused on regression testing. Whereas, value-based contributions in other important testing levels (for example, integration testing, installation testing, alpha/beta testing and usability testing) were not that many as shown in Figure 16. The reasons for not focusing these areas will be discussed in detail in analysis and discussion Section 5.1.5.

**Sys-Map RQ1.2: What types of contributions are presented in the selected studies?**

A lot of recommendations\(^\text{137}\) have been proposed. In addition, a number of models\(^\text{138}\), processes\(^\text{139}\) and frameworks\(^\text{140}\) are also proposed. However, methods\(^\text{141}\) and tools\(^\text{142}\) are fewer in numbers in value-based verification and validation.

Within software testing out of 41, 20 studies proposed recommendations\(^\text{143}\), eight studies proposed processes/approaches\(^\text{144}\) as can be seen from Figure 15. In addition, models\(^\text{145}\), frameworks\(^\text{146}\) and method/techniques\(^\text{147}\) are also proposed in software testing as shown in Figure 15. Moreover, recommendations\(^\text{148}\) as value-based contributions for inspection process were highly emphasized as can be seen from Figure 15. For example, [221] conducted an experiment for cost-benefit comparison of different inspections methods. Here cost refers to total effort spent in preparation and meeting with respect to development interval and detection effectiveness and benefits refer to detection of defects. Whereas, [240] recommended that benefits and net gain of re-inspection is lower than the initial inspection. Furthermore, [220] concluded that inspection without meeting resulted into more defects. Furthermore, out of 17, three studies\(^\text{149}\) proposed process/approach, two studies proposed method/technique\(^\text{150}\), two studies proposed model\(^\text{151}\), one study\(^\text{152}\) suggested a framework, and one developed a tool\(^\text{153}\) for inspection process as shown in Figure 15. For example, [238] proposed a model that is useful to calculate the benefits, net gain, and return-on-investment of inspection.
Within software testing level, 13 studies have provided value-based recommendations\(^{154}\) for different testing levels and four studies\(^{155}\) proposed frameworks one each for unit testing, module testing, usability testing and component based testing as can be seen in Figure 16. Moreover, within software testing process, it can be seen from Figure 15 that three studies\(^{156}\) proposed process/approaches, and three studies\(^{157}\) proposed models and four studies\(^{158}\) suggested some recommendations. Whereas, only one recommendation\(^{159}\) and process/approach\(^{160}\) were proposed for software testing techniques as shown in Figure 17. This clearly shows that less attention has been given to testing techniques in software testing. The reason for less attention will be discussed in discussion Section 5.1.5.

**Figure 15:** Bubble plot of Value-based verification and validation
With further exploration of studies about software testing levels, it is found that much emphasis is given to regression testing. Out of nine, five studies have suggested recommendations, three studies have suggested models and two studies have proposed processes/approaches for regression testing. For example, [218] proposed cost-benefit models that can assess mythologies of regression testing. Here cost refers to testing activities such as test setup, identifying and repairing obsolete test cases, execution, validation, test suite maintenance and management of test suite and overhead, database, and development of new test cases [218].

Whereas, [255] proposed a value-driven approach called PORT that prioritizes test cases at system level for regression testing based upon requirements volatility and fault proneness, customer importance, and implementation complications. Moreover, only one study proposed framework and three studies provided recommendations for value-based unit testing.

**Figure 16**: Bubble plot of value-based software testing levels
Research type
Value-based contributions
Software testing techniques
Framework
Model
Method/technique
Tool
Framework
Process/approach
Metric
Evaluation
research
Opinion
type
Solution
research
Experience
report
Validation
research
Philosophical
research

Usability testing
Fault based techniques
Usage based techniques
Specification based techniques
Code based techniques

Figure 17: Bubble plot of value-based software testing techniques

For less focused area like testing related measures authors have reported recommendations/practices\textsuperscript{166}, approach\textsuperscript{167}, proposed models\textsuperscript{168} and frameworks\textsuperscript{169}. Similarly, for testing techniques, authors have reported one recommendation\textsuperscript{212} and one process/approach\textsuperscript{229}. Whereas, value-based contributions have been completely ignored in the following sub-process areas: software testing fundamentals, alpha and beta testing, installation testing, system testing, integration testing, configuration testing, code based and fault based testing. The visual details of research types and value-based contributions in value-based verification and validation are presented in Figure 15, Figure 16, and Figure 17.

**Sys-Map RQ1.3: Which research types are used in the selected studies?**

Dominant research types in value-based verification and validation are validation research\textsuperscript{170}, evaluation research\textsuperscript{171} and solution proposal\textsuperscript{172}. Whereas, philosophical\textsuperscript{173} and experience report\textsuperscript{174} are relatively fewer in number as shown in Figure 15.

Studies about testing levels have used validation research\textsuperscript{175} (10 studies), evaluation research\textsuperscript{176} (eight studies), solution proposal\textsuperscript{177} (four studies), experience report\textsuperscript{178} (one study), and philosophical\textsuperscript{179} (one study) as shown in Figure 16.

In testing level, studies related regression testing used validation research\textsuperscript{180} as dominant research type as shown in Figure 16. Whereas, studies about software testing process used validation research\textsuperscript{181} (five studies), solution proposal\textsuperscript{182} (three studies), evaluation research\textsuperscript{183} (two studies), opinion reports\textsuperscript{184} (one study), experience\textsuperscript{185} (one study), and philosophical\textsuperscript{186} (one study) as shown in Figure 15.
Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?

From a total of 59 studies about value-based verification and validation, value estimation methods like others (49 studies) were highly focused. Here the category others contain methods such as cost-benefit analysis, return-on-investment, option value and earned value that calculate some aspects of value dimensions. In addition, value (eight studies), and business value (seven studies), were also emphasized in literature. Whereas, most of the value dimensions were given either less attention or completely ignored as shown in Figure 18. Detailed value dimensions along with value-based contributions in value-based verification and validation are presented in Appendix I and Appendix N.
4.1.7 Value-based Quality Management (VBQM)

**Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?**

Within value-based quality management, numbers of studies were found in sub-process areas: quality fundamentals cost of quality, and quality improvements. As can be seen from Figure 19, 13 studies\(^{187}\) were related to quality fundamentals, eight studies\(^{188}\) were related to the cost of quality and 14 studies\(^{189}\) were related to quality improvement. Value-based contributions in sub-process areas (for example, review and audits and quality control) were not that many however; their mapping details can be seen in Figure 19.

![Figure 19: Bubble plot of value-based quality management](image_url)

**Sys-Map RQ1.2: What types of contributions are presented in the selected studies?**

Within quality management, value-based contribution as models\(^{190}\), Processes\(^{191}\), and recommendations\(^{192}\) have been proposed in large number. Whereas, fewer methods\(^{193}\),
framework and tool have been proposed. The visual details of research types and value-based contributions in value-based quality management see Figure 19.

Within software quality fundamentals, out of 13, eight studies suggested recommendations/practices. For example, in [309], recommendations were provided in order to meet the challenges ranging from technical concerns (like safety and reliability) to strategic concerns (for example, customer satisfaction, market shares and economic profit). Similarly, a quality debate was presented in [318] by modeling and analyzing software quality, profitability, demand and welfare under open and closed source environments in monopoly and competitive markets. Furthermore, quality and economics were closely related and a thorough management of both of them is necessary for software development. However, several problems in research and practice hinder the modeling and evaluation of quality and economics. These issues and their possible solutions were presented in [323].

Within cost of quality, out of seven, five studies proposed models/techniques. For example, [273] proposed a quality-based cost estimation model called qCOPLIMO that investigates the effect of software quality cost on the ROI of software product lines. Moreover, defect-detection techniques are common methods to assure the quality of software. However, the economics behind them are not fully understood. Analytical models were proposed for understanding the economic relationships of these techniques with respect to quality.

Moreover; out of 14, three studies suggested recommendations/practices for quality improvement. For example, recommendations were provided in [289] for evaluating the re-inspection behaviour based on re-inspection decision criteria such as product quality after re-inspection and the cost-benefit of a re-inspection. Five studies suggested processes/approaches. For example, [287] proposed a value-based approach for the assessment and improvement of software process and product quality. It is a challenge to determine which processes to improve and what benefits the company can achieve from them. An approach [307] was presented for evaluating proposed process changes quantitatively and predicts the impact of given process changes in terms of project quality, development cost (effort), and project schedule.

Sys-Map RQ1.3: Which research types are used in the selected studies?

Evaluation research, solution proposals and validation research are the dominant types of research in studies about value-based quality management. Whereas, experience reports and philosophical research are not that many. Moreover, no opinion report was found about value-based quality management.

Studies about quality fundamentals used experience report (five studies), validation research (four studies), evaluation research (3 study), solution proposal (one study), and philosophical (one study). Whereas, studies about cost of quality used evaluation research (five studies), solution proposal (three studies) and validation research (two studies). Studies about quality improvement primarily used evaluation research (eight studies), solution proposal (three studies), validation research (two studies) and experience (one study) as shown in Figure 19.
Figure 20: Focused value dimensions in value-based quality management

Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?

From 54 studies about value-based quality management, value dimensions like *value* (30 studies) and *others* (34 studies) were highly emphasized as shown in Figure 20. Whereas, *stakeholder value* (five studies), and *business value* (four studies) were less emphasized and rest of value dimensions were ignored as shown in Figure 20. Detailed value dimensions along with value-based contributions in value-based quality management are presented in Appendix J and Appendix N.

4.1.8 Value-based Project Management (VBPM)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

Within, value-based project management (VBPM), a large numbers of studies were found in sub-process areas: project planning and monitoring, and project enactment. 27 studies\(^2\) focused on project planning and monitoring. Whereas, less emphasis was given to project review and evaluation\(^3\), and software metrics\(^4\) as can be seen from Figure 21.

By having a closer look at project planning and monitoring sub-process area, much emphasis was given to process planning and effort, schedule and cost estimation. 12 studies\(^5\) focused on process planning. Seven studies\(^6\) focused on effort, cost and schedule estimation sub-process area in project planning and monitoring.

Within project planning, effective risk management plan is crucial however, there are not many studies addressing this important aspect. Only four studies\(^7\) focused on risk management. Whereas, value-based contributions in other critical project planning and monitoring sub-process areas (for example, determine deliverables, quality management\(^8\) and plan management) were not that many however; their mapping details can be seen in Figure 21.

Project enactment is necessary to check whether a project’s progress is according to
the plan or not. Looking within project enactment, it was found that a large number of studies are related to project monitoring and control (nine studies). Whereas, value-based contributions in review and evaluation sub-process areas (for example, review and evaluation of performance, and software metrics) were not highly emphasized as their mapping details can be seen in Figure 21. The reasons for not focusing these areas will be discussed in detail in analysis and discussion Section 5.1.7.

**Figure 21**: Bubble plot of value-based project management

**Sys-MapRQ1.2: What types of contributions are presented in the selected studies?**

Value-based contributions as Processes, methods, models, and recommendations have been proposed in large number. However, few frameworks are proposed in value-based project management. The details of research types and value-based contributions in value-based project management are shown in Figure 21.

Within project planning and monitoring, out of 27 studies, nine studies suggested recommendations, six studies proposed process/approaches and seven studies proposed methods as shown in Figure 21. In addition, six studies proposed models, and two studies proposed framework in project planning and monitoring. For example, [336] proposed methodology that is used to identify missing, poor and
abnormal practices and assess the quality of practices for better performance outcome of the projects. Whereas, [339] investigated earned value management as how it can be applied into agile software projects. The important phase effort, cost and schedule estimation as compared to process planning in project planning has been less focused. Processes were proposed in three studies 237 and models were proposed in three studies 238 for effort, project completion cost and project schedule estimation. For example, [334] proposed an approach “earned value based approach” to human resource scheduling that could help to manage and facilitate optimization of human resource scheduling and results into high return on investment of human resources. Whereas, [327] proposed new model that is used to forecast the project completion cost and schedule of the projects and improved earned value management.

For risk management, [347] proposed risk management tool “Intelligent Risk Mapping and Assessment System (IRMAS™)” that is used to minimize all possible risks in projects. Whereas [328] proposed a model that is used to manage and control software risks effectively and quantitatively, increase chances of project success and elevate the project returns.

Moreover, for project enactment dominant contributions are proposed processes 239. For example, [335] proposed a process framework for software development and decision making based on balancing opportunities and risk in projects and a tool called “the Integration Studio (iStudio)” that is used to assess causes of components architectural miss match. Furthermore, less emphasis has been given to project review and evaluation, and software metrics. For project review and evaluation, only one process 240 and one model 241 have been proposed. whereas, for software metrics, three studies have proposed frameworks 242 and two studies have proposed processes 243 as can be seen from Figure 21.

Sys-Map RQ1.3: Which research types are used in the selected studies?

Solution proposals 244 (23 studies), evaluation research 245 (14 studies), and validation research 246 (eight studies) are the most dominant types of research in value-based project management. Whereas, experience reports 247 (six studies) and philosophical studies 248 (two studies) are fewer in numbers. Moreover, no opinion report was found during the study of value-based project management.

Evaluation research 249 (11 studies) and solution proposal 250 (13 studies) are used as dominant research types in project planning and monitoring. Whereas, solution proposal 251 (four studies), validation research (three studies) [341,352,363], experience paper (two studies) [340, 372], and evaluation research (one study) [345] have been applied in studies related to project enactment.
Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?

From 49 value-based project management studies, value dimensions like value (19 studies), business value (seven studies) and others (21 studies) were highly emphasized as shown in Figure 22. Whereas, stakeholder value (five studies), project value (four studies), and system value (four studies) were less emphasized and rest of value dimensions were either less emphasized or completely ignored as shown in Figure 22. Detailed value dimensions along with value-based contributions in value-based project management are shown in Appendix K and Appendix N.

4.1.9 Value-based Risk Management (VBRM)

Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?

Within risk-management, much of research has focused on risk management within requirements engineering (requirements traceability\(^{252}\), elicitation\(^{253}\), prioritization\(^{254}\), and risk management\(^{255}\), release planning\(^{256}\), and product line engineering\(^{257}\)) and project management.

Within project management, risk management has been primarily associated with schedule, size (effort) and quality. Risk management in other important sub-process areas such as architecture, design, quality and testing has been ignored as shown in Figure 23.
**Figure 23:** Bubble plot of Value-based risk management

**Sys-MapRQ1.2: What types of contributions are presented in the selected studies?**

For managing risks, the largest numbers of value-based contributions are proposed as processes\(^2\)\(^{258}\), methods\(^2\)\(^{259}\), models\(^2\)\(^{260}\), frameworks\(^2\)\(^{261}\) and recommendations\(^2\)\(^{262}\). However, few tools\(^2\)\(^{263}\) have been proposed to practically manage risks. The details of research types and value-based contributions in value-based risk management are presented in Figure 23.

Four studies have proposed process/approaches\(^2\)\(^{264}\) for risk management in requirements engineering. For example, [378] proposed value-oriented approach that is used to specify quality requirements based on risk assessment to overcome the issues associated with qualitative specification of requirements. Three studies have proposed models\(^2\)\(^{265}\) for risk management in requirements engineering. For example, [403] proposed an economic model that supports risk analysis and return-on-investment in product line engineering. Moreover, one study proposed method\(^2\)\(^{266}\), one study proposed tool\(^2\)\(^{267}\) and three studies proposed recommendations\(^2\)\(^{268}\) for risk management in requirements engineering as shown in Figure 23.

Within project management, three studies\(^2\)\(^{269}\) proposed frameworks for risk management as evident from Figure 23. For example, [398] proposed a cost-benefit and risk management framework that determines the costs and benefits (here cost refers to cost of mitigation such as detections, preventions and alleviations and benefits refer to risk alleviation) of software assurance decisions. Furthermore, three studies\(^2\)\(^{270}\) proposed methods for risk management. For example, [380] proposed a method called **Riskit**...
method that is helpful and usable to manage the risks in the project. In addition, two studies proposed process\textsuperscript{271} and two studies\textsuperscript{272} suggested recommendations for risk management.

Within architecture process area, two studies proposed processes\textsuperscript{273} and one study\textsuperscript{274} proposed model. Furthermore, two studies\textsuperscript{275} proposed methods and one study\textsuperscript{276} suggested recommendation in design for risk management.

**Sys-Map RQ1.3: Which research types are used in the selected studies?**

In general, the most dominant research type in risk management is solution proposal\textsuperscript{277}. Evaluation research\textsuperscript{278} was also employed. Whereas, other research types like validation\textsuperscript{279}, experience\textsuperscript{280}, and philosophical\textsuperscript{281} were less focused as shown in Figure 23.

In requirements engineering, most of the research type was evaluation research\textsuperscript{282} and solution proposal\textsuperscript{283}. Whereas, validation research\textsuperscript{284}, experience report and philosophical research were completely ignored as shown in Figure 23.

Within project management, solution proposal\textsuperscript{285} and evaluation research\textsuperscript{286} have been highly emphasized. Whereas, validation research, experience report and philosophical research have been completely ignored.

![Figure 24: Focused value dimensions drivers in value-based risk management](image)

**Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?**

From 49 value-based Risk management primary selected studies, value dimensions like value (13 studies), and others (23 studies) were highly emphasized as shown in Figure 24. Whereas, stakeholder value (five studies), project value (three studies), business value (three studies), and system value (three studies) were less emphasized and rest of value-based category drivers were either less emphasized or completely ignored as shown in Figure 24. Detailed value dimensions along with value-based contributions in value-based risk management are shown in Appendix L and Appendix N.
4.1.10 Value-based People Management (VBPPM)

**Sys-Map RQ1.1: What are the software development process areas and sub-process areas addressed in the selected studies?**

Within value-based people management, a number of studies have been found in sub-process areas: knowledge sharing, and intellectual capital. As can be seen from Figure 25, five studies are related to knowledge sharing and six studies are related to intellectual capital. Value-based contributions in sub-process areas (for example, human capital, knowledge management, tacit knowledge, stakeholder expectation management, and ethics considerations) are not that many however; their mapping details can be seen in Figure 25.

**Value-based people management**

- Intellectual capital
- Human capital
- Knowledge management
- Knowledge sharing
- Tacit knowledge
- Teamwork
- Stakeholder expectation management
- Ethical consideration

**Figure 25: Bubble plot of value-based people management**

**Sys-Map RQ1.2: What types of contributions are presented in the selected studies?**

Within people management, recommendations have been proposed in a large number. However, fewer processes, methods, models, frameworks and tools have been proposed. The details of research types and value-based contributions in value-based people management are presented in Figure 25.

Within knowledge sharing, four out of five studies have suggested recommendations/practices. For example, some of the studies expressed the need for a technology such as repositories for capturing the intellectual capital and enabling knowledge sharing in institutions.
Within intellectual capital, one study\textsuperscript{298} presented a tool, one study\textsuperscript{299} have suggested recommendations/practice and two studies\textsuperscript{300} have proposed method/technique. For example, [418] proposed a method that determines the balance between investment types (such as product quality, features, intellectual capitals) and project constraints (such as project development time and cost), in the software development process. Furthermore, one study\textsuperscript{301} suggested an approach that brings buyers (organizations, departments, projects and profiles) and sellers (people) together through a mechanism that values the goods (skills, expertise) based on weighted multi-criteria. Moreover, one study\textsuperscript{302} proposed a framework for the identification and measurement of important resources of the software firm.

**Sys-Map RQ1.3: Which research types are used in the selected studies?**

Evaluation research\textsuperscript{303} and philosophical research\textsuperscript{304} are the most dominant types of research in value-based people management. Whereas, validation research\textsuperscript{305} and experience report\textsuperscript{306} are few in numbers. Moreover, no solution proposal and opinion report is found during the study of value-based people management.

Studies about knowledge sharing primarily used evaluation research\textsuperscript{307} (three studies), experience\textsuperscript{308} (one study), validation research\textsuperscript{309} (one study) and philosophical research\textsuperscript{310} (one study). Whereas, studies about intellectual capital used evaluation research\textsuperscript{311} (three studies), philosophical research\textsuperscript{312} (two studies), validation research\textsuperscript{313} (one study) as shown in Figure 25.

![Figure 26: Focused value dimensions in value-based people management](image)

**Sys-Map RQ1.5: Which value dimensions are considered in the selected studies?**

From 22 value-based people management primary selected studies, value dimensions like intellectual capital (11 studies), value (nine studies), and competitive advantage (nine studies) and others (three studies) were highly emphasized as shown in Figure 26. Whereas, stakeholder value (two studies) and brand value (one study) were less focused and rest of value dimensions were either less emphasized or completely ignored as shown in Figure 26. Detailed value dimensions along with value-based contributions in value-based people management are presented in Appendix M and Appendix N.
Sys-Map RQ1.5: Are there any gaps with respect to the context, contribution and research type in the field of VBSE?

Evaluation research\(^{314}\) and solution proposal\(^{315}\) have been the most dominant research types in general. In addition validation research\(^{316}\) was also used by some studies however such studies are few in number. Similarly, studies reporting experience\(^{317}\) or using philosophical research\(^{318}\) were few in numbers. These two types of research are very important for an emerging field like VBSE.

VBSE borrows the concepts and ideas from various disciplines, for example, finance, economics, marketing strategies, business administration, innovation and entrepreneurship and, management, and the value mentioned in these fields is hard to quantify because different people have different interpretation of this term. Thus, there is a need for a collective effort of experts from all these domains to enrich taxonomy for the VBSE field. Moreover, since software engineering is mainly considered as a technical field, management and development activities are discussed more from technical perspective rather than a philosophical perspective. In addition, the knowledge of practitioners are important to share their experience regarding value dimensions. Moreover, only two opinion reports\(^{319}\) were identified among the selected studies.

From contribution perspective, processes\(^{320}\), and recommendations\(^{321}\) have been proposed in large number. Moreover, methods\(^{322}\) and models\(^{323}\) have also been proposed in general, whereas frameworks\(^{324}\) and tools\(^{325}\) have been relatively fewer in number.

From 364 VBSE primary selected studies, value dimensions as others (197 studies), value (109 studies), and business value (49 studies) were highly emphasized as shown in Figure 27. Whereas, stakeholder value (31 studies), system value (21 studies), customer value (19 studies), and economic value (17 studies) were focused. Value has been used in many studies, however the researchers did not clearly mention whether it is business value, product value or market value or any other value dimension. Figure 27 shows 2.55% of the studies discussed solutions to create/increase product value. Whereas, rest of value dimensions were either less emphasized or completely ignored as visible from Figure 27. The reasons for ignoring most of the value dimensions within VBSE will be discussed in Section 5. For detail, value dimensions regarding references and value-based contributions see Appendix N.

![Figure 27: Focused value dimensions in overall VBSE](attachment:image)
5 ANALYSIS AND DISCUSSION

5.1 Systematic Mapping

In this section, the extracted data is analyzed and discussed with respect to the research questions posed in Table 1.

5.1.1 Value-based Requirements Engineering

5.1.1.1 Sub-process area and value considerations

Value-based requirement engineering emphasizes alignment of product, project and business level decisions and involvement of multi stakeholder that leads into the creation of product, project and business value [81, 94, 117]. However, relatively little attention has been paid to the criteria that are used in decision making for requirement selection. In requirements selection decision, following factors need to be considered for product value creation:

1) Stakeholder value propositions.
2) Product market shares and growth, targeted market, intellectual capital (human capital, structure capital, and relational capital), development and risk management tools, methods or processes used inside organization.
3) Customer types [81, 94, 117].
4) Business risk associated with different types of requirements [400] (i.e. commercial requirements [138, 400], system improvement requirements[138, 400] and innovative requirements[138, 399, 400])

Analyzing the results of systematic mapping for value-based requirement engineering studies (see Figure 7), it has been found that very few studies have discussed value-based solutions for requirements elicitation and analysis. In today’s competitive market-driven environment, one of the major challenges faced by the software development companies is to elicit requirements with respect to the value considerations of their customers, competitors, business and environment. Thus, there is a gap between what industry demands and what has been proposed in VBRE literature [104, 112, 124, 130, 140].

Most often, when quality requirements are elicited from stakeholders, they are qualitative and consequently ambiguous in nature; for example, the system should be very fast [378]. Such requirements are hard to verify and either may not meet the stakeholders’ expectations or may over-exceed their expectations resulting in either a useless system or an expensive system respectively. It may also be the case that there is a disagreement between the developers and stakeholders whether the system meets the specified quality requirements [378]. One possible solution could be to quantify quality requirements however, this could be very costly. A cost effective solution could be to quantify some characteristics of quality requirements [378]. However, this needs further investigation and evaluation.

Another important concern is that, most of the studies [69, 70, 78, 121, 154, 157] have discussed requirements prioritization based on subjective estimations by stakeholders [121, 108]. In such estimations, it is a challenge to predict market fluctuations, changes in customers and user’s demands and competitor’s existence. Thus, there is a need to propose a solution for objective evaluations of such aspects.
In addition to the objective evaluations, there is also a need to estimate or predict return-on-investment of individual requirements [108]. There are methods that predict development cost and benefits of complete systems for example, value chain analysis [121], process analysis [121], business cases [121] or sensitivity analysis [121]. PARSEQ is one method [71] that post evaluates market value of implemented requirements. However, PARSEQ method is applicable in ideal situation and does not take into consideration factors like requirements dependencies [87], architectural choices [71], market fluctuation, competitor’s product, changes in business goals, risk volatility, changes in user’s and customer’s demands, business risk associated with requirements types[138, 399, 400] and strategic alliance with other companies. Thus, there is a need of investment in time and resources to develop a method for objective cost-benefit analysis (here cost refers to requirement implementation cost) considering all the above mentioned factors to find out ROI per requirement [108, 121]. Requirement dependencies [87] have a major impact on the cost-benefit of a requirement. For example, the implementation of one requirement results into negative ROI of another requirement (for example, making an on-line help manual would negatively affect the value of a printed help manual). Summing up all the above arguments, there is a need to develop techniques that can assist to predict the benefit of each requirement pre-release.

Requirements selected for implementation in a release should also be stored with a value-based rationale for their selection. This would enable reuse of requirements with respect to the rationale. To summarize, some of the possible future research directions in VBRE could be

1. Value-based criteria for requirements selection
2. Objective elicitation of quality requirements
3. Objective estimation and prediction of risk factors to do cost-benefit analysis of individual requirements
4. Storing value-based rationale for selected requirements

5.1.2 Value-based Architecture

5.1.2.1 Process area and value considerations

Number of studies discussing value-based solutions for architecture evaluation are relatively few. Kazman et al. [157] & Lee et al.[152] proposed ATAM and CBAM that are based on subjective and intuitive decision-making for evaluating architecture with respect to the quality attributes. The difference between these two methods is that the former provides no guidance for understanding economic benefits while the latter consider ROI of an architectural decision and provides guidance on the economic tradeoffs involved. Other architectural evaluation methods such as CBAM+AHP [161] and CBAM+ANP [161] were proposed which respectively contain Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP). Due to pair-wise comparison both methods are suitable for cost and benefit analysis and can also be more accurate [161]. Here cost refers to cost associated with architecture strategies with respect to efforts, schedule, and risk and benefits refer to return on each architecture strategy.

CBAM and its descendant’s methods (i.e. CBAM+AHP, and CBAM+ANP) were heavyweight processes because the optimal selection of architecture alternative took place when all the stakeholders agreed upon it.
Three fundamental issues with existing architectural evaluation proposed solutions are:

1. Stakeholders make subjective and intuitive evaluations of software architecture alternatives with respect to their corresponding quality attributes which gives rise to uncertainties [144, 161].

2. Usually such evaluations consider only technical quality attributes and business values such as cost-benefit (here cost refers to architecture strategy implementation cost and benefit refers to return on each architecture strategy), time-to-market and integration with legacy systems are ignored which naturally defeats the purpose of value-based evaluations [144].

3. Most of the proposed architecture evaluation methods [144, 152, 161] have scalability issues. Kim et al. [144] have proposed LiVASAE to address above mentioned issues. However, LiVASAE uses AHP which can have scalability issues if there are many quality attributes to be compared. Moreover, LiVASAE has the limitation that it could only include two business values for evaluation. And last but not the least; LiVASAE has not been validated within industry thus its usability and usefulness are questionable. Thus, there is a need for usable and useful value-based architecture evaluation solutions that enable objective evaluations and incorporate more than two business values in the evaluations.

While analyzing systematic mapping results, it was interesting to identify that few studies have discussed value-based solutions for linking requirements engineering activities to architecture [154, 155, 159]. This is particularly important in value-based context because if requirements negotiation and architecture evaluation are considered as separate concerns, it can lead to unnecessary iterations since many requirements are not discovered or clarified until the architecture is being designed. This would consequently result in wasted effort, re-work and extra cost later in the development cycle. Kazman et al. have proposed WinCBAM framework, extending an architecture design method, called cost benefit analysis method (CBAM) framework to include an explicit requirements negotiation component based on the WinWin methodology [154]. Here cost refers to architecture strategy implementation cost and benefit refers to return on each architecture strategy. The proposed framework assists stakeholders in eliciting, exploring, evaluating, negotiating and agreeing upon software architecture alternatives based on each of their requirement win conditions. However, one of the challenges in linking requirements to architecture is the difference in concepts and terminology between the two domains [159]. To address this challenge, Grunbacher et al. [159] have proposed a solution called CBSP, a lightweight approach intended to provide a systematic way of reconciling requirements and architectures using intermediate models. CBSP uses a simple set of architectural concepts (components, connectors, overall systems, and their properties) to recast and refine the requirements into an intermediate model facilitating their mapping to architectures. Although CBSP addresses the issue of differences in concepts and terminologies between requirements engineering and architecture and suggests a way to maintain traceability and consistency between requirements and architecture however; an explicit linking and/or mapping between business values (for example complementary value) and architecture quality attributes (for example, interoperability and portability) needs to be explicit. Moreover, usability and usefulness evaluation of the proposed solutions through industry validation is needed.
Elaborating on the above discussed issues in the context of bespoke and MDRE, in bespoke projects, solutions as LiVASAE and CBSP can be applied as the stakeholders are relatively few (single customer and the stakeholders within the company) and the requirements are fairly stable and common. Whereas, in MDRE, large number of customers, end-users, volatility of requirements, uncertainties in business environment make it harder to apply these solutions in a restricted time and resources. Therefore, scalable solutions keeping in view MDRE characteristics and constraints have to be designed and tested.

5.1.3 Value-based Design

5.1.3.1 Process area and value considerations

Within value-based design, Bajracharya et al. [177], presented Net Options Value (NOV) as a framework for evaluating options in software design (also known as technical potential of module) on the basis of his experience. The proposed approach only considers the technical potential of a module while ignoring other aspects during design evaluation. For example, the proposed approach does not deal with coupling and cohesion, different types of modular dependencies (such as social dependencies and value dependencies with respect to customers). Moreover, it does not account for changes in the software design and cannot scale up for evaluations of complex and large software designs. From research point of view little attention has been given to design evaluation as compared to architecture evaluation whereas it is equally important if not more.

Very few studies [175, 176, 178, 179] have discussed value-based solutions for making design decision. Factors such as customer perceived value, business goals, market trends, risk and volatility, brand-switching, compatibility with other products and features of competitors’ future product affect product requirements and consequently architecture and design decision [176]. Changes in the above mentioned factors may require a change in the design decisions. Inability to change design decisions can result into wasted efforts, reduced customer perceived value, lost market shares and growth, negatively affected strategic alliance with customers, wrong pricing strategy, reduced units sales [175] and competitive disadvantage [176] that would ultimately decrease revenues of the products and put a company’s reputation at stake.

Sazawal et al. [176] has proposed a light weight game theory for making right design decisions in order to overcome cost overrun (future change management cost) and competitive disadvantage. This method is validated in a hypothetical case study with a simplified example. Thus, its usability and usefulness in industrial context need to be validated. It utilizes two stakeholders. However, if the number of stakeholders increases (which will in case of market-driven products) this method will become complex and may yield uncertain results and cost overrun. Moreover, the proposed method does not take into account all the above mentioned factors that can affect design decision.
5.1.4 Value-based Development

5.1.4.1 Process area and value considerations

While analyzing systematic mapping results, some studies [183, 189, 194, 195, 197, 198, 200, 205, 206, 211] were found that discussed value-based solutions for code reusability/COTS components. From value-based perspective software reuse can increase software quality [183, 194], reduce development time and cost [183, 197, 200, 205], increase developer productivity [194, 200], improve maintainability of applications [200], and encourage sharing of knowledge [200]. However, on the other hand reusability restricts the creativity of developers because they do not have much freedom to creatively solve a problem rather reuse already existing components. Sometimes reusability/COTS do not give its potential benefits as it has been reported [183, 197, 200, 205]. For example, whenever, a segment of code (i.e. class or module) is reused, an extra wrapper or glue code has to be written in order to make it work in the current scenario. Development of this extra wrapper or glue code takes extra development and testing efforts and time, which may diminish the value of reuse. Thus, there is a need for a solution that carefully analyzes costs versus benefits of reuse and does not restrict it to technical benefits only. Here cost refers to development / reusability cost and benefits refer to software quality, reduce development time and cost, increase developer productivity, improve maintainability of applications, and encourage sharing of knowledge.

In the context of development processes, very few studies [185, 204] have discussed value-based solutions for Xtream programming (XP). XP practices such as pair programming and test-driven development have potential benefits such as fast development, improved quality and reduced defect density of the code [185, 192, 209]. But on the other hand due to shorter developmental cycles, redundant reviews of code, double efforts of the programmers on the same piece of code [204] and testing can lead to extra cost (i.e. % effort cost with respect to time to market) [185, 204]. In case of larger projects [452], it may not only lead to additional cost but may also require more time because of the extra testing required thus affecting time-to-market. From value-based perspective, it is fundamental to highlight that agile development methodology might not be the best suitable methodology in a certain context. For example, in medical imagining industry where products are release after five years, agile methodologies are neither suited nor needed. Whereas, for telecom projects and products, agile methodology might be the best suited given the volatility of requirements, market situations and lead time being the most critical success factors.
5.1.5 Value-based Verification and Validation

5.1.5.1 Process area and value considerations

Relatively larger number of studies has presented value-based solutions for software testing as shown in Figure 15. Testing is one of the fundamental and widely employed approaches for verification and validation (V&V) [223, 270]. Although testing does not create immediate product/project value like other development activities e.g. coding or user interface design; testing informs and supports other value generating tasks in software development (by reducing planning uncertainty, saving rework, increasing knowledge and improving processes to name a few). However, in today’s competitive environment where time-to-market is short and uncertainty is high, one of the major challenges is to manage testing activities: an expensive and resource-intensive activity consuming 30-60% of development time, keeping in view the value considerations of external (customers, end-users) and internal stakeholders (developers, project managers, analysts, maintenance staff) [270]. In the value-based context, this has a greater impact especially when 20% of software generates 80% of the value [1].

There is a need to integrate internal dimension of testing (i.e. cost-benefit analysis) and external dimension of testing (opportunities and risk, and stakeholder value propositions), i.e., alignment of internal test activities with the value propositions of customers and market [1]. Here cost refers to development/testing cost and benefits in internal dimensions refer to reducing planning uncertainty, risks alleviations, enrich decisions, controlling and managing efforts, and costs reduction. In addition, in external dimension, it refers to the realization of stakeholder value propositions.

There is a need to associate functional and quality attributes of the software with business goals to identify most value generating functionalities and qualities. For example, software’ compatibility, portability and interoperability with other external components or systems (technical aspects) can increase software’s interoperability which can result in increased market share (business value) Thus, there is a need that software companies align all system integration efforts with business objectives in order to maximize their business value.

Ramler et al. [270] have suggested several practices that can support value-based testing. Requirement-based testing is one of the practice that can be used to assure that system satisfies needs elicited from stakeholders and realizes the targeted value for the stakeholder [1, 270]. Moreover, it can enable verification of requirements so that defects are detected before implementation thus saving time and rework efforts. Similarly, risk-based testing can be used to focus on high value and on severe types of failures. For example, Amland, [453] proposed risk-based testing approach that helps in allocating resources to those areas representing high risk. However, this approach does not deal with the cost of testing activities. In market-driven software development context, risks, requirements and business needs are volatile in nature and keep on evolving. Thus, changes are unavoidable either because new understandings are developed during implementation and testing or because business environment changes. Proactive approach towards change anticipation and management, through iterative and concurrent testing with continuous involvement of stakeholders, can give higher competitive advantage. Ramler et al. [270] proposed a value-based framework for test management however it needs to be validated in industrial case studies. Moreover, [223] proposed a three-step method that aligns internal test activities and process with customer and market value objectives. This method calculates value of feature based on importance to business, quality risk and development cost/testing cost/ %effort cost by
using Karl Wiegers’s and AHP methods. However, this method does not deal with factors of market pressure in real life and requirements dependency. It considers only limited features and just gives an overview of cost. If number of features and risk factors increase then this method would face scalability and time constraint issues. Moreover, it is not favorable for safety critical projects.

In order to better comprehend and control value contribution of testing there is a need to tightly integrate release planning and test planning activities and include test budget planning and negotiation as an essential part of the re-planning activities [270]. However, none of the studies in the area of value-based V&V have addressed these aspects.

A critical part of the software engineering life cycle concerns usability testing [451]. System usability can be described as the effectiveness, efficiency and satisfaction with which users can use the system for their tasks. However, very few studies have discussed value-based solutions for usability testing [269, 451]. Kim et al. [269] proposed a framework for measuring business value of software quantitatively by utilizing usability test from five product attributes and four quality attributes. However, lack of user input is one of the common reasons for poor system usability [1, 269, 270, 451]. Whereas, one of the most important challenges is that stakeholder involvement is costly and difficult to organize. Collaborative software engineering methods can be used to increase user input in a cost-effective and efficient way. Fruhling et al. [451] suggested a repeatable collaborative usability testing process, which facilitates stakeholder involvement through stakeholder expectation management, visualization and trade-off analysis and a simple business case [451]. Although promising, this testing process needs to be thoroughly validated and needs another usability testing approach to compliment it for a complete evaluation of system’s usability.

Alpha and beta testing can be used as a means to verify that the software meets stakeholders’ expectation and value propositions [1, 270]. Their feedback during alpha and beta testing can assist project managers and developers to further improve the software from value perspective. However, an important challenge for alpha (in-house) and beta (outside) testing could be lack of interest of customers or users in identifying defects [8, 10, 66]. Therefore, there is a need of mechanism with the help of which customers and users take keen interest in identifying defects.

Regression testing is an expensive activity that constitutes large proportion of software maintenance budget because test planners add test cases into test suites as software evolves with the passage of time. Increase in test cases makes re-validation of software more expensive. Regression test selection techniques, test suite reduction and test case prioritization can reduce the number of regression tests. However, these techniques can be expensive to deploy and may or may not reduce overall regression testing cost. Thus, the researchers and practitioners cannot benefit from different techniques without cost-benefit analysis. [217] conducted an experiment to compare five regression testing techniques (i.e. minimization technique, dataflow technique, safe technique, ad-hoc technique and re-test all technique) in order to evaluate their relative cost and benefits. Here cost refers to cost of using a regression test selection technique and benefits refers to ability (efficiency and effectiveness of test selection techniques) to detect faults under the impact of some factors such as program design location and type of modifications, and test suite design [217]. Moreover, [244] proposed cost-benefits models for each regression test selection technique, test suite reduction, and test case prioritization in order to evaluate cost and benefits based on historical data. Here cost include cost of analysis, execution, result checking, selection, maintenance of the test suite and omitting faults by not selecting test suite [244]. However, these models do not predict
cost and benefits of techniques in advance. Moreover, these techniques do not take into account different testing costs involved and do not take into consideration time-to-market and complete system life. These limitations can cause ineffective assessment of techniques with respect to cost and benefits. In order to deal with some of these limitations, [218] proposed cost-benefit model that also considers other testing costs, system life and time-to-market. Here cost refers to testing activities such as test setup, identifying and repairing obsolete test cases, execution, validation, test suite maintenance and management of test suite and overhead, database, and development of new test cases. Moreover, [219] conducted an experiment to assess the impact of time-to-market on the cost and benefit of prioritization technique and concluded that it can have an impact on cost-effectiveness and relative cost-benefit tradeoffs among different prioritization techniques.

However, the above mentioned regression models are very specific and do not cover type, distribution and ranges of faults’ costs. Moreover, regression test selection techniques were evaluated using smaller systems or program size.

5.1.6 Value-based quality management

5.1.6.1 Process area and value considerations

Quality has been suggested by software engineers as the solution to many of the crucial challenges faced by software companies in the 1990s; these challenges ranging from technical concerns (for example reliability and maintainability) to strategic concerns (for example market share, customer satisfaction and economic profit) [309]. However, blind adoption of any of the existing quality framework or model, for example ISO 9000, would not address the challenges stated above. Favaro stressed the need to adopt management approaches that incorporate quality with a strategic framework, for example value-based management (VBM). VBM includes a set of principles and processes that link quality related aspects to economic value, highlighting the unavoidable tradeoffs between improvements in product quality versus higher economic cost, ROI versus market share, short-term gains versus competition [309]. However, calculation of economic cost for quality is itself a challenge due to the fact that existing quality models do not take into consideration economics of quality. Furthermore, there is a lack of empirical knowledge in research and lack of relevant data in industry. And last but not the least due to inflation and differences in currencies it is difficult to calculate economics of quality in monetary terms [323].

Within a project, value-based approaches proposed, COCOMO II cost estimation model, COQUALMO quality estimation model and VER’s (business value estimating relations), by Haung et al. [282, 285] can be combined with risk analysis in order to perform project effort cost/schedule/reliability tradeoff analysis. These approaches can assist project decision makers to determine software assurance and quality levels. Furthermore, application of qCOPLIMO model in a case study to N number of products being developed through product line development has shown that savings achieved due to product line development were based on two reasons 1) product line reuse and 2) reduction in an overall software quality cost.

Within quality attributes, reliability is one of the most important one. Value-based solutions proposed for quality improvement have mainly focused on reliability. However, value-based solutions for other important quality attributes such as maintainability, availability etc. that might be valuable for the customer and thus
necessary for the success of product in market and consequently for the success and revenues for the company are missing.

Furthermore, there are different defect detection techniques available but there is a need to investigate as how to model the relationships between economics and defect-detection techniques. Wagner [317] proposed an analytical model that relates the economics and defect-detection techniques. This model calculates the cost of different defect-detection techniques and provides the return-on-investment of each technique. However, the model is on hypothetical basis and the usability or usefulness is not reported in this study.

Continuous process improvement is very important because it is believed that if the process quality is improved it will contribute directly in improving product quality. However, it is very hard to judge which processes should be improved. Raffo [307] proposed a way to view process changes with respect to increase in customer value and an approach that is used to evaluate process changes with respect to cost, quality and time to market and find out return-on-investment for organization. Besides aligning processes to maximize customer value, it is difficult to integrate process and business value perspectives quantitatively. Madachy [288] has proposed modeling and simulation to assess process tradeoffs for business case analysis. However, the proposed solution is example driven and usability and usefulness are questionable.

Prediction of software quality at design level has been completely ignored [445, 446, 447, 448, 449, 450]. There is a need to align design process with customer value, business value and product value and other relevant value dimensions qualitatively.

5.1.7 Value-based Project Management

5.1.7.1 Process area and value considerations

According to the literature one of the most useful techniques used for monitoring and controlling of the project is earned value management system (EVM) [327, 334, 339, 340, 341, 345, 351, 352, 354, 355, 372] which is generally used for tracking the project against original plans in terms of cost and schedule. However, EVM technique has a fundamental limitation and that is it does not track other value considerations necessary for a product’s and/or a company’s success [1]. For example, a project can be successful by meeting its cost budgets and time limitations but if actual requirements of the customer were not implemented keeping in view customers value propositions, the resulting product can be a failure and consequently the company would lose. Similarly, the success of a project does not guarantee that the business need for a product is still there by the time the product is released. Boehm et al. [442] proposed a framework that integrates the concepts of stakeholder value with EVM through benefit realization analysis, stakeholder value proposition elicitation and reconciliation, and business case analysis. However, the framework would work best if value-based solutions are used in other process areas of software engineering such as requirements engineering, design, development, verification and validation to ensure alignment and continuous feedback.

Wagner et al. [325] proposed five-step method that enriches earned value concept with other important value considerations such as stakeholder value and system value. According to Wagner et al. [325] requirements clarity is a fundamental contributor in increasing system’s value, thus their proposed method prescribes to identify relevant stakeholders and elicit their value propositions and expectations. However, the proposed method is example driven and its usability and usefulness in industrial context is yet to be determined.
In today’s fast-paced competitive business environment, project monitoring and control becomes very hard to manage and administer because project plan may change with the passage of time [34]. The reasons could be any or all of the following:

1) Requirements are not fully, comprehensively, and accurately specified and are incomplete at the beginning of the project [32, 34, 110]
2) Inappropriate pre-project RE decision making [110]
3) 40% to 60% decisions regarding requirements selection is incorrect [110, 441]
4) Dynamic and volatile nature of requirements in MDRE
5) Changes in any type of requirements such as commercial requirements [138, 400], system improvement requirements [138, 400] and innovative requirements [138, 399, 400] results into change in plan because of high business risk is associated with these type of requirements
6) Risk volatility
7) Changes in business needs
8) Stakeholder’s different perspective

In order to effectively and efficiently manage changes in the project planning and monitoring, following important steps can be used for the development of a value-based framework for project planning and monitoring

**Step1: Adoption of agile methodology, and agile management techniques:**
In order to manage changes that occur in project planning, agile development methodology can be relevant as it welcomes the changes [357]. It is customer oriented, communication oriented, iterative and concurrent, flexible, lean, responsive and learning [357]. However, if EVM is used in agile projects issues such over-run or under-run [357] might arise because of unknown scope in the beginning of the projects. To overcome such issues, agile management techniques such as burn charts can be used because they are designed for agile context.

**Step2: Identification of success critical stakeholders and value propositions and reconciliation:**
Second step is to find out Success Critical Stakeholder (SCS). SCS is a stakeholder, whose interest is taken into consideration for the success of the project [325]. It is difficult task to involve the right person in decision-making. SCS change throughout the project life cycle. Ignoring the needs, demands, and expectations of any of the SCS can increase the risk of failure of the project.

Identification of SCS is based on determining significance and relative power of each stakeholder. The significance of stakeholder refers to the extent to impact on project success, if needs, demands and expectations are addressed or not. Whereas, relative power means the extent to which stakeholder influence the key and critical decisions. Those stakeholders who have high significance and relative power would be the SCS in project [325]. New SCS often have problem in expressing their value propositions whereas, value propositions of old SCS can easily be converted into a set of objectives. Value propositions of stakeholders come from experience rather than survey or workshop [1]. SCS often have conflicting needs, demands and expectations and there is a need to resolve the conflicts to achieve win-win. There are different techniques for reconciliation of stakeholder’s value propositions, such expectation management [1], visualization and trade-off analysis [1], prioritization [1], groupware [1], and business case analysis [1], which can be used.
To identify and involve success critical stakeholders in several meetings for identifying and managing theirs’ value proposition is very costly. There is a need to identify a better alternative for eliciting and reconciling stakeholder value propositions by comparing above mentioned techniques with respect to the cost versus benefit.

**Step 3: Identification of value dimensions’ metrics for each software development process area and its alignment with values:**

Wagner et al. [325] proposed process measures at abstract level. While, elaborating process measures in detail for making explicit connection between sub-process areas and value dimensions, following four sub steps are as follows to identify:

- Sub process areas for each development process area.
- SCS expectations from each sub process area
- Most important value dimensions as an output of each sub process area and process area
- Metrics for most important value dimensions by using Goal Question Metric [443] (GQM).

Let us consider an example for requirements engineering process:

<table>
<thead>
<tr>
<th>Requirements engineering</th>
<th>SCS expectations</th>
<th>Value dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements elicitation</td>
<td>To elicit complete requirements with respect to needs, demands, and problems [444 ], and quality requirements in quantitative form [83]</td>
<td>Stakeholder value proposition</td>
</tr>
<tr>
<td>Analysis , negotiation and validation</td>
<td>Requirements conformance with business goals, unambiguous, testable, complete, clear, and traceable [444 ]</td>
<td>Stakeholder value propositions Business value</td>
</tr>
<tr>
<td>Prioritization</td>
<td>Prioritize list of requirements’ w.r.t SCS, value dimensions, available resources, risk and cost.</td>
<td>Product value Business value Market value Customer value Stakeholder value proposition and reconciliation</td>
</tr>
<tr>
<td>Release planning</td>
<td>Selection of requirements in release’ w.r.t high value dimensions, less dependency, available resources, budget, time and risk</td>
<td>Product value Business value Market value Customer value Intrinsic value N/W externality Economic value</td>
</tr>
</tbody>
</table>

| Product line engineering  | • Set of products development as a single, coherent task from core asset base [73] • Does it pay? [74] | Business value⁹ |

By having a complete picture of value dimensions with respect to associated sub-process areas then it will be easy for researchers and practitioners to determine the metrics for each value dimension by using GQM [443].
All the metrics identified need to be aligned with the business, product and project values to ensure value-based planning and monitoring through and through. This would enable not only project’s success but success all the way for the product and for the company.

**Step 4: Identification and deployment of value-based contributions in process areas based on cost-benefit analysis and return on investment:**
There is a need to compare all value-based contributions (i.e. methods, tools, and techniques reported in this study [68-440]) from usability and usefulness perspectives to select cost-effective and efficient value-based contributions for the application of the development process.

5.1.8 **Value-based Risk Management**

5.1.8.1 **Process area and value considerations**

Software risk management becomes a very critical point in the field of software engineering. Large number of software projects fails or do not provide benefits that causes loss of billions of dollars [328]. Software development companies try to maximize their benefits and reduce risks associated with the project up to certain level.

One of the most important factors that prevent organization to achieve benefits is improper management of associated risks [328]. Failing to identify, analyze, prioritize, and understand project risk [328] can result into different many issues like schedule overrun, cost overrun, no realization of users requirements, hard to realize project value, business value, system value and stakeholder value. There are several types of risk [347], for example schedule risk [347], technical risk [347], external risk [347], organizational risk [347], communication risk [347], location risk [347], financial risk [347], and resources risk [347]. 60-70% project managers do not follow any risk management approach despite knowing the concepts and terminology of software risk [32, 328]. Therefore, risk management is not effectively followed in practice in software industry. Very few studies have discussed value-based solution for software project risk management in different process areas of software engineering. Less attention has been given to risk assessment (risk identification, risk analysis, risk prioritization) [17], and risk control (risk management planning, risk resolution and risk monitoring) [17]. To maximize organizational value, product value, economic value, project value, customer value, system value and business value risks have to be systematically identified and proactively managed.
5.1.9 Value-based people management

5.1.9.1 Process area and value considerations

While analyzing the results of systematic mapping, it was observed that some studies have discussed intellectual capital (IC) from organizational perspective. IC plays a very critical role in the development of a successful software product. The reported benefits of intellectual capital are the identification of risk [424], identification of companies’ future potential [426, 435], comparison of different units within the company and identification of areas for further development and improvement [418]. It is also a source of sustainable competitive advantage, increase market value, economic value. However, there are other important aspects such as features, cost and time that are also considered very important during the development of software products. The challenge is to find the right balance in investment in IC and in the above mentioned aspects. Berney et al. [418], proposed a method that helps to determine the balance between these aspects in the software development process. However, the author did not report the usability and/or usefulness of the proposal method, therefore the results cannot be generalized.

Some studies have discussed knowledge management, and knowledge sharing [419, 421, 427, 428, 429]. Software management and development are knowledge intensive activities. It is also a way for companies to be innovative and competitive. Human capital possesses’ knowledge which is extracted from them, formalized and then stored in knowledge repositories [419, 421]. This knowledge is then transferred via media in order to share with other workers [419]. However, a large part of human capital knowledge is tacit which is hard to extract and then to be stored and transferred through knowledge repositories [421, 428]. Consequently, a great part of knowledge is only in the brains of the experts. Therefore, it is essential to explore value-based solutions that make it possible to extract, store and transfer tacit knowledge from experts to others.

Very few studies [420] have discussed about value considerations for teamwork. Collaboration and cooperation among team members build trust that causes sharing of their assets such as knowledge, skills, experiences, combine effort for solving a business problem [420]. These characteristics of team not only create organizational value but also provide a competitive advantage for the software organizations. Similarly, enthusiastic teamwork finishes the project on time that generates project value. It can also generate product value by developing features and retain quality of the software product.
5.1.10 Research type

There could be several possible reasons for less focus on validation, experience and philosophical research, which are explained as follows.

It is difficult to assess benefits of requirements regarding value dimensions in laboratory setting such as business value, economic value, system value, intrinsic value, etc. In order to determine cost-benefit or return-on -investment of individual requirement it requires a complete development life cycle. In addition, it is difficult to create/simulate industrial requirements prioritization challenges like conflicting interests of multiple stakeholders, fixed deadlines, large number of requirements to prioritize, fewer resources etc, in a controlled environment.

One of the possible reasons for less experience reports in VBSE could be that since value is hard to quantify and different people have different interpretation of the term value it becomes harder for industry practitioners to evaluate a value-based solution and report it.

The reason for having relatively fewer philosophical research with VBSE could be that VBSE borrows concepts and ideas from various disciplines, for example, finance, economics, marketing strategies, business administration, innovation and entrepreneurship and management. Thus, there is a need for a collective effort of experts from all these domains to enrich VBSE taxonomy. Moreover, since software engineering is mainly considered as a technical field, management and development activities are discussed more from technical perspective rather than from a philosophical perspective.
5.2 Systematic Review

This section presents overview of the results of the systematic review within VBRE and their analysis (for results overview see Section 5.2.1 & for detail results and analysis see Section 5.2.2).

The format for data labels in Figures (i.e. from Figure 28 - Figure 37) is based on data extraction categories’ names, number of studies, and percentage of studies. For example, data label like “Empirical basis of needs; 27; 11%” in Figure 28 means that 26 studies claim empirical basis of need that is 11% of selected studies.

5.2.1 Results overview

As evident from Figure 28, out of 70 studies, 26 studies\textsuperscript{326} claims empirical basis of need, 58 studies\textsuperscript{327} have used some application/validation method, 16 studies\textsuperscript{328} have reported some form of usability and 47 studies\textsuperscript{329} have reported some sort of usefulness. 56 studies\textsuperscript{330} were written by researchers. Whereas, 15 studies\textsuperscript{331} were written by practitioners. Only one study [138] reported replication. In total 37 studies\textsuperscript{332} have built their research on previous work or have used VBSE agenda presented by [1] as basis for their proposed research (for details see Section 3.3.6).

Figure 28: Overview of included studies
5.2.2 Results and Analysis

In this section the Results are analyzed and discussed with respect to systematic review questions stated in Table 4.

5.2.2.1 Sys-Rev_RQ2.1: Are value-based contributions based on needs identified in industry?

Relatively fewer studies\(^{333}\) are based on the needs identified in industry (see Section 5.2.1). In depth analysis of the “empirical basis reported as” shows that 28% of the studies\(^{334}\) have reported need identified as “statements only”. For example, [78] referred need/problem that has been identified by other studies based on survey such as “A recent survey shows that few companies know how to establish and communicate requirements priorities; another identified prioritization as a key but neglected issue in requirements engineering research” [78]. 27% studies\(^{335}\) reported need/problem through VBSE agenda. As can be seen from Figure 29 only 1% studies\(^{336}\) have used case study method, 1% study\(^{337}\) stated participation knowledge and 1% study\(^{338}\) reported field study to identify the needs as shown in Figure 29. Whereas, 40% studies\(^{339}\) haven’t explicitly reported any empirical investigation for need identification in industry.

While analyzing the results based on empirical evidence of needs/problems, some studies\(^{340}\) referred to VBSE agenda\(^{341}\) as a basis for proposed solutions. Moreover, few studies\(^{342}\) have reported empirical basis of need through case study, participation knowledge and field study that provide affirmed basis for proposed solutions.

Some of the studies\(^{343}\) did not report empirical investigation of a need rather have built their proposed research on previous research thus providing indirect empirical basis for the need addressed.

Moreover, few studies\(^{344}\) reported empirical investigation of a need on the basis of observation in industries that also provide strong motivation for proposed solution. However, in contrast researchers formulate need/problem reported in few studies\(^{345}\) based on mathematical analysis in laboratory settings but it need to be checked that whether industries face these problems/needs in reality or not.

![Figure 29: Empirical basis of needs identified](image-url)

\(^{333}\) Relatively fewer studies...  
\(^{334}\) In depth analysis of the “empirical basis reported as” shows that 28% of the studies...  
\(^{335}\) 27% studies...  
\(^{336}\) As can be seen from Figure 29 only 1% studies...  
\(^{337}\) 1% study...  
\(^{338}\) 1% study...  
\(^{339}\) 40% studies...  
\(^{340}\) While analyzing the results based on empirical evidence of needs/problems, some studies...  
\(^{341}\) as a basis for proposed solutions. Moreover, few studies...  
\(^{342}\) have reported empirical basis of need through case study, participation knowledge and field study that provide affirmed basis for proposed solutions.  
\(^{343}\) Some of the studies...  
\(^{344}\) Moreover, few studies...  
\(^{345}\) However, in contrast researchers formulate need/problem reported in few studies...
5.2.2.2 Sys-Rev_ RQ2.2: Are value-based contributions, proposed for the selected process area, applied and/or validated in a laboratory setting or in industry?

While analyzing application/validation method (shown in Figure 30), it is evident that 68% studies\(^{346}\) have been applied/validated proposed solutions in industrial environment through case studies (54%), questionnaire (2%), survey (4%), interview (3%), field study (4%), and longitudinal study (1%). For example, [78] proposed cost-value AHP prioritization technique and applied/validated in industry through two case studies. Moreover, [105] proposed tool based on AHP for practical support of prioritization of large-scale requirements and applied and validated in industrial setting through case study.

10% studies\(^ {347}\) have used example-driven approach or good line of argumentation for application/validation. For example, [83] proposed risk-based value oriented approach for elicitation of quality requirements and applied/validated the approach through examples. 11% studies\(^ {348}\) have used laboratory experiments or prototyping or hypothetical case study as application/validation method. For example, [80] proposed an approach for release planning. Problem formulation and application/validation of proposed approach were carried out in laboratory setting. 6% studies\(^ {349}\) proposed solutions based on theirs’ experience and observations. For example, [102] suggested some recommendations for creation of customer value based on theirs’ observations and experience in six companies. Only 3% studies\(^ {350}\) used interview, and 4% studies\(^ {351}\) used survey as application/validation method. This means that 49 studies have applied/validated proposed solutions in industrial environment and seven studies used only laboratory setting.

Furthermore, 11% studies have applied/validated proposed solutions through experiment (9%), prototyping (1%) or hypothetical case study (1%). One of the reasons of less focus validation research could be that, it is difficult to assess benefits of requirements regarding value dimensions in a laboratory setting in terms of stakeholder value propositions, business value, economic value, system value, intrinsic value, etc. For example, determining cost-benefit or return on investment of individual requirement requires a complete development life cycle. Moreover, it is difficult to create/simulate industrial requirements prioritization challenges like conflicting interests of multiple stakeholders, fixed deadlines, large number of requirements to prioritize, fewer resources etc. in a controlled environment.
Moving on from the analysis of application/validation methods used to the analysis of the application/validation design details, Figure 31 shows the categorization of the application/validation design explanation given in the included studies claiming some form of application/validation. It can be seen that 23% studies have reported detailed design of application/validation. For example, [81] used case study as an application/validation method and explained design of the case study in detail including hypothesis, research questions, results, validity threats. 36% studies summarized design for application/validation (for example see study [89]). Whereas, 21% studies stated application/validation design in a few statements only. Application/validation design details described in 59% of the studies (23% detail and 36% summary) seems to be a positive outcome that most studies have explained application/validation design in some form.
From Figure 32, it is possible to see that 59% of the studies\textsuperscript{355} presented quantitative results, 14% studies\textsuperscript{356} presented results as experts’ opinion. Furthermore, 14% studies\textsuperscript{357} presented both qualitative and quantitative results. Whereas, 4% studies\textsuperscript{358} have only statements about the results and 9% studies\textsuperscript{359} didn’t report results at all. In summary, 87% studies presented qualitative or quantitative or both types of application/validation results. This indicates that these results can be helpful in order to assess the credibility of proposed solutions with respect to usability and usefulness.

Besides results, a majority of studies\textsuperscript{360} (55%) reported scale of application/validation as “industrial” whereas 25% studies\textsuperscript{361} used “down scale real example” to demonstrate application of their proposed solutions. And, 18% studies\textsuperscript{362} reported “toy example” as shown in Figure 33.
Summarizing all the aspects discussed above, majority of the studies have used case study as an application/validation method with detailed design in industrial environment, and have presented results as qualitative or quantitative or in both forms. Thus, these studies can be considered as good quality candidate for the assessment of usability and usefulness. Furthermore, the results of these proposed solutions can be applied in other similar context because of the detailed design presented in these studies.

In addition, several other studies can also be considered as a candidate for the assessment of usability and usefulness. However, it might be difficult to validate the solutions proposed in these studies as the application/validation design has been presented only as summary.

Summarizing key aspects based on Sys-Rev_RQ2.1 and Sys-Rev_RQ2.2, less than half of the studies have reported empirical basis of needs through VBSE agenda, case study, survey and field study, and used case study, survey, and interviews as an application/validation method with detail or summarize design in industrial setting. Moreover, have presented results as qualitative or quantitative or in both forms. Strong empirical basis of need and application/validation method reported in these studies increase the credibility of proposed solutions for further research investigation. However, relatively few studies are “build on” studies with effective application/validation method, design and results need in depth investigation of empirical basis of need.

Moreover, few studies have used application/validation method as experiments with detail design and quantitative results. However, there is a need of further investigation of empirical basis of need and dynamic validation of proposed solutions in industrial setting [64]. While, rest of the studies have presented application/validation method design either “statement only” or “nothing” and require further in depth investigation of empirical basis of need. It would be difficult to generalize the results of these studies and may be hard for researchers and practitioners to replicate these types of studies in the absence of detail application/validation method’s design.
5.2.2.3 Sys-Rev_ RQ2.3: Are the value-based contributions, proposed for the selected process area, usable?

**Usability**

Out of 70, 22% (16) studies have mentioned usability as part of the proposed solutions (see overview Figure 28). Results and analysis of the attributes of usability are explained in following sections.

**Scalability of introduction**

Looking at Figure 34, it is possible to see that only 3% studies have statements as claims for scalability of introduction for the proposed solutions. For example, “As final note, the improved process and its support tool were highly appreciated and regarded as useful in commercial software development projects. The developers agreed that this effective and accurate approach to visualizing requirements value and cost is very beneficial in commercial projects.” [105]. 1% studies have presented qualitative evidence of scalability of introduction. While 96% of studies did not provide any evidence for the scalability of introduction of the proposed solutions.

![Figure 34: “Usability” Scalability of introduction](image)

**Scalability of use**

Looking at Figure 35, it is possible to see that 14% studies have claimed scalability of use as “statements only”. Examples of this can be illustrated by the statements: “Due to the new approach, there was no doubt about requirements during programming and as a result it became the first project in the company that was completed on time and without stress” [113]. 6% studies have presented qualitative evidence of scalability
of use. While 80% of studies\textsuperscript{374} did not provide any evidence that demonstrates the scalability of use for the proposed solutions.

![Figure 35: “Usability” Scalability of Use](image)

From the above analysis, it is concluded that that majority of studies do not report usability of proposed solutions with respect to scalability of introduction and scalability of use. The ones that have reported have done mostly statements about the usability aspects. Consequently, it hinders software companies and practitioners to adopt the proposed solutions. Expert’s opinion about proposed solutions with respect to scalability of use is also missing. One of the possible reason for not reporting the scalability of use for the proposed solution could be that to see the consequences of some of the value dimensions (i.e. product value, business value, intangible benefits etc.) as an output of the proposed solutions could take longer time. Thus, it might be possible that researchers and practitioners couldn’t utilize their resources to determine the scalability of use of the proposed solutions.

5.2.2.4 Sys-Rev RQ2.4: Are the value-based contributions, proposed for the selected process area, useful?

Usefulness

From Figure 28, it is evident that 18% (47) studies\textsuperscript{375} have claimed usefulness for the proposed solutions, which is a good sign for the practitioners. Results and analysis of the attributes of usefulness are explained as follows.

Better Alternative Investment

It is evident from Figure 36, that 9% of studies\textsuperscript{376} have statements-based claims about usefulness with respect to better alternative investment for the proposed solutions. Examples of this can be illustrated by the statements: “The knapsack approach presented here provides an easier, more reliable way to find an optimal solution than plotting cost-value points on an xy-plane.” [111], and “One of the limitations of the
Easy WinWin model is that negotiation is based on subjective measures. Which alternative will be chosen is a decision to be made by the project manager based on more or less accurate estimates. What is missing is a sound, quantitative evaluation of alternatives. In this paper, we have described a new and promising approach to support decision-making in the context of requirements selection. The added value of the Quantitative WinWin approach is its ability to offer quantitative analysis as a backbone for actual decisions. ” [116].

10% of the studies\textsuperscript{377} provide quantitative data about the usefulness of the proposed solutions in terms of better alternative investment. For example in [120], the proposed approach for requirements change management is compared to other approaches, that produced better results in terms of handling requirements change request, reduces effort and cost to analyze change scope and to maintain requirements traceability links. Moreover 1% studies\textsuperscript{378} have reported qualitative data about the usefulness of the proposed solutions. Whereas, 79% of studies\textsuperscript{379} did not provide any evidence about the usefulness of the proposed solutions in terms of better alternative investment.

![Figure 36: “Usefulness” Better Alternative Investment](image)

**Effectiveness**

Majority of the studies\textsuperscript{380} have claimed effectiveness for the proposed solutions. However, deeper analysis (see Figure 37) shows that 39% of studies\textsuperscript{381} have claimed effectiveness for the proposed solutions as “statements only”. For example, “During the case study, we experienced a reduction of the time spent in pre-planning to less than 20% compared to the 60% using the ad hoc approach” [119]. 14% studies\textsuperscript{382} have provided quantitative evidence of usefulness and 4% of the studies\textsuperscript{383} have provided qualitative evidences about the effectiveness of the proposed solutions. However, almost half (40%) of the studies\textsuperscript{384} have not presented any evidence of usefulness at all.

Only five studies\textsuperscript{385} have claimed both better alternative investment” and effectiveness.
From the results presented above, it can be concluded that majority of studies do not report usefulness of proposed solutions in terms of better alternative investment and/or effectiveness. Moreover, very few studies reported better alternative investment of the proposed solutions either statements only, qualitative or quantitative. One of the possible reasons for not reporting the better alternative investment for the proposed solutions is that validation and evaluation research methodologies for comparing proposed solutions have not been used by the research community. Other possible reason could be it is difficult for example, to assess benefits of requirements regarding value dimensions in laboratory setting with respect to stakeholder value propositions, business value, economic value, system value, intrinsic value, etc. For example, determining cost-benefit or return-on-investment of individual requirement requires a complete development life cycle, and thus it is difficult to do it with different solutions proposed for determining cost-benefit of requirements in a laboratory setting. Moreover, it is difficult to create/simulate industrial requirements prioritization challenges like conflicting interests of multiple stakeholders, fixed deadlines, large number of requirements to prioritize, fewer resources etc. in a controlled environment thus making it harder to do better alternative comparison between requirements prioritization techniques. Thus, it is very difficult to judge the better alternative investment of the proposed solutions in the absence of experts’ opinion and experiments. But absence of usability and usefulness evidence can make software companies and practitioners reluctant to adopt proposed solutions.

Metrics are used to capture information about attributes/components/determinants of value dimensions. You cannot control value dimensions if you cannot measure it. In order to see that how better alternative investment and effectiveness of proposed solutions can be measured. For this purpose, we have to find out that whether any metrics has been reported or not. Very few studies have reported metrics for measurement of improvement (see Table 6). These metrics have not explicitly stated in above-mentioned studies but are stated as part of proposed solutions. For example, [97] proposed metrics (such as M1: Degree of importance, M2: Degree of correlation between customer requirements and function) that are used to measure the customer value. However, majority of studies have not stated any metrics as shown in Figure 38 that becomes very difficult to assess/measure the improvements. Most of the metrics for
measurement of value dimensions have been ignored. For example, a measure e.g. requirements clarity (% of requirements needing clarification, Removal effort for discrepancies / cost of requirements work package) that is also used to contribute in system value [325], has been ignored in VBRE studies.

![Pie chart showing metrics reported and not reported](image)

**Figure 38:** Metrics for proposed solutions

Since most of the application/validation results were reported in qualitative and quantitative form (see Section 5.2.2.2), therefore, it was expected that effectiveness of the proposed solutions would also be discussed/presented explicitly. However, the results regarding effectiveness are against the expectations as they are majority as statements.

The answer to Sys-Rev_RQ2.3 is that majority of the studies do not report usability of the proposed solutions. While usefulness of the majority of proposed solutions (answer to Sys-Rev_RQ2.4) are mostly statements only. As time and resources are scarce in industry, therefore if a practitioner cannot clearly determine the time and resources required to implement a solution against the usefulness of the solution in comparison to available better alternative investments, it is very unlikely that the solution will be adopted based “statements only” made by the creators of the solution. Similarly if the authors do not present scalability in terms of introduction cost, input, processing time, and output of the proposed solutions; practitioners would be reluctant to adopt the proposed solutions, as they fall short on reporting basic evidence on efficiency.

**Table 6:** Metrics reported for proposed solutions

<table>
<thead>
<tr>
<th>Short Solution description</th>
<th>Study ID</th>
<th>Measures/metrics to evaluate improvement achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product-line process model and common value metric that effectively link drivers of product value with the software engineering</td>
<td>74</td>
<td>customer value metric</td>
</tr>
<tr>
<td>Decisions that have an effect on those drivers [74].</td>
<td>77</td>
<td>Maintainability Indicator (IM), Extendibility Indicator (IE/C), Modifiability Indicator (ICM), Indicator of Components Usage (ICi), Number of Profiles (#Pr)</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------------------------------------------</td>
<td>----</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Assess the value of a product line with respect to maintainability, extensibility and configurability by keeping in view different stakeholders’ interests such as customers, maintainers, producers.</td>
<td>79</td>
<td>Coverage, correctness, automation</td>
</tr>
<tr>
<td>Best-of-breed approach to traceability, that is used to maximize return on investment of requirement traceability with the help of different traceability techniques.</td>
<td>82</td>
<td>Quality metrics</td>
</tr>
<tr>
<td>Conceptual model that takes into account quality, cost and value dimensions to support decision making in requirements engineering activities</td>
<td>83</td>
<td>metrics for portability: $\text{Mport}(s) = 1 - \frac{\text{Eport}(s)}{\text{Enew}(s)}$, where $\text{Eport}(s)$ is the average effort for porting the system $s$ to a new platform, $\text{Enew}(s)$ is the average effort for developing $s$ from scratch for a given platform.</td>
</tr>
<tr>
<td>Value oriented risk based approach is used to specify quality requirements and shows quantification of quality requirements based on risk.</td>
<td>84</td>
<td>Cost(Core Assets), Cost(Non-Variable Features), Cost(VPi), Cost(VPiVj), Cost(VDk), Cost(Variable Features)</td>
</tr>
<tr>
<td>Process for domain analysis and economical analysis of core asset scope also guidelines that are used to maximize reusability in product line engineering.</td>
<td>87</td>
<td>coupling measure</td>
</tr>
<tr>
<td>Recommendations and a technique for visualizing interdependencies are used to support release planning activities</td>
<td>90</td>
<td>Feature Complexity (FComp), Feature Inheritance (FInh), Feature Coupling (FCoup), Feature Cohesion (FCoh)</td>
</tr>
<tr>
<td>using object oriented design metrics</td>
<td><strong>91</strong></td>
<td>Value-based priority (i.e. $\text{value}(i, p)$), satisfaction-based priority (i.e. $\text{sat}(i, p)$), SD-coupling measure</td>
</tr>
<tr>
<td>Technique that is used to detect coupling between features sharing same components that implement these features.</td>
<td><strong>97</strong></td>
<td>M1: Degree of importance, M2: Degree of correlation between customer requirements and function</td>
</tr>
<tr>
<td>Customer value based partitioning decision (CVPD) method is used to identify, analyze, and estimate the value of customer requirements during partition decision-making process.</td>
<td><strong>100</strong></td>
<td>measure: strength of trace link</td>
</tr>
<tr>
<td>Simple techniques are explored that are used to predict and manipulate cost-benefit trade-off during traceability link generation.</td>
<td><strong>101</strong></td>
<td>Readability score, Defect density score</td>
</tr>
<tr>
<td>Automated analysis tool is evaluated with the help of process simulation that determine that where it add high value and where it add less value</td>
<td><strong>112</strong></td>
<td>Service usage</td>
</tr>
<tr>
<td>Suggested requirements engineering practices that are used to support practitioners to focus on customer value creation rather than feature development.</td>
<td><strong>113</strong></td>
<td>hit rat, time to detect the defect, Saved work hours to report and handle a defect, (net rework time), For reported defects that were not repaired or repaired only partially: the market value minus development time if it had been dealt with earlier. 4. Effect on early development if requirements had been better known.</td>
</tr>
<tr>
<td>Approach that is used for defect identifications and prevention with respect to usability testing</td>
<td><strong>119</strong></td>
<td>Savings on initial planning, replanning, stakeholder savings, increase in sales revenue</td>
</tr>
<tr>
<td>Set of recommendations for</td>
<td><strong>126</strong></td>
<td>low, medium and high Life cycle objective</td>
</tr>
<tr>
<td>process in addition with win-win model</td>
<td>grade (requirements, operational concept, architecture, life-cycle, and feasibility rationale documents)</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Value Gap Model for requirements elicitation</td>
<td>130</td>
<td>profits</td>
</tr>
<tr>
<td>Intelligent fuzzy logic based technique for requirements prioritization</td>
<td>132</td>
<td>consistency, time, scalability, ease of use, accuracy</td>
</tr>
<tr>
<td>Requirement engineering process (i.e. value-innovative requirements engineering) for requirements elicitation</td>
<td>140</td>
<td>increase number of users, user satisfaction, new market exploration, system success</td>
</tr>
<tr>
<td>Process for assessment of product line in terms of success, consistency and quality</td>
<td>439</td>
<td>source code metrics</td>
</tr>
</tbody>
</table>

5.2.2.5 Sys-Rev_RQ2.5: Which of the following factors that challenge or impair the project are considered in studies?

It is quite positive to observe that most of the challenges of project failure indicated by the Standish group are addressed/discussed in different phases of requirement engineering as shown in Table 7. However, since most of the studies fall short of reporting even rudimentary evidence of usability and usefulness (see Section 5.2.2.4), it is difficult to apply and/or validate the solutions proposed to address these challenges.

Most important challenge is “How to Eliciting and reconciling stakeholders’ value propositions”. Some of the studies proposed solutions to address this challenge but these studies do not consider reconciliations techniques in an effective way. There are different techniques for reconciliation of stakeholder’s value propositions, such expectation management [1], visualization and trade-off analysis [1], prioritization [1], groupware [1], and business case analysis [1], that can be used. There is a need to identify a better alternative for eliciting and reconciling stakeholder value propositions by comparing these reconciliation techniques with respect to the cost versus benefit. Moreover, to identify and involve success critical stakeholders in several meetings for identifying and managing theirs’ value proposition is very costly.

Within release planning the most important challenge is how to select most valuable requirements. However, in the absence of explicit description of the value consideration targeted and the value components constituting the given value consideration, it is clear that the criteria used for maximizing value is quite hard to identify and quantify. This inherent limitation in all the selected studies is further discussed in Section 5.2.2.6.

Moreover, these studies do not consider the role of innovative and system improvement requirements in product value creation. These types of requirements also have a major role in product value creation. Ignorance of innovative requirements in requirements selection and relation of innovation with value dimensions are further discussed in Section 5.2.2.8.

Another largely discussed challenge is related to the alignment between different stakeholders within an organization (for example, business, marketing, and
This is a very important challenge because the core essence of value-based software engineering is to incorporate business value considerations while selecting, prioritizing and implementing requirements. For this it is required that technical stakeholders understand business value and use it as an important criteria when taking decisions.

Last but not the least a fundamental issue, which we identified from our industrial experience and empirical research is the lack of metrics and measurements to evaluate/measure the potential improvements achieved by applying for example a value-based requirements prioritization solution. In most of the studies this has not been addressed and described which poses a greater challenge as how to evaluate the proposed solutions with respect to the improvement made. This has been discussed in detail in Section 5.2.2.4. This is in general important to have a discrete strategy and measures to valuate improvement in general and within VBSE in particular because the basis of VBSE is to add value. Unless that value can be measured/evaluated in some way, the very basic principle of VBSE is being violated.

Another discussion aspects could be that challenges identified by Standish group are project based like lack of resources, changing and incomplete requirements specification, lack of planning whereas market-driven software products development faces additional challenges like continuous release planning, risk planning and mitigation, coordinating between multiple releases [129, 139], identifying value propositions of larger group of customers/users [112]. Some solutions have been proposed to address these challenges but they need to be validated and refined based on industry needs.

Table 7: Challenges categorization

<table>
<thead>
<tr>
<th>Sub process area within VBRE</th>
<th>Challenges</th>
<th>Study ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release planning</td>
<td>Challenge 1: Lack of planning, unclear objectives</td>
<td>71,</td>
</tr>
<tr>
<td></td>
<td>Challenge 2: Eliciting and reconciling stakeholders’ value propositions</td>
<td>76, 94, 95, 125,</td>
</tr>
<tr>
<td></td>
<td>Challenge 3: Unrealistic Time Frames,</td>
<td>80,</td>
</tr>
<tr>
<td></td>
<td>Challenge 4: Lack of Planning</td>
<td>80,</td>
</tr>
<tr>
<td></td>
<td>Challenge 5: Unrealistic Expectations</td>
<td>80,</td>
</tr>
<tr>
<td></td>
<td>Challenge 6: Lack of alignment between product, project and organization decisions</td>
<td>81,</td>
</tr>
<tr>
<td></td>
<td>Challenge 7: Lack of decision-support for non-functional requirements road mapping</td>
<td>82,</td>
</tr>
<tr>
<td></td>
<td>Challenge 8: Issues related to requirements interdependencies</td>
<td>87,</td>
</tr>
<tr>
<td></td>
<td>Challenge 9: Changing Requirements &amp; Specifications and the issue of dependencies</td>
<td>90,</td>
</tr>
<tr>
<td></td>
<td>Challenge 10: Identifying most valued requirements for a release</td>
<td>99,</td>
</tr>
<tr>
<td></td>
<td>Challenge 11: Decision support for how to maximize business value keeping in view time, resources and uncertainty constraints</td>
<td>103,</td>
</tr>
<tr>
<td></td>
<td>Challenge 12: Decision support for how to maximize business value keeping in view cost uncertainties</td>
<td>106,</td>
</tr>
<tr>
<td></td>
<td>Challenge 13: Lack of solution to handle business</td>
<td>107,</td>
</tr>
<tr>
<td>Requirements prioritization</td>
<td>Challenge 1: Lack of accurate data for feasibility analysis</td>
<td>69</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>Challenge 2: Eliciting and reconciling stakeholders’ value propositions</td>
<td>70, 78,</td>
<td></td>
</tr>
<tr>
<td>Challenge 3: How to prioritize requirements</td>
<td>105,</td>
<td></td>
</tr>
<tr>
<td>Challenge 4: Decision support for how to maximize business value keeping in view cost constraints</td>
<td>111,</td>
<td></td>
</tr>
<tr>
<td>Challenge 5: find some means of prioritizing changes to take account of technical risk and development risk in an appropriate way.</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>Challenge 6: Lack of software process improvement in RE</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Challenge 7: What - in terms of methods and activities - is needed to prioritize requirements using cost and benefit predictions as criteria</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>Challenge 8: Lack of planning</td>
<td>132</td>
<td></td>
</tr>
<tr>
<td>Challenge 9: how to value-based requirements prioritization in small companies</td>
<td>137</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirements traceability</th>
<th>Challenge 1: Lack of resources</th>
<th>79</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge 2: Finding the importance of trace links</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Challenge 3: Factors driving decisions related to traceability of requirements</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Challenge 4: Complexity and costs for traceability</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Challenge 5: how to do requirements change management</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Challenge 6: requirements tracing options to facilitate</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Requirements elicitation</td>
<td>Challenge 1: Lack of actors input</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>Challenge 2: perception gap between developers and users in digital consumer products.</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Challenge 3: Changing Requirements &amp; Specifications</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>Challenge 4: How to innovate value?</td>
<td>140</td>
</tr>
</tbody>
</table>

| Product line engineering | Challenge 1: Lack of planning for maintenance and evolution | 73 |
| | Challenge 2: Lack of alignment between business and technical departments | 74 |
| | Challenge 3: Lack of accurate data for feasibility analysis | 75 |
| | Challenge 4: Eliciting and reconciling stakeholders' value propositions | 77 |
| | Challenge 5: How to find the right scope for core assets | 84 |
| | Challenge 6: Is business value created through product line engineering | 92 |
| | Challenge 7: perception gap between developers and users in digital consumer products. | 112 |
| | Challenge 8: Value of adopting/introducing software product lines | 439 |
| | Challenge 9: Deriving individual products from their shared software assets is a time- and effort-consuming activity. | 440 |

| Requirements fundamentals | Challenge 1: Lack of alignment between business and technical departments | 86 |
| | Challenge 2: Lack of solutions for understanding and measuring value from customers' perspective | 102 |

| Requirements analysis | Challenge 1: How to do value assessment for product requirements | 89 |
| | Challenge 2: Impact analysis of tool/technology adoption on project | 101 |
| | Challenge 3: Find a good-enough quality level of the decision material, which can be acquired within the allowed budget for the pre-project decisions. | 110 |
| | Challenge 4: Decision support for how to maximize business value keeping in view cost constraints | 111 |
| | Challenge 5: Incomplete Requirements & Specifications | 113 |
5.2.2.6 Sys-Rev_RQ2.6: Are value dimensions clearly defined in VBRE studies?

Almost half of the studies\(^{397}\) have given description/defined value dimensions in some form. However, majority of studies\(^{398}\) have not defined value dimensions in its appropriate form as shown in Figure 39 that results into misinterpretation of value dimensions.

![Figure 39: Overview of value dimensions definitions/descriptions](image)

By having a closer look at definition of value dimensions, it has been observed that nine studies\(^{399}\) have defined business value in some form. However, six studies have not defined business value. Similarly, five studies\(^{400}\) defined customer value in some form for example, [97] defined customer value as “customer value reflects the relation between customer requirements and functional components and its degree of relation which is ultimately represented as some quantitative numeric values (i.e. degree of strength or weakness in relationship between requirements and components)”. Moreover, [86] defined customer perceive value as “This is the benefit derived from the product and is a measure of how much a customer is willing to pay for it”. Nevertheless, six studies\(^{401}\) have not explicitly stated any definition of customer value.

Seven studies\(^{402}\) defined product value as shown in Figure 40. For example, few studies\(^{403}\) defined product value “This is the market value of the product (i.e. exchange value) and related to the product, and is influenced by the quality attributes of the software product”. Moreover, [81] defined product value as “Product value is related to the product price and influenced by the quality attributes of the software product. The value of a product increases in direct proportion to its advantage over competitive products or decreases in proportion to its disadvantage”.

---

\(^{397}\) Assume a page number or a citation.

\(^{398}\) Assume a page number or a citation.

\(^{399}\) Assume a page number or a citation.

\(^{400}\) Assume a page number or a citation.

\(^{401}\) Assume a page number or a citation.

\(^{402}\) Assume a page number or a citation.

\(^{403}\) Assume a page number or a citation.
Table 8: Value dimensions definitions

<table>
<thead>
<tr>
<th>Value consideration</th>
<th>Frequency of studies</th>
<th>Definition/description stated</th>
<th>Definition/description not stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business value</td>
<td>15(^{104})</td>
<td>9(^{105})</td>
<td>6(^{106})</td>
</tr>
<tr>
<td>Product value</td>
<td>9(^{107})</td>
<td>7(^{108})</td>
<td>1(^{109})</td>
</tr>
<tr>
<td>Project value</td>
<td>4(^{110})</td>
<td>3(^{111})</td>
<td>1(^{112})</td>
</tr>
<tr>
<td>Customer value</td>
<td>11(^{113})</td>
<td>5(^{114})</td>
<td>6(^{115})</td>
</tr>
<tr>
<td>User value</td>
<td>7(^{116})</td>
<td>3(^{117})</td>
<td>4(^{118})</td>
</tr>
<tr>
<td>Market value</td>
<td>6(^{119})</td>
<td>3(^{120})</td>
<td>3(^{121})</td>
</tr>
<tr>
<td>System Value</td>
<td>5(^{122})</td>
<td>2(^{123})</td>
<td>2(^{124})</td>
</tr>
<tr>
<td>Stakeholder value</td>
<td>4(^{125})</td>
<td>3(^{126})</td>
<td>1(^{127})</td>
</tr>
<tr>
<td>Value</td>
<td>14(^{128})</td>
<td>12(^{129})</td>
<td>2(^{130})</td>
</tr>
<tr>
<td>Feature value</td>
<td>3(^{131})</td>
<td>2(^{132})</td>
<td>3(^{133})</td>
</tr>
<tr>
<td>Requirements value</td>
<td>4(^{134})</td>
<td>2(^{135})</td>
<td>2(^{136})</td>
</tr>
<tr>
<td>ROI/Cost-benefit</td>
<td>8(^{136})</td>
<td>1(^{137})</td>
<td>7(^{138})</td>
</tr>
<tr>
<td>Economic value</td>
<td>1(^{139})</td>
<td>1(^{140})</td>
<td>1(^{141})</td>
</tr>
<tr>
<td>Value of technology</td>
<td>2(^{141})</td>
<td>1(^{142})</td>
<td>1(^{143})</td>
</tr>
<tr>
<td>Relationship value</td>
<td>1(^{144})</td>
<td>1(^{145})</td>
<td>1(^{146})</td>
</tr>
<tr>
<td>Software value</td>
<td>1(^{146})</td>
<td></td>
<td>1(^{147})</td>
</tr>
<tr>
<td>Utility value</td>
<td>1(^{148})</td>
<td>1(^{149})</td>
<td></td>
</tr>
</tbody>
</table>

Few studies used the term value but have not explicitly defined that what kind of value is it that ultimately results into misinterpretation and diminish importance of research contribution. See detail results in Table 8.

![Figure 40: Value dimensions definitions/descriptions](image)

98
5.2.2.7 Sys-Rev_RQ2.7: Which methods (tools, techniques etc.) are used to elicit given value consideration or how the value consideration is assigned a value?

Conceptual background of value dimensions (conceptual analysis)

As VBSE borrows concepts and ideas from various disciplines, for example, finance, economics, marketing strategies, business administration, innovation and entrepreneurship, management science, economics, humanities, and cognitive sciences and the value mentioned in these fields is hard to quantify because different people have different interpretation of this term. So it important to do conceptual analysis of value dimensions in order to reflect coherent concepts. Very few studies perform conceptual analysis of value dimensions and introduce concepts from marketing, business administration and economics field into VBRE. Moreover, few studies reported cost-benefit analysis/return on investment methods that are used in finance or economics. However, majority of studies do not provide sufficient conceptual background for value dimensions. Concepts from finance, innovation and entrepreneurship, management science, humanities, and cognitive sciences have been completely ignored in VBRE studies (see detail in Table 9). For example, discounted cash flow and traditional net present value, decision trees, real options and option pricing theory, utility theory and portfolio theory etc.

Empirical investigations of value dimensions

While analyzing the results of empirical investigation of value estimation/evaluation, more than half of the studies have used application/validation method as case studies, surveys, interviews, questioners, and field studies for proposed solutions, but when it comes to value dimensions, to see the consequences of value dimensions as an output of proposed solutions for product, project, organization or society could take longer time. In spite of effective utilization of application/validation methods and their designs, the consequences of value dimensions are missing in VBRE studies. Moreover, some of the studies reported value dimensions through examples, experiences and laboratory settings that lack expert’s opinion.

Methods/Process/scales to determine value dimensions

Moreover, if we analyze value dimensions in depth then we see the discrepancies in the methods or process that are used to assess the value dimensions. For example, some of the studies reported customer value. Only one study used customer value analysis process and approach to determine the customer value and one study used Kano Model and Kano questionnaire to determine/assess customer value. Three studies used scale to determine/assess customer value. While, rest of the studies ignore an effective method/process to determine customer value (see details in Table 9). Methods like GAP and CVA analysis have been completely ignored in VBRE studies for assessment of perceived customer value/user value. Gap analysis is used to measure/evaluate positive and negative gaps between what the product delivers and what customers expect/perceives. Positive gap means that product delivers more than the expectation of customers and negative gap means that product deliver less than the expectations of customers. Customer value analysis performs function like Gap analysis but also consider features of competitor’s product...
during analysis. Moreover, it is evident from studies that business criteria for requirements selection are the most influential criteria for product value creation. A technique that is called Internal Value Analysis (IVA) \([459]\) that has direct relation with product value has been ignored in those studies that reported product value. Because, it is used to measure the alignment of product with product strategies (business strategies).

**Table 9: Value dimensions evaluation/estimation/determining**

<table>
<thead>
<tr>
<th>Value dimension</th>
<th>Value consideration is evaluated /estimated.</th>
<th>Value evaluation /estimation reported</th>
<th>Not reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business value</td>
<td>Web surveys([70]), targeted article surveys([70]), key customer and prospect interviews([70]), industry analyst interviews([70]), win-and-loss reports in competitive situations([70]), and business process and value chain modeling([70]), concepts from economics and marketing([81]), surveys ([81]), interviews and surveys from practitioners and going on([81]), conceptual analysis([86]), value of feature(0-9 scale but stakeholder voting as an example)([90]) and business value(no effective way)([90]), literature description([91]), literature review concepts, interview and questioners([92]), Process simulation model([101]), numerical methods such as rejection sampling([103]), observation([108]), Initial screening([110]), relative value of requirements assigned by stakeholders([116]), weighted relative importance from stakeholders perspective([131]), stakeholder’s subjective evaluation on a 1-10 scale([137])</td>
<td>12(^{156})</td>
<td>3(^{157})</td>
</tr>
<tr>
<td>Product value</td>
<td>Concepts from economics and marketing([81]), survey ([81]), interviews and surveys from practitioners and going on([81]), conceptual analysis([86]), literature review concepts, interview and questioners([92]), Surveys([94, 95]), Brainstorming([95]) , Conceptual analysis([95]), Survey with companies([117]), stakeholders relative evaluation([133])</td>
<td>8(^{358})</td>
<td>1(^{359})</td>
</tr>
<tr>
<td>Project value</td>
<td>Economics and marketing concepts([81]), surveys ([81]), interviews and surveys([81]), conceptual analysis([86]), Process simulation model([101])</td>
<td>3(^{460})</td>
<td>1(^{461})</td>
</tr>
<tr>
<td>Customer</td>
<td>Stakeholders’ opinion([71]), customer value</td>
<td>10(^{462})</td>
<td>1(^{463})</td>
</tr>
<tr>
<td>Value Type</td>
<td>Methodology</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td><strong>User value</strong></td>
<td>Stakeholders' opinion[78], AHP method [105], Service usage[112], Stakeholder's qualitative opinion[114], stakeholders subjective assignment[125], users subjective evaluation[130], interviews with customers (importance for customers rated by customers on a 5 point scale)[140].</td>
<td>6(^{464}) 1(^{465})</td>
<td></td>
</tr>
<tr>
<td><strong>Market value</strong></td>
<td>Stakeholders' opinion [71], interviews with domain experts[82], AHP and the Planning game, and in addition we included the $100 technique[106], Interviews[107], unit price[113] and unit sales data[113].</td>
<td>5(^{466}) 1(^{467})</td>
<td></td>
</tr>
<tr>
<td><strong>System Value</strong></td>
<td>Stakeholder's opinion about cost estimations[69], cost = man-hours[69], tangible benefits = baseline cost - residual cost[69], intangible benefits = custom benefit[69], literature description[91]</td>
<td>2(^{468}) 2(^{469})</td>
<td></td>
</tr>
<tr>
<td><strong>Stakeholder value</strong></td>
<td>Literature[77], case study[77], genetic algorithm[80], experiment[80], observation[83], win-win model[88].</td>
<td>4(^{470})</td>
<td></td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>Stakeholders' opinion[76], financial model for comparing costs and returns of various trace methods [79], empirical study [85], interviews[89], brainstorming[89], function analysis[89], Stakeholders' subjective opinion[115], Stakeholders subjective opinion[118], Stakeholders value propositions[122], Precision, [128] Completeness[128], Correctness[128], and Timeliness generated from test-based trace analysis approach [128], stakeholder subjective prioritization of requirements[134].</td>
<td>11(^{471}) 3(^{472})</td>
<td></td>
</tr>
<tr>
<td><strong>Feature value</strong></td>
<td>value of feature(0-9 scale but stakeholder voting as an example)[90], literature description[91], stakeholder subjective evaluation[129]</td>
<td>3(^{473})</td>
<td></td>
</tr>
<tr>
<td><strong>Requirements value</strong></td>
<td>Interviews [107], fuzzy logic on requirements subjectively prioritized by stakeholders [132], students as stakeholder's subjective evaluation[138].</td>
<td>3(^{474}) 1(^{475})</td>
<td></td>
</tr>
<tr>
<td><strong>ROI/Cost-benefit</strong></td>
<td>Monte carlos simulation[75], economic model[75], financial model for comparing</td>
<td>4(^{476}) 4(^{477})</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Economic value</td>
<td>Literature survey[84], case study[84].</td>
<td>1478</td>
<td></td>
</tr>
<tr>
<td>Value of technology</td>
<td>Process simulation model[101], one stakeholder's subjective evaluation[135].</td>
<td>2479</td>
<td>1480</td>
</tr>
<tr>
<td>Relationship value</td>
<td>Conceptual analysis[86].</td>
<td>1481</td>
<td></td>
</tr>
<tr>
<td>Software value</td>
<td>Approximated by piecewise linear functions resulting from monthly and quarterly estimates, which mirrors the real-world approach of soliciting stakeholder opinion about monthly and quarterly income potential[139].</td>
<td>1482</td>
<td></td>
</tr>
<tr>
<td>Utility value</td>
<td>Literature review[104].</td>
<td>1483</td>
<td></td>
</tr>
</tbody>
</table>
5.2.2.8 Sys-Rev_RQ2.8: Which type of value and their components are considered in the study?

Majority of value dimensions (i.e. product value, business value, customer value etc.) have been reported in VBRE studies (see Table 10), however, important value dimensions (i.e. intrinsic value, innovation value, value of technology, complementary value and network externalities etc.) have not been reported in VBRE studies(see Appendix DD). By considering reported value dimensions, it is important to see that whether the components of value dimensions are reported or not. 42 studies\(^{484}\) reported components of value dimensions in some form. Whereas, 32 studies\(^{485}\) have not reported any components of value dimensions as shown in Figure 41.

![Figure 41: Overview of value dimensions components](image)

While analyzing the results of value dimensions with respect to components in detail, it has been observed that 11 studies\(^{486}\) have reported components of business value, nine studies\(^{487}\) reported components of customer value and seven studies\(^{488}\) reported product value in some form as shown in Figure 42. However, economic value, value of technology, and software value has been given less attention (see details in Table 10). Moreover, 14 studies\(^{489}\) reported value dimension as “Value” but did not mention that whether it is product value, business value or customer value. An interesting aspect here is that majority of studies that report product value, business value and customer value ignore the relation of these value dimensions with innovation.
<table>
<thead>
<tr>
<th>Value dimension</th>
<th>Value components</th>
<th>Value components reported</th>
<th>Value components not reported</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business value</strong></td>
<td>Product sales[81, 86, 110], stakeholder savings[119], increase in sales revenue[119], sales value[137], marketing value [137], competitiveness[137], strategic alliance[137], customer retention[137], customer satisfaction[137], integrity[137], balance between high value of release and modifiability[90], value of feature[90, 91], product diversification[92], improving process [92], product or new business opportunities [92], meeting business goals and customer needs [92], reduced time-to-market [92, 101], revenue generation[92, 101, 110], impact of tool[101], value of technology[101], return on investment[101, 103], usefulness[101], conditions[101], performance standards for tool or technology[101], market shares[101], User stories size[103], expected project velocity[103], project completion time[103], robust requirements process[108], measurable requirements[108], reusable requirement[108], embrace change[108], contractual innovation[108], savings on initial planning[119], re-planning [119],</td>
<td>11^490</td>
<td>4^491</td>
</tr>
<tr>
<td><strong>Product value</strong></td>
<td>product price[81, 86], non-functional requirements[81, 86,], advantages over competitor’s products[81, 86], importance of customer[81], customer satisfaction(business perspective)[86, 94], software features(business perspective)[86, 94], business strategy (business perspective)[86, 94], development cost-benefit(project perspective)[86, 94, 95], delivery date/calendar time(project perspective)[86, 94, 95], status of competitors with respect to the requirements[81], customer requirements[86], market requirements[86], deliver on customers’ needs and requirements[92], products integration[92], components sharing[92], shorter time frame[92], quality of the core assets[92], product maturity[92], evolution (Product)[94], requirements issuer[95], priority of that requirement [95], resources available [95], market share increase[133], quality and reliability improvements[133], risk</td>
<td>7^492</td>
<td>1^493</td>
</tr>
<tr>
<td></td>
<td></td>
<td>04&lt;sup&gt;494&lt;/sup&gt;</td>
<td>01&lt;sup&gt;495&lt;/sup&gt;</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Project value</strong></td>
<td>total benefits (tangible and intangible), total implementation cost[69], project budget/timing/delivery, etc.[81, 86], reduce effort[101], reduce duration[101], high quality[101]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Customer value</strong></td>
<td>buyer’s beliefs about the product [74], company [74], buying situation, the buyer’s motivations[74], customer’s perceptions of economic [74], customer’s perceptions of performance[74], customer’s perceptions of supplier value[74], clear, unambiguous knowledge about requirement priorities [78, 105], tradeoffs among quality, cost, and time-to-market [78, 105], resource allocations based on the requirement’s importance to the project [78, 105], requirements importance[78, 105], benefit derived[86], willingness[86], importance to the customer[87], level of satisfaction[97], correlation degree between customer requirements and functional components[97], importance of services[102], relationship benefits between supplier and consumer[102], awareness about product or service[102], customers selection[102], ordering and purchasing product or service[102], product installation[102], product or service paid for[102], solution[102], product repaired[102] and serviced[102], addressing problems[102], upgrading[102], customer satisfaction[107], customer satisfaction[140]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>User value</strong></td>
<td>extra income generated[114], cost of development[114], user satisfaction[130]</td>
<td>02&lt;sup&gt;498&lt;/sup&gt;</td>
<td>05&lt;sup&gt;499&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Market value</strong></td>
<td>If competitors had it[71], utility breakpoint[82], differentiation breakpoint[82], saturation breakpoint [82], relative values of requirements in market[106], market expectations[106], development costs[106], potential sales[107], saving costs[107], business risk[107], level of variability[107], maintenance costs [107], ROI[107]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System Value</strong></td>
<td>net present value[69], cost of unmitigated threats[69], number of features shares impacted components[91]</td>
<td>02&lt;sup&gt;502&lt;/sup&gt;</td>
<td>02&lt;sup&gt;503&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Stakeholder value</strong></td>
<td>overcoming clashes [77], maximize stakeholder satisfaction with respect to project risk, cost and requirements interdependencies[80], requirements that deliver value[83], benefit of reducing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature value</td>
<td>development risk [83], satisfy stakeholders’ desires[83] and needs[83], Quantification of quality requirements with respect to high risk, needs, demands and wishes[83], importance of stakeholders[83], stakeholders priorities and importance[88], stakeholder's conflicts and resolution [88]</td>
<td>05</td>
<td>09</td>
</tr>
<tr>
<td>Requirements value</td>
<td>coverage, [79], correctness[79], precision[79], automation[79], maintainability[79], minimum cost[79], external constraints [79], requirements classification[85], value of artifacts[85], overlapping among artifacts [85], quality of trace links[85, 100], trace links between artifacts [85], traceability links efforts[85, 100], trace rework [85], worth[89], cost[89], innovative[99], sellable [99], quality improving</td>
<td>02</td>
<td>1</td>
</tr>
<tr>
<td>Economic value</td>
<td>cost of building or evolving systems as a product line[73], cost of treating building or evolving system independently [73], financial terms[75], coverage, [79], correctness[79], precision[79], automation[79], maintainability[79], minimum cost[79], external constraints [79], trace implementation cost[79], user quality perception and market value [82], investments in development effort [82], Requirements classification[85], value of artifacts[85], overlapping among artifacts[85], quality of trace links[85], the level of detail of trace links between artifacts[85], traceability links efforts [85], trace rework [85], trace generation and rework cost[85].</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Value of technology</td>
<td>productivity, and cost, economic value=(expected gain-(cost without core assets)-(cost with core assets +total cost of products with core assets)) [84]</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Feature value</td>
<td>implementation effort[90], risk[90] and projected value on scale(0-9)[90], importance with respect to business stakeholders[91]</td>
<td>02</td>
<td>1</td>
</tr>
<tr>
<td>Requirements value</td>
<td>customer satisfaction[107], potential sales[107], saving costs[107], business risk[107], level of variability[107], faster and cheaper development [107], decreased maintenance costs[107], return on investment[107].</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>ROI/Cost-benefit</td>
<td>cost of building or evolving systems as a product line</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Economic value</td>
<td>productivity, and cost, economic value=(expected gain-(cost without core assets)-(cost with core assets +total cost of products with core assets))</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Value of technology</td>
<td>Improve clarification of requirements[101], improves engineering design decisions[101], improve productivity, reduce number of defects [101], less effort[101], less duration[101],high quality[101].</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Moreover, VBRE studies do not consider the role of innovative and system improvement requirements in product value creation. These types of requirements also have a major role in product value creation. One of the most important challenges is the market pull and technology push that was introduced by Tony Gorschek [469]. He emphasized on the balance between market pull and technology push. Selecting or prioritizing technology push (innovation requirements) requirements may leave customers or users unsatisfied, or selecting or prioritizing market pull requirements ignore innovation requirements that could generate high product value, business value, customer value and organization value in near future. One of the possibilities of not reporting the role of these types of requirements in product value creation could be, that to the best of our knowledge there are no business models that predict/evaluate business risk associated with system improvements requirements and innovative requirements. That is why most of the organizations prefer commercial requirements to rest of the requirements having high business risk. Business risk associated with different types of requirements is different [400] (i.e. business risk associated with commercial requirements is low [138, 400], business risk associated with system improvement requirements and innovative requirements [138,399, 400].

**Product innovation and business value**

Majority of VBRE studies have not shown any relation between product innovation and business value. If we analyze the theme of product innovation and most important components of business value, then it shows a clear connection that product innovation plays a key role in business value creation. The improved and/or development of new successful product is vital for the success of an organization and is considered to be an important specifically for long-term business growth [468]. It has strong connection with business valuation [468]. To retain market growth, products have to be improved and completely renewed. It helps companies to maintain and grow to competitive position. Innovated product (i.e. either improved one or new one) may contain additional features or improved functionality [468]. Here, if we analyze the most important drivers of business value then it shows that these important drivers are obtained as an output of product innovations. The possible important drivers of business value are product sales [81, 86, 110], stakeholder savings [119], increase in sales revenue [119], sales value [137], marketing value [137], competitiveness [137], strategic alliance [137], customer retention [137], customer satisfaction [137], integrity [137], product diversification [92], improving process [92], product or new business opportunities [92], meeting business goals and customer needs [92], reduced time-to-market [92, 101], revenue generation [92, 101, 110], value of technology [101], return on investment [101, 103], usefulness [101], market shares [101], project completion
time [103], robust requirements process [108], measurable requirements [108], reusable requirement [108], embrace change [108], and contractual innovation [108]. Product innovation is important for long-term business growth. It sustain market growth and is strongly connected with the business valuation [468], therefore we can say that product innovation is a major contributor in driving business value.

**Product innovation and product value**

Product innovation can be described as new or improved product that not only satisfy known but also unknown needs of customers and provide competitive edge over competitive products [468]. Therefore, prioritizing and selecting requirements with respect to customer/market needs and satisfying their both known and unknown needs up to greater extent because of innovative product.

whereas, if we have a look at product value then most important value drivers are product price [81, 86], non-functional requirements [81, 86], advantages over competitor’s products [81, 86], importance of customer [81], customer satisfaction(business Perspective) [86, 94], software features(business perspective) [86, 94], business strategy (business perspective) [86, 94], development cost-benefit(project perspective) [86, 94, 95], delivery date/calendar time(project perspective) [86, 94, 95], status of competitors with respect to the requirements [81], customer requirements [86], market requirements [86], deliver on customers’ needs and requirements [92], products integration [92], components sharing [92], shorter time frame [92], quality of the core assets [92], product maturity [92], evolution (Product perspective) [94], requirements issuer [95], priority of that requirement [95], resources available [95], market share increase [133], quality and reliability improvements [133], risk reduction [133], health or safety improvements [133], and improvements in client operations [133].

Most of the product value drivers mentioned above is also satisfied by innovative product. Hence, it is concluded that product innovation plays an important role in driving product value.

**Process innovation and value dimensions**

Process innovation offers the ways for protecting and improving quality and saving cost and time. It offers product in lower prices to the customers. It unites quality function deployment and business process reengineering [468]. Whereas, implementing such a process that monitor and control cost and schedule of the projects generates earned value [1]. Earned value itself is an important driver of financial value [133]. By analyzing process innovation and value dimensions’ drivers, it seems to be a major contributor in driving product and business value generation. So here, we can say that process innovation generates financial value and have indirect relation with product value and business value.

**Organizational innovation and value**

Organization innovation [468] can be described as introducing new or change in organization structure [468], advance management techniques implementation [468], and new or changed corporate strategic orientation implementation [468]. Organization innovation drives the creation of financial value, organizational value, and business value. Brief description is as follows
Deployment of new or improved advance management techniques

As organizational innovation can be a new or improved business model [468]. When an organization implements “Earned value management” to monitor and control cost and schedule of project. The project can be successful in terms cost and schedule oriented “earned value” but may have great impact on the organization value [468]. However, if we implement “value realization feedback” process in order to supplement the results of earned value management that will ultimately results into the creation of organizational value [1].

Introducing change in organization structure

Change in organization structure also plays key role in value creation [468]. Close collaboration and coordination among employees of different departments within the same organization results into greater exchange of ideas and experiences. Joint collaboration and coordination among employees’ lead to innovation that ultimately result into the creation of value.

New or changed corporate strategic orientation implementation

New or change strategic orientation [468] is also an important business value driver that also plays a major role in business value creation. Becoming business partners with other organizations through strategic integration/alliance [137] creates business value. Therefore, we can say that organization innovation also plays an important role in the creation of business value.

Example: Suppose a company A operates in a market for long time. Its product is used for the documentation, management of changes in requirements and relationship among the requirements. The customer ranges from small consulting firm to high level organization who utilizes its product. The demand for support of extra processes increases from customers with passage of time. The marketing and customer support departments within organization also start focus on demanding additional functionalities and features in the next release of the product. Now for company to sustain the market shares and satisfy customer’s needs, demands and wishes within a short period of time and under limited resources. The company will move toward strategic integration alliance with other partners. Strategic integration alliance helps company to deliver product to the market in short period of time by providing additional features that satisfy customers and retain market growth and shares. However, new or improved corporate strategic orientation is organization innovation and is an important driver of business value. Therefore, we can say that organization innovation drives business value.

Innovation and technology value

Innovation can be considered as a fundamental factor that drives technology value [33]. Firstly, idea comes from academia or industry and then developed into technology [33] (i.e. it can be methods, tools, techniques etc.). Technology passes through several steps from static validation to dynamic validation utilizing different research methods and improves with passage of time. Usability and usefulness of the technology is evaluated using industrial practitioners [33]. Cost-benefit analysis, return on investment and comparison in terms of best alternative is assessed in industry. If cost associated with implementation or introduction of new technology is less as compared to other
alternatives, provides long-term benefits and generates high return-on-investment, then it results into financial value, economical value and technology value. Therefore, we can say that innovation is a fundamental factor that creates technology value.

**Innovation and customer value**

Innovative solution increases the performance/functional value of the product that is an important driver of customer value from product perspective [31]. Moreover, if innovative solution comes in form of awareness about product or services [102], ordering and purchasing of products or services, product installation, product or service paid for, solutions, product repairing and servicing, addressing problems, and up gradation results into creation of customer value from Product perspective.

![Figure 42: Reporting of value dimensions’ components](image_url)
5.2.2.9 Sys-Rev_RQ2.9: In which perspective (project, product organization), authors discuss value dimensions?

To answer this question, value dimensions are viewed/mapped into different levels of onion model [459]. While analyzing results of perspectives of value dimensions, it has been found that almost half of the studies [519] reported value dimensions from product perspectives and 20 studies [520] reported value dimensions from project perspectives. However, these studies only discuss value dimensions from product perspectives or project perspectives but do not consider overall value considerations at organization level. For example, few studies [521] that reported stakeholder value from project perspectives. However, missing success critical stakeholders’ interest at product level and organizational level that results into missing the most important features into resulting products. Very few studies [522] have reported value dimensions from both product and project perspectives and few studies [523] from both product and organization perspectives as shown in Figure 43. However, little attention has been given to report value dimensions from tri perspectives in combination (see details in Appendix EE).

![Figure 43: Overview of value dimensions perspectives](image)

By going into detail, it has been found that out of 15 studies, six studies [524] reported business value from project perspectives, three studies [525] from product perspectives, and two studies [526] from organization perspectives as shown in Figure 44. However, only one study [81] mentioned business value from product and project perspectives and one study [137] from product and organization perspectives (see detail in Appendix EE). Describing business value from project or product perspectives may adversely affect organization revenues, hitting revenue targets, return on investment, market share, market growth. For example, a project A is over budget and deliver late but has high business value and resulting product is successful in targeted market. However, late delivery and excessive cost of project A can adversely affect project B in organization that can be considered most important for organization business value (increase in
revenue, increase in profit, increase in sales, increase in market shares, and market growth)

Besides business value, value is reported in some studies. Out of 14 studies\(^{527}\), five studies\(^{528}\) reported value from product perspectives and five studies reported value from project perspectives. However, value from rest of the perspectives have been either given less attention or completely ignored. Here, it is important to state value in a clear way that whether it is product value, business value or customer value etc. to avoid confusion and misinterpretations. Moreover, out of 11 studies\(^{529}\) seven studies reported customer value from product perspectives. However, rest of the studies has given less attention or completely ignored customer value from different perspectives. Some of the important components of customer value at organization level are buyers’ beliefs about the products [74], buyers’ beliefs about the company [74], buying situation [74], buyers’ motivations [74], perception of customers about economic [74], perception of customers about performance [74], and perceptions of customers about supplier value [74]. However, describing customer value from project or product perspectives results into missing customer value from organization perspectives that can ultimately affect customer organization relationship.

Moreover, three studies\(^{530}\) reported product value from product perspective and three studies\(^{531}\) reported product value from project and product perspectives, while missing organization perspectives. The selection of requirements that create product value has to be viewed from organization perspective because, in product line engineering, selection of one requirement can potentially affect the ability of several products regarding customers’ needs and requirements [92, 459], products integration and common components sharing[92, 459], time to market[92, 459], core assets quality and efficiency[92, 459].

![Figure 44: Value dimensions perspectives](image)
**Coefficient correlation**

In order to find out relation between multiple variables, we have to answer the following questions by applying coefficient correlation on multiple variables.

- Is there a correlation between quality of the study (study design described in detail) and how to measure the improvement?
- Is there a correlation between empirical basis of the need and how to measure the improvement?
- Is there a correlation between empirical basis of the need and quality of the study and how well value is defined?

It has been observed that there is positive relation between application/validation design method and results presented in VBRE studies as shown in Table 11. However, there is no possible linear relation between study design described in detail and how to measure the improvement as shown in table. Moreover, results presented in VBRE studies also do not have any relation with metrics.

**Table 11: Coefficient correlations**

<table>
<thead>
<tr>
<th></th>
<th>Emp_need_reported</th>
<th>Method_design</th>
<th>Value_definition</th>
<th>Results_presented_as</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emp_need_reported</strong></td>
<td>Pearson Correlation</td>
<td>1</td>
<td>-.201</td>
<td>.031</td>
<td>-.190</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.096</td>
<td>.798</td>
<td>.115</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>70</td>
<td>70</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td><strong>Method_design</strong></td>
<td>Pearson Correlation</td>
<td>-.201</td>
<td>1</td>
<td>-.216</td>
<td>.492**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.096</td>
<td>.075</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>70</td>
<td>70</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td><strong>Value_definition</strong></td>
<td>Pearson Correlation</td>
<td>.031</td>
<td>-.216</td>
<td>1</td>
<td>-.108</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.798</td>
<td>.075</td>
<td>.375</td>
<td>.425</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td><strong>Results_presented_as</strong></td>
<td>Pearson Correlation</td>
<td>-.190</td>
<td>.492**</td>
<td>-.108</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.115</td>
<td>.000</td>
<td>.375</td>
<td>.389</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>70</td>
<td>70</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td><strong>Metrics</strong></td>
<td>Pearson Correlation</td>
<td>.062</td>
<td>.063</td>
<td>-.098</td>
<td>.105</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.609</td>
<td>.605</td>
<td>.425</td>
<td>.389</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>70</td>
<td>70</td>
<td>69</td>
<td>70</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**
6 CONCLUSION

Systematic mapping shows that majority of research has suggested recommendations and have proposed processes in the following process areas: value-based requirements engineering, value-based verification and validation, value-based quality management, value-based project management, and value-based risk management. Other most value-based contribution in requirements engineering and quality management included new methods and models respectively. However, in value-based architecture, value-based design, and value-based people management, few value-based contributions as process, methods, models, tools and frameworks have been proposed.

Dominantly evaluation research, solution proposal and validation research types have been used within value-based requirements engineering, value-based verification and validation and value-based quality management. However, other types of research such as experience reports and philosophical research have not been that many.

Moreover, we identified some interesting value dimensions such as product value, customer value, stakeholder value, business value and intellectual capital that can play a central role in companies’ success. We could not find concrete definition of value dimensions in studies instead; we found explanations. We have aggregated and classified views of different authors and the factors that affect value dimensions (see Appendix O).

The systematic review was conducted within value-based requirements engineering including studies published from the year 1990 to 2010. 70 studies were selected as primary studies. In order to analyze the practical application and validation of proposed value-based solutions and to assess their usability and usefulness, four research questions were formulated (see Section 3.3.1). Data extraction categories (see Section 3.3.6) were defined on the basis of formulated research question. The main data extraction categories were empirical basis of need, application/validation method, usability and usefulness.

Major finding of this systematic review are as under:

- Most of the studies claim having an empirical basis of needs but only as statements or based on other studies. They fall short on the approach used to identify the need for a solution. This makes it difficult for the practitioners to understand the context of specific needs/problems that lead are addressed by the proposed solutions. Without interviewing experts in industry or performing some form of process assessment, it is hard to assess the need identified thus raising the issue that the need may not be representative of the current situation. As a result, this poses questions about the internal and external validity of the needs identified, which consequently questions the basis for the solution proposed. However, few studies have reported empirical need as “VBSE agenda” and thus provide relatively solid base for empirical evidence of need. Some studies reported empirical basis of need through case study, participation knowledge or field study providing affirmed basis for proposed solutions.

- Several studies have employed reasonable application/validation methods for application/validation in industry. These studies have described design in detail
and have presented qualitative, quantitative or both types of results. Thus, most of the proposed solutions can be applied/validated because detailed design is presented in these studies.

- However, majority of studies do not report usability and usefulness of the proposed solutions. Some of the studies report usability of proposed solutions however as statements only. Without experts’ opinions and/or quantitative data supporting the usability and usefulness claims, it is difficult to evaluate the validity of the claims, and similarly it is difficult for the practitioners to evaluate the usability and usefulness of a proposed solution for application in industry.

- Few studies [76, 77, 81, 94, 95] have presented application/validation methods’ design in detail and empirical basis of need is strong. Thus, the proposed solutions reported in these studies have the potential to cope with industry challenges. Moreover, most of the studies have presented application/validation methods’ design in detail since the empirical basis was described mostly as statements only. Thus, it is difficult to triangulate the needs and conclude that whether the proposed solutions address commonly faced challenges in industry or not.

- Very few studies\textsuperscript{535} have reported metrics for measurement of improvement. However, majority of studies have not stated any metrics that becomes very difficult to assess/measure the improvements of proposed solutions reported in VBRE studies.

- It is quite positive to observe that most of the challenges of project failure indicated by the Standish group are addressed/discussed in different phases of requirement engineering as shown in Table 7. However; since most of the studies fall short of reporting even rudimentary evidence of usability and usefulness.

- Most important challenge is “\textit{How to Eliciting and reconciling stakeholders' value propositions}”. Some of the studies\textsuperscript{536} proposed solutions to address this challenge but these studies do not consider reconciliations techniques in an effective way.

- Moreover, VBRE studies do not consider the role of innovative and system improvement requirements in product value creation. These types of requirements also have a major role in product value creation. Ignorance of innovative requirements in requirements selection and relation of innovation with value dimensions are discussed in detail in Section 5.2.2.8.

- Almost half of the studies\textsuperscript{537} have given description/defined value dimensions in some form. However, majority of studies\textsuperscript{538} have not defined value dimensions in its appropriate form that results into misinterpretation of value dimensions

- Lack of metrics and measurements to evaluate/measure the potential improvements achieved by applying proposed solutions. In most of the studies,
this has not been addressed and described which poses a greater challenge as how to evaluate the proposed solutions with respect to the improvement made.

- Very few studies \(^{539}\) perform conceptual analysis of value dimensions and introduce concepts from marketing, business administration and economics field into VBRE. Moreover, few studies \(^{540}\) reported cost-benefit analysis/return on investment methods that are used in finance or economics. However, majority of studies do not provide sufficient conceptual background for value dimensions. Concepts from finance, innovation and entrepreneurship, management science, humanities, and cognitive sciences have been completely ignored in VBRE studies. There is a need of joint efforts from different field to integrate knowledge about value dimensions in an accurate and precise way to a coherent understanding of value dimensions.

- More than half of the studies \(^{541}\) have used application/validation method as case studies, surveys, interviews, questioners, and field studies for proposed solutions, but when it comes to value dimensions, to see the consequences of value dimensions as an output of proposed solutions for product, project, organization or society could take longer time. In spite of effective utilization of application/validation methods and their designs, the consequences of value dimensions are missing in VBRE studies.

- Majority of studies do not report effective methods that are specifically used for determining or assessing value dimensions. Methods like CVA \(^{459, 467}\) analysis, GAP analysis \(^{459, 466}\), Kano model or Kano questionnaires, Boston consulting matrix (for product portfolio) \(^{459}\), and IVA analysis (Product value) \(^{459}\) etc. are largely ignored that makes the value dimensions questionable.

- Majority of value dimensions (i.e. product value, business value, customer value etc.) have been reported in VBRE studies (see Table 10). However, important value dimensions (i.e. intrinsic value, innovation value, value of technology, complementary value and network externalities etc.) have not been reported in VBRE studies (see Appendix DD). It withdraws attention of practitioners and researchers to do much in VBRE with respect to reported and missing value dimensions. More than half of the studies reported components of value dimensions. However, these components are not sufficient for 100% results because much effort is needed to integrate knowledge from different fields that also contain components of these value dimensions reported in VBRE studies.

- Majority of studies reported value dimensions from product or project. However, less attention has been given to describe value dimensions from all perspectives that results into missing interest of different success critical stakeholders (both internal and external stakeholders).

Many studies have presented application/validation design in detail that should make it easier to perform replication study by both researchers and practitioners. Internal or external replications would 1) validate the empirical need for a proposed solution, 2)
application of the proposed solution to address the need and 3) reflect on the usability and usefulness of the solution thus providing stronger evidence of its usability and usefulness in industrial context. In addition, it is one of the cornerstones in research to replicate studies. However, only one replication study has been conducted so far in VBRE.

Absence of usability and usefulness evidence for the proposed solutions in general makes it difficult for the practitioners to do cost-benefit analysis of the proposed solutions, which is the basis of value-based software engineering. Thus, the fundamental gist of VBSE is missing in the solutions proposed for value-based requirements engineering. As a starting point the definitions of usability and usefulness can be used to report cost and benefits of the proposed solutions.
7 FUTURE WORK

Following important facts that should be taken into consideration regarding value dimension from future perspective:

- **Introduction and validation of other value dimensions with in software engineering from other fields such as economics, management, finance, cognitive sciences.**
- **Determinants:** To identify determinants (drivers) of value associated challenges with them, and mitigations of these challenges, for value dimensions in state of art and state of practice.
- **Metrics:** To identify metrics, associated challenges with them, and mitigations of challenges, for value dimensions in state of art and state of practice.
- **Evaluation frameworks:** Development of evaluation framework for the assessment of different value dimensions.
- **Onion model:** Categorization of value dimensions at different levels of onion model [459].
- **RAM model:** Introducing value aspects in RAM model [458].
- **Innovation:** explore the relationship of innovation (i.e. product innovation, market innovation, organization innovation and process innovation) with value dimensions and its impact.
- **Validation** of systematic mapping and systematic review results through empirical means.

Based on resulting maps in systematic mapping, there seems to be relative lack of value-based contributions in some sub-process areas (for example, requirements elicitation, validation, linking RE activities with architecture, design strategies and methods, design maintainability, design evaluation, design review, development models, integration and anticipating change, software testing techniques, software testing process, integration testing, installation testing, alpha/beta testing, usability testing, quality process and quality control, software metrics, human capital, knowledge management, tacit knowledge, and stakeholder expectation management). This can be potential areas for future work. There is also a need for better empirical research like application/validation methods use for evaluation and validation research. Solutions proposed in solution proposal needs be to be empirically validated that will strengthen the empirical research.

Systematic review should be carried out for value-based architecture, value-based design, value-based development, value-based verification and validation, value-based quality management, value-based project management, and value-based risk management for investigation of practical application and validation of proposed solutions in industry to determine their usability and usefulness because usability and usefulness are very important quality attributes and inputs for cost-benefits analysis.
8 REFERENCES


**Value-based Requirements engineering**

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
</table>


T. Tourwé, W. Codenie, N. Boucart and V. Blagojević, Demystifying release definition: From requirements prioritization to collaborative value quantification, 2009


<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Title</th>
<th>Conference/Journal</th>
<th>Pages</th>
<th>Year</th>
</tr>
</thead>
</table>
Value-based Architecture

References


Value-based design

References


Value-based development

References


[184]. P. Sajja and B. Chaudhary, “A tool for software development driven by customer


Value-based verification and validation


[225]. P. Srivastava and D. Pareek, Component prioritization schema for achieving maximum time and cost benefits from software testing, Communications in Computer and Information Science, 2009, pp. 347-349.


[240]. S. Biffl, B. Freimut, and O. Laitenberger, “Investigating the cost-effectiveness of


Value-based quality management

References


Value-based project management

References


[339]. A. Cabri and M. Griffiths, “Earned value and agile reporting.” Agile Conference, 2006,


Value-based risk management


Value-based risk management


<table>
<thead>
<tr>
<th>Reference</th>
<th>Details</th>
</tr>
</thead>
</table>


### Value-based people management

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>[430].</td>
</tr>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>-----------</td>
</tr>
</tbody>
</table>


### Appendix A: Value, development and management process areas and sub-process areas keywords

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Population</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value OR Value-based OR Value-oriented OR value-driven OR Value engineering OR value assessment OR Business value OR Perceive value OR stakeholder value OR stakeholders’ value OR economic value OR intrinsic value OR option value OR priority value OR Worth OR product value OR customer’s perceived value OR project value OR value creation OR customer value OR valuation OR user value OR Earned value OR Value considerations OR Relationship value OR Producer value OR Value Estimating OR Value estimation OR Value capture OR Value innovation OR Value-innovative OR value evaluation OR historical value OR Intellectual property valuation OR Software economics OR Economic value OR economic-driven OR Economics-Driven OR Economic profit OR Investment value OR Cost-Value OR Cost/benefit OR cost-benefit OR Benefits realization OR Business case analysis OR Return on investment OR ROI OR Stakeholder win-win OR Decision Multiple criteria OR Competitive Position OR internal value OR value notion OR Market value OR Market shares OR Sales OR alignment of requirements to the business goals OR Alignment of technical decision with business strategy OR Aligning requirements with business objectives OR aligning technical and business perspective OR COTS OR Use value OR Complementary value OR Network externalities OR User experience value OR Customer lifetime value OR Shareholder value OR Production value OR Market requirements value OR Physical value OR Market action value OR Differentiation value OR Differentiation value with respect to perceived value OR Differentiation with respect to availability OR Differentiation with respect to sales and promotion OR Differentiation with respect to cost OR Price OR Intellectual capital value OR human capital value OR structural capital value OR Customer capital value OR Innovation value OR value of technology OR value of Market</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Requirements Engineering</td>
<td>Software requirements fundamentals: software requirement, Functional requirements, Nonfunctional requirements</td>
</tr>
</tbody>
</table>
quality and improvement.

**Requirements elicitation:** Requirements elicitation techniques

**Requirements analysis:** requirements classification, conceptual modeling, requirements allocation, requirements negotiation, Requirements analysis techniques.

**Requirements prioritization:** prioritization techniques,

**Requirements specification:** system definition, system requirements specification, software requirements specification

**Requirements validation:** requirements reviews, prototyping, model validation, acceptance tests, Requirements testing.

**Practical considerations:** Stable and volatile requirements, change management, maintenance of requirements, requirements traceability, requirements measurement.

**Release planning:** Release planning, Planning release, Software release plan, Software release planning, Planning software release, Strategic software release plan, Strategic software RP, planning strategic software release, retrospective / post release analysis, Requirements selection, Selecting requirements, Analyzing software release defects, Managing software release, Road-mapping, Strategic release planning models,

**Product line engineering:** Requirements model, conceptual model, commonality and variability model, domain model, feature model, scenario model, commonality analysis, variability analysis, domain evaluation, domain scope, asset scope.

### 3 Software Architecture

**Software architecture**, architectural structures, strategies, Organizational factors, Technological factors, Product factors, Conceptual view, Module view, Code view, Execution view, architectural styles, design patterns, architectural styles, architecture evaluation, Review, families of programs and frameworks, software architecture evaluation methods.

### 4 Software Design

**Software design fundamentals:** context of software design, software design process, techniques for software design

**Key issues in software design:** concurrency, control and handling of events, distribution of components error, exception handling, fault tolerance, interaction, presentation, data persistence

**Software design quality analysis and evaluation:** quality attributes quality analysis, evaluation
| 5 | **Software development** | **Software development /construction fundamentals**: Minimizing complexity, anticipating change, developing/constructing for verification, standards for development  
**Managing Development**: Development models, Development planning, Development measurement  
**Practical considerations** Development design, Development languages, Coding, Development testing, Reuse, Development quality, Integration |
|---|---|---|
| 6 | **Verification and Validation** | Conformance testing, formal verification, program testing, software/ fault/ diagnostics/diagnosis, proof / confirmation, unit testing, integration testing, debugging, dynamic verification, test cases, analysis, evaluation, review, inspection, assessment, testing of both products and processes.  
**Software Testing Fundamentals**: Relationships of Testing to Other Activities  
**Test Levels**: Test Techniques, Specification-based, Code-based, Fault-based, Usage-based, Based on Nature of Application, Selecting and Combining Techniques  
**Test Related Measures**: Evaluation of the Program under Test, Evaluation of the Tests Performed  
**Test process**: Practical Considerations, Test Activities |
| 7 | **Software Quality** | **Software Quality Fundamentals**: Software Culture and Ethics, Value and Costs of Quality, Models and Quality Characteristics, Quality Improvement  
**Software Quality Management Processes**: Software Quality Assurance,  
**Verification and Validation**: Reviews, Audits  
**Practical Considerations**: Application Quality Requirements, Defect Characterization, Software Quality Management Techniques, (Static techniques, People-intensive techniques, Analytic techniques, Dynamic techniques), Software Quality Measurement.  
**Software metrics**: measurement scales, scale types, framework for software measurement, software measurement validation, data collection, measurement of internal/external software attributes, aspects of quality, prediction, prediction process, estimation methods, measurement tools, cost estimation, cost and effort models, software quality metrics, software quality methodology.  
**Software reliability**: Prevention techniques, evaluation, measures, validation process, modeling |
growth, growth models, prediction, Estimation, failure count models, fault seeding, input domain models, model fitting, times between failures.

| 8 | Risk Management | **Risk Assessment:**
|   |                | Risk (identification, Decision Driver analysis, Assumption Analysis, Decomposition, Risk factor Risk handling, Risk leverage factor, Methods, tools, techniques, processes, models).
|   |                | **Risk analysis** (Performance models, Cost models, Network analysis, Decision analysis, Quality factor Metric)
|   |                | **Risk prioritization** (Risk exposure, Risk leverage, Compound risk reduction)
|   |                | **Risk control:**
|   |                | **Risk Management planning** (Risk avoidance, Risk transfer, Risk reduction, Risk element planning, Risk plan Integration, Contingency plan, Continuous risk management)
|   |                | **Risk resolution:** Simulations, Benchmark, Analysis, Staffing, Risk mitigation
|   |                | **Risk monitoring:** Top 10 tracking, Risk reassessment, Corrective action.

| 9 | Planning & Control | **Software Project Planning:** Process Planning; Determine Deliverables, Effort, Schedule and Cost Estimation, Resource Allocation, Risk Management, Quality Management, Plan Management, Decision Support, Genetic Algorithm.

| 10 | People management | Team building, team build, knowledge management, knowledge sharing, tacit knowledge, postmortem review, KJ Method, process workshop, group process, shared goal, mutual trust, fairness, equal opportunity, liberty, participation in decision making, integration of ethics, ethics consideration, ethical consideration, intellectual capital, human capital |
**Appendix B:** Classification and definitions of research types and value-based contributions

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Category</th>
<th>definitions</th>
</tr>
</thead>
</table>
| 1     | **Research type classification**| **Validation research:** techniques resulted by using any research method (i.e. experiment, simulation, prototyping etc.) and are not implemented in practice [46].  

**Evaluation research:** evaluation of technique is conducted after it’s practical implementation. Benefits, drawbacks and consequences of techniques are shown in the study [46].  

**Solution proposal:** solution for any identified problem is suggested. Solution can be based on either novelty or extension of existing technique. Solution may be example driven or argumentation driven [46].  

**Philosophical research:** study describes a new way of looking at things or aggregating relevant things and giving them proper structure for example Framework [46].  

**Opinion report:** expression of personal opinion about technique without related work and research methodologies [46].  

**Experience report:** sharing personal experience about the things going on in practice [46]. |
| 2     | **Contributions**               | **Process/Approach:** refers to the description of activities, roles, responsibilities, actions and their workflow in a systematic way [22]. For example, [78, 80]  

**Method/technique:** refers to the description of rules and regulations that how tasks should be done [22]. In this category, Strategies and methodologies are also included. For example, [88, 91]  

**Model** refers to the description of the factual omitting details associated with high level formality (i.e. it should contain notions and semantics for example UML)[22]. For example, [82, 86] |
| **Tool** | refers to the software tool that is used to solve specific problems in each VBSE process and sub process area [22]. For example, [101] |
| **Metric** | refers to the measurement that is used in each process and sub process areas of VBSE. For example, [183] proposed three metrics Reuse Percent, Reuse Cost Avoidance, and Reuse Value Added |
| **Framework** | refers to the structuring, planning, managing, and controlling the processes that is used to develop a sub system or system and provide a structured taxonomy in VBSE. For example, [186, 197]. |
| **Recommendations** | refers to the guidelines, practices, factors, criteria, theory, Suggestions with respect to comparison of factors, metrics, models, methods etc. for example, [203, 204, 206] |
### Appendix C: Search queries

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Area</th>
<th>Database</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value-based requirement engineering</td>
<td>Inspec &amp; Compendex</td>
<td>(((&quot;Value&quot; OR &quot;valuation&quot; OR &quot;Intellectual property valuation&quot; OR &quot;cost-benefit&quot; OR &quot;Benefit realization&quot; OR &quot;Business case analysis&quot; OR &quot;economic value&quot; OR &quot;Economic profit&quot; OR &quot;Economic-driven&quot; OR &quot;Return on investment&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Network externalities&quot; OR &quot;Differentiation value&quot; OR Differentiation ONEAR/5 &quot;perceived value&quot; OR Differentiation ONEAR/5 &quot;cost&quot; OR Differentiation ONEAR/5 &quot;Price&quot;) AND (&quot;software&quot;) AND (&quot;requirement&quot; OR &quot;requirements engineering&quot;) AND (&quot;Functional&quot; OR &quot;non functional&quot; OR process OR model OR &quot;process actors&quot; OR &quot;process support&quot; OR management OR &quot;process quality&quot; OR &quot;elicitation&quot; OR technique OR &quot;analysis&quot; OR classification OR &quot;conceptual modeling&quot; OR &quot;allocation&quot; OR &quot;negotiation&quot; OR &quot;prioritization&quot; OR &quot;specification&quot; OR validation OR review OR &quot;acceptance test&quot; OR &quot;testing&quot; OR Stable OR volatile OR &quot;change management&quot; OR maintenance OR traceability OR measurement OR Release planning OR selection OR defects OR &quot;Road-mapping&quot; OR Product line OR &quot;conceptual&quot; OR &quot;commonality and variability&quot; OR &quot;domain model&quot; OR &quot;feature model&quot; OR &quot;scenario model&quot; OR &quot;commonality analysis&quot; OR &quot;variability analysis&quot; OR &quot;domain evaluation&quot; OR &quot;domain scope&quot; OR &quot;asset scope&quot;) wn KY) AND ((english) WN LA)), 1990-2010</td>
</tr>
<tr>
<td></td>
<td>ACM</td>
<td></td>
<td>(((Abstract:&quot;Value&quot; OR Abstract:&quot;valuation&quot; OR Abstract:&quot;Intellectual property valuation&quot; OR Abstract:&quot;cost-benefit&quot; OR Abstract:&quot;Benefit realization&quot; OR Abstract:&quot;Business case analysis&quot; OR Abstract:&quot;economic value&quot; OR Abstract:&quot;Economic profit&quot; OR Abstract:&quot;Economic-driven&quot; OR Abstract:&quot;Return on investment&quot; OR Abstract:&quot;Stakeholder win-win&quot; OR Abstract:&quot;Decision Multiple criteria&quot; OR Abstract:&quot;Competitive Position&quot; OR Abstract:&quot;Network externalities&quot; OR Abstract:&quot;Differentiation value&quot;) AND (&quot;software&quot;) AND (&quot;requirements&quot;) AND (&quot;requirements engineering&quot;) AND (&quot;Functional&quot; OR &quot;non functional&quot; OR process OR model OR &quot;process actors&quot; OR &quot;process support&quot; OR management OR &quot;process quality&quot; OR &quot;elicitation&quot; OR technique OR &quot;analysis&quot; OR classification OR &quot;conceptual modeling&quot; OR &quot;allocation&quot; OR &quot;negotiation&quot; OR &quot;prioritization&quot; OR &quot;specification&quot; OR validation OR review OR &quot;acceptance test&quot; OR &quot;testing&quot; OR Stable OR volatile OR &quot;change management&quot; OR maintenance OR traceability OR measurement OR Release planning OR selection OR defects OR &quot;Road-mapping&quot; OR Product line OR &quot;conceptual&quot; OR &quot;commonality and variability&quot; OR &quot;domain model&quot; OR &quot;feature model&quot; OR &quot;scenario model&quot; OR &quot;commonality analysis&quot; OR &quot;variability analysis&quot; OR &quot;domain evaluation&quot; OR &quot;domain scope&quot; OR &quot;asset scope&quot;)))) and (PublishedAs:journal OR PublishedAs:proceeding) and (AbstractFlag:yes)</td>
</tr>
<tr>
<td></td>
<td>IEEE</td>
<td></td>
<td>(((&quot;Value&quot; OR &quot;valuation&quot; OR &quot;cost-benefit&quot; OR &quot;Benefit realization&quot; OR &quot;Economic profit&quot; OR &quot;Economic-driven&quot; OR &quot;Return on investment&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Differentiation value&quot;) AND (&quot;software&quot;) AND (requirement OR &quot;requirements engineering&quot;) AND (Abstract:&quot;Value&quot; OR Abstract:&quot;valuation&quot; OR Abstract:&quot;Intellectual property valuation&quot; OR Abstract:&quot;cost-benefit&quot; OR Abstract:&quot;Benefit realization&quot; OR Abstract:&quot;Business case analysis&quot; OR Abstract:&quot;economic value&quot; OR Abstract:&quot;Economic profit&quot; OR Abstract:&quot;Economic-driven&quot; OR Abstract:&quot;Return on investment&quot; OR Abstract:&quot;Stakeholder win-win&quot; OR Abstract:&quot;Decision Multiple criteria&quot; OR Abstract:&quot;Competitive Position&quot; OR Abstract:&quot;Network externalities&quot; OR Abstract:&quot;Differentiation value&quot; OR Differentiation ONEAR/5 &quot;perceived value&quot; OR Differentiation ONEAR/5 &quot;cost&quot; OR Differentiation ONEAR/5 &quot;Price&quot;) AND (&quot;software&quot;) AND (&quot;requirement&quot; OR &quot;requirements engineering&quot;) AND (&quot;Functional&quot; OR &quot;non functional&quot; OR process OR model OR &quot;process actors&quot; OR &quot;process support&quot; OR management OR &quot;process quality&quot; OR &quot;elicitation&quot; OR technique OR &quot;analysis&quot; OR classification OR &quot;conceptual modeling&quot; OR &quot;allocation&quot; OR &quot;negotiation&quot; OR &quot;prioritization&quot; OR &quot;specification&quot; OR validation OR review OR &quot;acceptance test&quot; OR &quot;testing&quot; OR Stable OR volatile OR &quot;change management&quot; OR maintenance OR traceability OR measurement OR Release planning OR selection OR defects OR &quot;Road-mapping&quot; OR Product line OR &quot;conceptual&quot; OR &quot;commonality and variability&quot; OR &quot;domain model&quot; OR &quot;feature model&quot; OR &quot;scenario model&quot; OR &quot;commonality analysis&quot; OR &quot;variability analysis&quot; OR &quot;domain evaluation&quot; OR &quot;domain scope&quot; OR &quot;asset scope&quot;))))</td>
</tr>
</tbody>
</table>
(functional OR "non functional" OR Quality OR process OR model OR process actor* OR "process support" OR management OR elicit OR technique OR analysis OR classification OR "conceptual modeling" OR allocate OR negotiate OR prioritize OR specify OR valid OR review OR "acceptance test" OR "testing" OR Stab OR volatile OR "change management" OR maintenance OR traceable OR measurement OR release plan OR selection OR defect OR "Road-mapping" OR "Product line" OR "conceptual" OR "commonality and variability" OR domain OR feature OR scenario OR "commonality analysis" OR "variability analysis" OR "domain evaluation" OR "domain scope" OR "asset scope")

Scopus

TITLE-ABS-KEY({{Value} OR "valuation" OR "Intellectual property valuation" OR "cost-benefit" OR "cost-value" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "Economic profit" OR "Economic-driven" OR "Return on investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR [Competitive Position] OR "Network external*" OR [Differentiation value] OR (differentia* PRE/5 cost) OR (differentia* PRE/5 promotion) OR (differentia* PRE/5 availability) OR (differentia* PRE/5 perceived value) OR (differentia* PRE/5 sale AND promotion) OR (differentia* PRE/5 cost AND price)) AND ("software") AND (requirement OR "requirements engineering") AND (functional OR "non functional" OR process OR model OR "proce* actor*" OR "proce* support*" OR management OR "proce* quality" OR "elicitation" OR technique OR "analysis" OR classification OR "conceptual modeling" OR "allocation" OR "negotiation" OR "prioritization" OR "specification" OR "validation" OR review OR "acceptance test*" OR "testing" OR "Stab*" OR volatile OR "change management" OR maintenance OR traceability OR measurement OR release planning OR selection OR defect OR "Road-mapping" OR "Product line" OR "conceptual" OR "commonality and variability" OR "domain" OR "feature" OR "scenario" OR "commonality analysis" OR "variability analysis" OR "domain eval*" OR "domain scop*" OR "asset* scop*") AND (EXCLUDE(SUBJAREA, "MEDI") OR EXCLUDE(SUBJAREA, "SOCI") OR EXCLUDE(SUBJAREA, "PHYS") OR EXCLUDE(SUBJAREA, "MATE") OR EXCLUDE(SUBJAREA, "BIOC") OR EXCLUDE(SUBJAREA, "EART") OR EXCLUDE(SUBJAREA, "ENVI") OR EXCLUDE(SUBJAREA, "CENG") OR EXCLUDE(SUBJAREA, "AGRI") OR EXCLUDE(SUBJAREA, "ENER") OR EXCLUDE(SUBJAREA, "NURS") OR EXCLUDE(SUBJAREA, "HEAL") OR EXCLUDE(SUBJAREA, "PHAR") OR EXCLUDE(SUBJAREA, "CHEM") OR EXCLUDE(SUBJAREA, "IMMU") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "DENT") OR EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "VETE") OR EXCLUDE(SUBJAREA, "Undefined")

SpringerLink

ab:("Value" or "Cost-benefit" or "Return on investment" or "Competitive Position") and ab:("Requirements Engineering" or "Requirements Specification" or "Requirements Analysis" or "Requirement elicitation" or "Requirements and Prioritization")

ab:("Economic profit" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Differentiation value") AND ab:("Requirements Engineering" OR "Requirements Specification" OR "Requirements Analysis" OR "Requirement elicitation" OR "Requirements and Prioritization")
"Requirement elicitation" OR "Requirements Prioritization"

ab:("Value" or "Cost-benefit" or "Return on investment") and ab:("Requirements") and ab:("Release planning" or "Tracing" or "Traceability")

ab:("Value" or "Cost-benefit" or "Return on investment") and ab:("Product line") AND ab: ("Requirement" OR "Requirements engineering")

2 Value-based architecting

Value-based architecting

Inspec & Compendex

ACM

IEEE
<table>
<thead>
<tr>
<th>Source</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scopus</td>
<td>Your query: TITLE-ABS-KEY( {value} or “valuation” or {cost-benefit} or {cost-value} or “Benefit* realization*” or “Business* case* analysis” or “economic* value” or “Economic* profit*” or {Economic-driven} or “Return on investment” or &quot;Stakeholder win-win&quot; or &quot;Decision Multiple criteria&quot; or {Competitive Position} or “Network* external*” or {Differentiation value} or {differentia* PRE/5 sales} or {differentia* PRE/5 cost} or {differentia* PRE/5 promotion} or {differentia* PRE/5 availability} or {differentia* PRE/5 perceived value} or {differentia* PRE/5 price}) AND (&quot;Software* Architecture&quot; or {High-level design} or &quot;abstract design&quot;) AND (structure OR strategy OR &quot;Organization* factors&quot; OR &quot;Technological factors&quot; OR &quot;Product* factors&quot; OR &quot;Conceptual* view*&quot; OR &quot;Module* view*&quot; OR &quot;Code view&quot; OR &quot;Execution* view*&quot; OR style OR &quot;design* pattern*&quot; OR evaluation OR &quot;evaluation method*&quot; OR Review OR &quot;family* of programs and framework*&quot;) )</td>
</tr>
<tr>
<td>SpringerLink</td>
<td>ab:(“Value” or “Cost-benefit” or “Return on investment” or “Competitive Position”) and ab:(“software architecture*” or “High-level design” or “Abstract design”)</td>
</tr>
<tr>
<td>ACM</td>
<td>(((Abstract:&quot;Value&quot; OR Abstract:&quot;valuation&quot; OR Abstract:&quot;Intellectual property valuation&quot; OR Abstract:&quot;cost-benefit&quot; OR &quot;Benefit realization&quot; OR &quot;Business case analysis&quot; OR &quot;economic value&quot; OR &quot;Economic profit&quot; OR &quot;Economic-driven&quot; OR &quot;Return on investment&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Network externalities&quot; OR &quot;Differentiation value&quot; OR Differentiation ONEAR/5 &quot;perceived value&quot; OR Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 &quot;sales and promotion&quot; OR Differentiation ONEAR/5 &quot;cost&quot; OR Differentiation ONEAR/5 &quot;Price&quot;) AND (&quot;software design&quot;) AND (context OR process OR technique OR concurrency OR &quot;control event&quot; OR &quot;handling event&quot; OR &quot;components error&quot; OR &quot;exception handling&quot; OR &quot;fault tolerance&quot; OR &quot;interaction&quot; OR &quot;presentation&quot; OR &quot;data persistence&quot; OR &quot;quality analysis&quot; OR &quot;quality evaluation&quot; OR &quot;quality attribute&quot; OR &quot;quality analysis&quot;) AND (&quot;evaluation technique&quot;) AND (&quot;component-oriented design&quot;) AND (&quot;after-oriented design&quot;) AND (&quot;quality analysis&quot;) AND (&quot;function-oriented design&quot;) AND (&quot;data-structure centered&quot;) AND (&quot;component-based design&quot;) OR &quot;Modeling language&quot; OR &quot;customer oriented design&quot; OR &quot;customer oriented development&quot;) wn KY ) AND (({software design} OR {computer software} OR {software engineering} OR {project management} OR {object-oriented programming} OR {cost benefit analysis} OR {computer science} OR {cost reduction}) wn CV) AND (({english} WN LA)), 1990-2010</td>
</tr>
<tr>
<td>Value-based Design</td>
<td>(({value} OR &quot;valuation&quot; OR &quot;Intellectual property valuation&quot; OR &quot;cost-benefit&quot; OR &quot;Benefit realization&quot; OR &quot;Business case analysis&quot; OR &quot;economic value&quot; OR &quot;Economic profit&quot; OR &quot;Economic-driven&quot; OR &quot;Return on investment&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Network externalities&quot; OR &quot;Differentiation value&quot; OR Differentiation ONEAR/5 &quot;perceived value&quot; OR Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 &quot;sales and promotion&quot; OR Differentiation ONEAR/5 &quot;cost&quot; OR Differentiation ONEAR/5 &quot;Price&quot;) AND (&quot;software design&quot;) AND (context OR process OR technique OR concurrency OR &quot;control event&quot; OR &quot;handling event&quot; OR &quot;components error&quot; OR &quot;exception handling&quot; OR &quot;fault tolerance&quot; OR &quot;interaction&quot; OR &quot;presentation&quot; OR &quot;data persistence&quot; OR &quot;quality analysis&quot; OR &quot;quality evaluation&quot; OR &quot;quality attribute&quot; OR &quot;quality analysis&quot;) AND (&quot;evaluation technique&quot;) AND (&quot;function-oriented design&quot;) AND (&quot;object-oriented design&quot;) AND (&quot;data-structure centered&quot;) AND (&quot;component-based design&quot;) OR &quot;Modeling language&quot; OR &quot;customer oriented design&quot; OR &quot;customer oriented development&quot;) wn KY ) AND (({software design} OR {computer software} OR {software engineering} OR {project management} OR {object-oriented programming} OR {cost benefit analysis} OR {computer science} OR {cost reduction}) wn CV) AND (({english} WN LA)), 1990-2010</td>
</tr>
</tbody>
</table>
external** OR (Differentiation value) OR (differentia* PRE/5 sales) OR (differentia* PRE/5 cost) OR (differentia* PRE/5 promotion) OR (differentia* PRE/5 availability) OR (differentia* PRE/5 perceived value) OR (differentia* PRE/5 price)) AND ("Software Design") AND (context OR process OR technique OR concurrency OR "control event" OR "handling event" OR "component* error**" OR "exception handling" OR "fault tolerance" OR "interaction" OR "presentation" OR "data persistence" OR "quality analysis" OR "quality evaluation" OR "quality attribute" OR "quality analysis" OR "evaluation technique" OR "evaluation measure" OR {function-oriented} OR {object-oriented} OR {data-structure} OR {component-based}) development OR "Modeling language"))) AND (EXCLUDE(SUBJAREA, "MEDI") OR EXCLUDE(SUBJAREA, "SOCI") OR EXCLUDE(SUBJAREA, "BIOC") OR EXCLUDE(SUBJAREA, "MATH") OR EXCLUDE(SUBJAREA, "DECI") OR EXCLUDE(SUBJAREA, "HEAL") OR EXCLUDE(SUBJAREA, "PHYS") OR EXCLUDE(SUBJAREA, "MATE") OR EXCLUDE(SUBJAREA, "AGRI") OR EXCLUDE(SUBJAREA, "NURS") OR EXCLUDE(SUBJAREA, "CENG") OR EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "ENER") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "EART") OR EXCLUDE(SUBJAREA, "CHEM") OR EXCLUDE(SUBJAREA, "ARTS") OR EXCLUDE(SUBJAREA, "IMMU") OR EXCLUDE(SUBJAREA, "ENVI") OR EXCLUDE(SUBJAREA, "PHAR") OR EXCLUDE(SUBJAREA, "DENT") OR EXCLUDE(SUBJAREA, "VETE") OR EXCLUDE(SUBJAREA, "Undefined"))
((("Value" OR "valuation" OR "Intellectual property valuation" OR "cost-benefit" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "Economic profit" OR "Economic-driven" OR "Return on investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "Network externalities" OR "Differentiation value" OR Differentiation ONEAR/5 "perceived value" OR Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 "sales and promotion" OR Differentiation ONEAR/5 "cost" OR Differentiation ONEAR/5 "Price") AND ("software development") AND ("development phase" OR "coding" OR "implementation" OR "programming") AND ("Minimizing complexity" OR "anticipating change" OR "developing for verification" OR "standards for development" OR "Development models" OR "Development planning" OR "Development measurement" OR "Development design" OR language OR "Development testing" OR "Reuse" OR "Integration" OR "development time lead" OR "saving effort" OR productivity OR "improving maintainability" OR "technology transfer" OR "technology evaluation" OR "customer oriented development" OR "new technology" ONEAR/5 development OR traceability ONEAR/5 development OR ROI ONEAR/5 SPI OR ROI ONEAR/5 "software Process Improvement")\n KY ) AND (\{(computer software) OR \{software engineering\} OR \{computer programming languages\} OR \{object-oriented programming\} OR \{java programming language\} OR \{object oriented programming\} OR \{project management\} OR \{cost benefit analysis\} OR \{c (programming language)\} OR \{software reusability\} OR \{query languages\}) WN CV) ) AND (\{english\} WN LA))

((("Value" OR "valuation" OR "Intellectual property valuation" OR "cost-benefit" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "Economic profit" OR "Economic-driven" OR "Return on investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "Network externalities" OR "Differentiation value" OR Differentiation ONEAR/5 "perceived value" OR Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 "sales and promotion" OR Differentiation ONEAR/5 "cost" OR Differentiation ONEAR/5 "Price") AND ("software development") AND ("development" OR "coding" OR "construction") AND ("Minimizing complexity" OR "anticipating change" OR "developing for verification" OR "standards for development" OR "Development models" OR "Development planning" OR "Development measurement" OR "Development design" OR language OR "Development testing" OR "Reuse" OR "Integration" OR "development time lead" OR "saving effort" OR productivity OR "improving maintainability" OR "technology transfer" OR "technology evaluation" OR "customer oriented development" OR "new technology" ONEAR/5 development OR traceability ONEAR/5 development OR ROI ONEAR/5 SPI OR ROI ONEAR/5 "software Process Improvement")\n KY ) AND (\{english\} WN LA) ) AND (\{software development management\} OR \{software engineering\} OR \{project management\} OR \{software quality\} OR \{computer software\} OR \{software reusability\} OR \{object-oriented programming\} OR \{cost-benefit analysis\} OR \{product development\} OR \{cost benefit analysis\} OR \{software maintenance\} OR \{value engineering\} OR \{customer
<table>
<thead>
<tr>
<th>Source</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>((Abstract:&quot;Value&quot; OR Abstract:&quot;valuation&quot; OR Abstract:&quot;Intellectual property valuation&quot; OR Abstract:&quot;cost-benefit&quot; OR Abstract:&quot;Benefit realization&quot; OR Abstract:&quot;Business case analysis&quot; OR Abstract:&quot;economic value&quot; OR Abstract:&quot;Economic profit&quot; OR Abstract:&quot;Economic-driven&quot; OR Abstract:&quot;Return on investment&quot; OR Abstract:&quot;Stakeholder win-win&quot; OR Abstract:&quot;Decision Multiple criteria&quot; OR Abstract:&quot;Competitive Position&quot; OR Abstract:&quot;Network externalities&quot; OR Abstract:&quot;Differentiation value&quot;) AND (&quot;Software development&quot;) AND (&quot;development phase&quot; OR coding OR implementation OR construction)) ) and (PublishedAs:journal OR PublishedAs:proceeding) and (AbstractFlag:yes)</td>
</tr>
</tbody>
</table>
| IEEE       | (("Value" OR "valuation" OR "cost benefit" OR "cost value" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "economical value" OR "Economic profit" OR "Economical profit" OR "Economic-driven"
| Scopus     | TITLE-ABS-KEY(((Value OR valuation OR Intellectual property valuation OR [cost-benefit] OR [Benefit realisation*] OR [Business* case* analysis] OR [economic* value] OR [Economic* profit*] OR [Economic-driven]) OR "Return on investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "Network externalities" OR "Differentiation value" OR differential ONear/5 "sales" OR differential ONear/5 "cost" OR differential ONear/5 "promotion" OR differential ONear/5 "availability" OR differential ONear/5 "perceived value" OR differential ONear/5 "price") AND ("software development") AND ("development phase" OR coding OR implementation OR program) AND ("Minimum complexity" OR "anticipating change" OR verification OR standard OR model OR plan OR measurement OR design OR LANGUAGE OR test OR reuse OR integration OR "time lead" OR "saving effort" OR productivity OR "improving maintainability" OR "technology transfer" OR "technology evaluation" OR "customer oriented development" OR (new technology ONear/5 development) OR (traceability ONear/5 development) OR (roi ONear/5 spi) OR (roi ONear/5 "software Process Improvement"))) |
| SpringerLink| ab:(("Value" or Cost-benefit or "Return on investment" or "Competitive" or "Stakeholder win-win" or economic) and ab:(("Software development phase" or coding or Programming) REMOVE Content Type > Journal Articles) |

5 Value-based Inspec &

(("Value" OR "valuation" OR "Intellectual property valuation" OR "cost-benefit" OR "Benefit realization" OR
<table>
<thead>
<tr>
<th>Database</th>
<th>Query</th>
</tr>
</thead>
</table>
| IEEE | ("Value" OR "valuation" OR "cost-benefit" OR "cost-value" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "economic-driven" OR "Economic profit" OR "Economy-driven" OR "Return on investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "Network externalities" OR "Differentiation value" OR differentiation "cost" OR differentiation "promotion" OR differentiation "availability" OR differentiation "perceived value" OR differentiation "price") AND ("Software") AND ("Verification and Validation" OR "test" OR "V&V" OR "Validation" OR Abstract: "Testing" OR Abstract: "inspection" OR Abstract: "reinspection" OR Abstract: "reuse" OR Abstract: "test case prioritization") |}
| Scopus | TITLE-ABS-KEY(("Value" OR "valuation" OR "cost-benefit" OR "cost-value" OR "Benefit realization" OR "Business case analysis" OR "economic value" OR "Economic-driven" OR "return of investment" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "Network externalities" OR "Differentiation value" OR differentiation "cost" OR differentiation "promotion" OR differentiation "availability" OR differentiation "perceived value" OR differentiation "price") AND ("Software") AND ("Verification and Validation" OR "test" OR "V&V" OR "Validation" OR Abstract: "Testing" OR Abstract: "inspection" OR Abstract: "reinspection" OR Abstract: "reuse" OR Abstract: "test case prioritization")) |}
<table>
<thead>
<tr>
<th>SpringerLink</th>
<th>6</th>
<th>Value-based Quality</th>
<th><strong>Inspec</strong> &amp; <strong>Compendex</strong></th>
<th>ACM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1:</strong> ab:(&quot;Value&quot; or &quot;Cost-benefit&quot; or &quot;Return on investment&quot; or &quot;Competitive Position&quot;) and ab:(&quot;Software&quot;) and ab:(&quot;Verification and Validation&quot; or test or &quot;V&amp;V&quot; or &quot;Validation and Verification&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Abstract:"Economic profit" OR Abstract:"Economic-driven" OR Abstract:"Return on investment" OR Abstract:"Stakeholder win-win" OR Abstract:"Decision Multiple criteria" OR Abstract:"Competitive Position" OR Abstract:"Network externalities" OR Abstract:"Differentiation value") AND ("software quality") AND (culture OR ethic OR "cost and value" OR model OR characteristic OR improvement OR management OR assurance OR review OR audit OR verification OR validation OR requirement OR "Defect Characterization" OR "Management technique" OR "Network externalities" OR "People intensive" OR "Analytic technique" OR "Dynamic technique" OR measurement OR process OR model OR tool OR technique OR method OR framework)) AND (PublishedAs:journal OR PublishedAs:proceeding) AND (AbstractFlag:yes)
"Earned value" OR "Value considerations" OR "Relationship value" OR "Producer value" OR "Value Estimating" OR "Value estimation" OR "Value capture" OR "Value innovation" OR "Value-innovative" OR "value evaluation" OR "historical value" OR "Intellectual property valuation" OR "Software economics" OR "Economic value" OR "economic-driven" OR "Economics-Driven" OR "Economic profit" OR "Investment value" OR "Cost-Value" OR "Cost/benefit" OR "cost-benefit" OR "Benefits realization" OR "Business case analysis" OR "Return on investment" OR "ROI" OR "Stakeholder win-win" OR "Decision Multiple criteria" OR "Competitive Position" OR "internal value" OR "value notion" OR "Market value" OR "Use value" OR "Intrinsic value" OR "Complementary value" OR "Network externalities" OR "User experience value" OR "Customer lifetime value" OR "Production value" OR "Market requirements value" OR "Physical value" OR "Market action value" OR "Differentiation value" OR "Intellectual capital value" OR "human capital value" OR "structural capital value" OR "Customer capital value" OR "Innovation value" OR "value of technology" OR "value of Market" OR "Differentiation ONEAR/5 perceived value" OR "Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 "sales and promotion" OR Differentiation ONEAR/5 "cost" OR Differentiation ONEAR/5 "Price" OR "Shareholder value") AND ("Software" OR "Product" OR "Project" OR "Process") AND ("Risk Management" OR "Risk Assessment" OR "Risk control" OR "Risk identification" OR "Risk analysis" OR "Risk prioritization" OR "Risk management plan" OR "risk resolution" OR "Risk Monitor" OR "Risk") AND ((Abstract:"Value" OR Abstract:"valuation" OR Abstract:"Intellectual property valuation" OR Abstract:"cost-benefit" OR Abstract:"Benefit realization" OR Abstract:"Business case analysis" OR Abstract:"economic value" OR Abstract:"Economic profit" OR Abstract:"Economic-driven" OR Abstract:"Return on investment" OR Abstract:"Stakeholder win-win" OR Abstract:"Decision Multiple criteria" OR Abstract:"Competitive Position" OR Abstract:"Network externalities" OR Abstract:"Differentiation ONEAR/5 value") AND ("Software" OR "Product" OR "Project" OR "Process") AND ("Risk Management" OR "Risk Assessment" OR "Risk control" OR "Risk identification" OR "Risk analysis" OR "Risk prioritization" OR "Risk management plan" OR "risk resolution" OR "Risk Monitor" OR "Risk")).

ACM

6157 RECORDS

IEEE

33
<table>
<thead>
<tr>
<th>Scopus</th>
<th>Final Query:</th>
</tr>
</thead>
</table>
EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "VETE") OR EXCLUDE(SUBJAREA, "DENT") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "Undefined") RECORDS 577

TITLE-ABS-KEY((((Software) AND (Risk Management)) AND ("Risk Assessment" OR "Risk control*" OR "Risk identification" OR "Risk analysis" OR "Risk prioritization" OR "Risk management plan*" OR "risk resolution" OR "Risk Monitor*" OR (Risk)) AND (identification OR "Decision Driver analysis" OR "Assumption Analysis" OR decomposition OR factor OR handle OR "Leverage factor*" OR "Performance model*" OR "Cost model*" OR "Network analysis" OR "Decision analysis" OR "Quality factor* analysis" OR metric OR exposure OR leverage OR "Compound risk reduction" OR avoidance OR transfer OR reduction OR "element plan*" OR plan OR simulation OR benchmark OR analysis OR staffing OR mitigation OR "Top 10 tracking" OR reassessment OR "Corrective action*")) AND (EXCLUDE(SUBJAREA, "MEDI") OR EXCLUDE(SUBJAREA, "SOCI") OR EXCLUDE(SUBJAREA, "MATH") OR EXCLUDE(SUBJAREA, "EART") OR EXCLUDE(SUBJAREA, "ENVI") OR EXCLUDE(SUBJAREA, "CENG") OR EXCLUDE(SUBJAREA, "ENER") OR EXCLUDE(SUBJAREA, "DECI") OR EXCLUDE(SUBJAREA, "BIOC") OR EXCLUDE(SUBJAREA, "AGRI") OR EXCLUDE(SUBJAREA, "HEAL") OR EXCLUDE(SUBJAREA, "PHYS") OR EXCLUDE(SUBJAREA, "PHAR") OR EXCLUDE(SUBJAREA, "MATE") OR EXCLUDE(SUBJAREA, "NURS") OR EXCLUDE(SUBJAREA, "CHEM") OR EXCLUDE(SUBJAREA, "IMMU") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "DENT") OR EXCLUDE(SUBJAREA, "MULT") OR EXCLUDE(SUBJAREA, "Undefined"))

TITLE-ABS-KEY(((Value) OR "valuation" OR "insurance" OR "Intellectual property valuation" OR "cost-benefit" OR {cost-value} OR "Benefit* realization*" OR "Business* case* analysis" OR "economic* value" OR "Economic* profit*" OR "Economic-driven" OR "Return on investment" OR "Stakeholder win-win" OR competitive OR "Network external*" OR (Differentiation value) OR (differentia* PRE/5 sales) OR (differentia* PRE/5 cost) OR (differentia* PRE/5 promotion) OR (differentia* PRE/5 availability) OR (differentia* PRE/5 perceived value) OR (differentia* PRE/5 sale AND promotion) OR (differentia* PRE/5 cost AND price)) AND ((Software) AND (Risk Management)) AND ("Risk Assessment" OR "Risk control*" OR "Risk identification" OR "Risk analysis" OR "Risk prioritization" OR "Risk management plan*" OR "risk resolution" OR "Risk Monitor*" OR (Risk)) AND (identification OR "Decision Driver analysis" OR "Assumption Analysis" OR decomposition OR factor OR handle OR "Leverage factor*" OR "Performance model*" OR "Cost model*" OR "Network analysis" OR "Decision analysis" OR "Quality factor* analysis" OR metric OR exposure OR leverage OR "Compound risk reduction" OR avoidance OR transfer OR reduction OR "element plan*" OR plan OR simulation OR benchmark OR analysis OR staffing OR mitigation OR "Top 10 tracking" OR reassessment OR "Corrective action*")) AND
| SpringerLink | (EXCLUDE(SUBJAREA, "EART") OR EXCLUDE(SUBJAREA, "MEDI") OR EXCLUDE(SUBJAREA, "CENG") OR EXCLUDE(SUBJAREA, "ENVT") OR EXCLUDE(SUBJAREA, "SOCI") OR EXCLUDE(SUBJAREA, "ENER") OR EXCLUDE(SUBJAREA, "DECI") OR EXCLUDE(SUBJAREA, "BIOC") OR EXCLUDE(SUBJAREA, "AGRI") OR EXCLUDE(SUBJAREA, "HEAL") OR EXCLUDE(SUBJAREA, "MATE") OR EXCLUDE(SUBJAREA, "NURS") OR EXCLUDE(SUBJAREA, "CHEM") OR EXCLUDE(SUBJAREA, "PHAR") OR EXCLUDE(SUBJAREA, "PHYS") OR EXCLUDE(SUBJAREA, "NEUR") OR EXCLUDE(SUBJAREA, "PSYC") OR EXCLUDE(SUBJAREA, "Undefined"))

| ab: Wertbasierte Projektmanagement | Value-based project management | Inspec & Compendex | 8 | 

Value-based project management

- Value
- Value-based
- Value-oriented
- Value-driven
- Value engineering
- Value assessment
- Business value
- Perceive value
- stakeholder value
- economic value
- intrinsic value
- option value
- priority value
- Worth
- value neutral
- product value
- customer perceived value
- project value
- value creation
- customer value
- valuation
- user value
- Earned value
- Value considerations
- Relationship value
- Producer value
- Value Estimating
- Value estimation
- Value capture
- Value innovation
- Value-innovative
- value evaluation
- historical value
- Intellectual property valuation
- Software economics
- Economic value
- economic-driven
- Economics-Driven
- Economic profit
- Investment value
- Cost-Value
- Cost/benefit
- cost-benefit
- Benefits realization
- Business case analysis
- Return on investment
- ROI
- Stakeholder win-win
- Decision Multiple criteria
- Competitive Position
- internal value
- value notion
- Market value
- Use value
- Intrinsic value
- Complementary value
- Network externaliti
- User experience value
- Customer lifetime value
- Production value
- Market requirements value
- Physical value
- Market action value
- Differentiation value
- Intellectual capital value
- human capital value
- structural capital value
- Customer capital value
- Innovation value
- value of technology
- value of Market
- Differentiation ONEAR/5 perceived value
- Differentiation ONEAR/5 availability
- Differentiation ONEAR/5 sales and promotion
- Differentiation ONEAR/5 cost
- Differentiation ONEAR/5 Price
- Shareholder value
- Software
- Project management
- Project Planning
- Project enactment
- Project closure
- Project Review
- Project evaluation
- software metric
- software measurement

{english}
<p>| ACM | ((&quot;Abstract:&quot;Value&quot; OR Abstract:&quot;valuation&quot; OR Abstract:&quot;Intellectual property valuation&quot; OR Abstract:&quot;cost-benefit&quot; OR Abstract:&quot;Benefit realization&quot; OR Abstract:&quot;Business case analysis&quot; OR Abstract:&quot;economic value&quot; OR Abstract:&quot;Economic profit&quot; OR Abstract:&quot;Economic-driven&quot; OR Abstract:&quot;Return on investment&quot; OR Abstract:&quot;Stakeholder win-win&quot; OR Abstract:&quot;Decision Multiple criteria&quot; OR Abstract:&quot;Competitive Position&quot; OR Abstract:&quot;Network externalities&quot; OR Abstract:&quot;Differentiation value&quot;) AND (&quot;Software&quot; OR &quot;Product&quot; OR &quot;Project&quot; OR &quot;Process&quot;) AND (&quot;Software&quot;) AND (&quot;project&quot;) (&quot;management&quot; OR &quot;Planning&quot; OR &quot;Control&quot; OR &quot;closure&quot; OR &quot;Review&quot; OR &quot;evaluation&quot; OR &quot;metric&quot; OR &quot;measurement&quot;)) AND (PublishedAs:journal) AND (AbstractFlag:yes) |
| IEEE | (&quot;Value&quot; OR &quot;Value-based&quot; OR &quot;Value-oriented&quot; OR &quot;value-driven&quot; OR &quot;Value engineering&quot; OR &quot;value assessment&quot; OR &quot;Business value&quot; OR &quot;Perceive value&quot; OR &quot;stakeholder value&quot; OR &quot;economic value&quot; OR &quot;intrinsic value&quot; OR &quot;option value&quot; OR &quot;priority value&quot; OR &quot;Worth&quot; OR &quot;value neutral&quot; OR &quot;product value&quot; OR &quot;customer perceived value&quot; OR &quot;project value&quot; OR &quot;value creation&quot; OR &quot;customer value&quot; OR &quot;valuation&quot; OR &quot;user value&quot; OR &quot;Earned value&quot; OR &quot;Value considerations&quot; OR &quot;Relationship value&quot; OR &quot;Producer value&quot; OR &quot;Value Estimating&quot; OR &quot;Value estimation&quot; OR &quot;Value capture&quot; OR &quot;Value innovation&quot; OR &quot;Value-innovative&quot; OR &quot;value evaluation&quot; OR &quot;historical value&quot; OR &quot;Intellectual property valuation&quot; OR &quot;valuation&quot; OR &quot;User experience value&quot; OR &quot;Customer lifetime value&quot; OR &quot;Production value&quot; OR &quot;Market requirements value&quot; OR &quot;Physical value&quot; OR &quot;Market action value&quot; OR &quot;Differentiation value&quot; OR &quot;Intellectual capital value&quot; OR &quot;human capital value&quot; OR &quot;structural capital value&quot; OR &quot;Shareholder value&quot; OR &quot;Customer capital value&quot; OR &quot;Innovation value&quot; OR &quot;value of technology&quot; OR &quot;value of Market&quot; OR &quot;cost benefit&quot; OR &quot;cost value&quot; OR &quot;Benefit realization&quot; OR &quot;Business case analysis&quot; OR &quot;economic value&quot; OR &quot;economical value&quot; OR &quot;Economic profit&quot; OR &quot;economical profit&quot; OR Economic-driven OR &quot;Return on investment&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Network externalities&quot; OR &quot;Differentiation value&quot; OR differentiation &quot;Near/5 &quot;sales&quot; OR differentiation &quot;Near/5 cost&quot; OR differentiation &quot;Near/5 promotion&quot; OR differentiation &quot;Near/5 availability&quot; OR differentiation &quot;Near/5 perceived value&quot; OR differentiation &quot;Near/5 price&quot;) AND (&quot;Software&quot; OR &quot;Product&quot; OR &quot;Project&quot; OR &quot;Process&quot;) AND (&quot;Software&quot;) AND (&quot;project management&quot; OR &quot;Project Planning&quot; OR &quot;Project Control&quot; OR &quot;Project closure&quot; OR &quot;Project Review&quot; OR &quot;Project evaluation&quot; OR &quot;software metric*&quot; OR &quot;software measurement&quot;) |</p>
<table>
<thead>
<tr>
<th>SpringerLink</th>
<th>Value-based people management</th>
<th>Inspec &amp; Compendex</th>
</tr>
</thead>
<tbody>
<tr>
<td>{Economic value} OR {economic-driven} OR {Economics-Driven} OR {Economic profit} OR {Investment value} OR {Cost-Value} OR {Cost/benefit} OR {cost-benefit} OR &quot;Benefit* realization&quot; OR &quot;Business case analysis&quot; OR &quot;Return on investment&quot; OR &quot;ROI&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;internal value&quot; OR &quot;value notion&quot; OR {Market value} OR {Use value} OR {Intrinsic value} OR {Complementary value} OR &quot;Network externalities&quot; OR {User experience value} OR {Customer lifetime value} OR {Production value} OR {Market requirements value} OR {Physical value} OR {Market action value} OR {Differentiation value} OR {Intellectual capital value} OR {human capital value} OR {structural capital value} OR {Customer capital value} OR {Innovation value} OR {value of technology} OR {value of Market} OR {Differentiation value} OR (differentia* PRE/5 sales) OR (differentia* PRE/5 cost) OR (differentia* PRE/5 promotion) OR (differentia* PRE/5 availability) OR (differentia* PRE/5 perceived value) OR (differentia* PRE/5 sale AND promotion) OR (differentia* PRE/5 cost AND price) OR &quot;Shareholder value&quot;) AND (&quot;Software&quot;) AND (&quot;project management&quot; OR &quot;Project Planning&quot; OR &quot;Project enactment&quot; OR &quot;Project closure&quot; OR &quot;Project Review&quot; OR &quot;Project evaluation&quot; OR &quot;software metric*&quot; OR &quot;software measurement&quot;)) AND (EXCLUDE(SUBJAREA, &quot;SOCI&quot;) OR EXCLUDE(SUBJAREA, &quot;EART&quot;) OR EXCLUDE(SUBJAREA, &quot;BIOC&quot;) OR EXCLUDE(SUBJAREA, &quot;CENG&quot;) OR EXCLUDE(SUBJAREA, &quot;PHYS&quot;) OR EXCLUDE(SUBJAREA, &quot;MEDI&quot;) OR EXCLUDE(SUBJAREA, &quot;ENVI&quot;) OR EXCLUDE(SUBJAREA, &quot;ENER&quot;) OR EXCLUDE(SUBJAREA, &quot;AGRI&quot;) OR EXCLUDE(SUBJAREA, &quot;CHEM&quot;) OR EXCLUDE(SUBJAREA, &quot;NURS&quot;) OR EXCLUDE(SUBJAREA, &quot;HEAL&quot;) OR EXCLUDE(SUBJAREA, &quot;MULT&quot;) OR EXCLUDE(SUBJAREA, &quot;IMMU&quot;) OR EXCLUDE(SUBJAREA, &quot;ARTS&quot;) OR EXCLUDE(SUBJAREA, &quot;NEUR&quot;) OR EXCLUDE(SUBJAREA, &quot;DENT&quot;) OR EXCLUDE(SUBJAREA, &quot;PSYC&quot;) OR EXCLUDE(SUBJAREA, &quot;Undefined&quot;))</td>
<td>ab:(&quot;Value&quot; or Cost-benefit or &quot;Return on investment&quot; or &quot;return on investment&quot; or &quot;Competitive&quot; or &quot;Stakeholder win-win&quot; or economic) and ab:(Software) and ab:(&quot;project Management&quot;) ab:(&quot;Value&quot; or Cost-benefit or &quot;Return on investment&quot; or &quot;return on investment&quot; or &quot;Competitive&quot; or &quot;Stakeholder win-win&quot; or economic) and ab:(Software) and ab:(&quot;project&quot;)</td>
<td>{&quot;Value&quot; OR &quot;valuation&quot; OR &quot;Intellectual property valuation&quot; OR &quot;cost-benefit&quot; OR &quot;Benefit realization&quot; OR &quot;Business case analysis&quot; OR &quot;economic value&quot; OR &quot;Economic profit&quot; OR &quot;Economic-driven&quot; OR &quot;Return on investment&quot; OR &quot;ROI&quot; OR &quot;Stakeholder win-win&quot; OR &quot;Decision Multiple criteria&quot; OR &quot;Competitive Position&quot; OR &quot;Network externalities&quot; OR &quot;Differentiation value&quot; OR Differentiation ONEAR/5 &quot;perceived value&quot; OR Differentiation ONEAR/5 availability OR Differentiation ONEAR/5 &quot;sales and promotion&quot; OR Differentiation ONEAR/5 &quot;cost&quot; OR Differentiation ONEAR/5 &quot;Price&quot;) AND (&quot;software&quot;) AND (&quot;people management&quot; OR &quot;team building&quot; OR &quot;team build&quot; OR &quot;knowledge management&quot; OR &quot;knowledge sharing&quot; OR &quot;tacit knowledge&quot; OR &quot;postmortem review&quot; OR &quot;KJ Method&quot; OR &quot;process workshop&quot; OR &quot;group process&quot; OR &quot;shared goal&quot; OR &quot;mutual trust&quot; OR participation ONEAR/4 &quot;decision making&quot; OR integration ONEAR/4 ethic OR ethic ONEAR/4</td>
</tr>
</tbody>
</table>
external"

SpringerLink

ab:("Value" or Cost-benefit or "Return on investment" or "return on investment" or "Competitive" or "Stakeholder win-win" or economic) and ab:(Software) and ab:("people Management")

ab:("Value" or Cost-benefit or "Return on investment" or "return on investment" or "Competitive" or "Stakeholder win-win" or economic) and ab:(Software) and ab:("knowledge Management")

ab:(Economic or "Stakeholder win-win" or "Decision Multiple criteria" or "Differentiation value") and ab:(Software) and ab:("knowledge management")

ab:(Economic or "Stakeholder win-win" or "Decision Multiple criteria" or "Differentiation value") and ab:(Software) and ab:("people management")
**Appendix D: Definitions of development and management process areas and sub-process areas**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Classification category</th>
<th>Definitions</th>
</tr>
</thead>
</table>
| 1    | Software Engineering Process areas | **Requirements engineering**: It is a process area which is concerned with the systematic handing of requirements. The sub-process areas include elicitation, analysis, specification, validation, prioritization and requirement management [66].

**Requirements elicitation**: It is also known as requirements discovery, requirements capture and requirements acquisition. At this stage, all the functional and non-functional requirements are collected from the stakeholders by software engineers. Furthermore, relationship with the stakeholders is also established at this stage. There are different techniques available for the elicitation of requirements such as interviews, scenarios, prototypes, facilitated meetings, observations etc. [66].

**Requirements Analysis and negotiation**: It is concerned with the process of analysing requirements to find out and resolve conflicts between requirements, discover the bounds of software and its interaction with the environment, elaborate system requirements in detail in order to drive software requirements from them. These conflicts are resolved through negotiation [66].

**Requirements specification**: In this sub-process area the requirements’ document is produced that can be systematically reviewed, evaluated, and approved. There are three documents produced at this level such as system definition, system requirements specification and software requirements specification [66].

**Requirements prioritization**: In this sub-process area, it is determined that which candidate requirements are most suitable and should be included in a certain release. It is helpful in minimizing the risk associated with requirements by implementing the most important and high risk requirements first during development of the software product [66].

**Requirements validation**: The aim of this sub-process area is to highlight problems before resources are committed to addressing the requirements. It is concerned with the activity of testing the requirements documents to ensure that they are defining the right software system (i.e. the software system that the user expects) [66].

**Requirements management**: Requirements have the iterative nature, therefore most often maintenance and changes in requirements taking place that is managed in this sub-process area [66].

**Requirements traceability**: It focuses on the source of requirements and predicting its effects. It is helpful in performing impact analysis when requirements changes [66].

**Release planning**: To manage, better satisfy the continuous flow of requirements from internal and external sources in market-driven requirements engineering, the requirements are developed and delivered in an incremental fashion. This process is called release planning. As a result of release planning the customer receives in a good way what he want. According to this process, requirements are delivered to the market in different releases and the mechanism is called release planning [87, 90, 93, 99].

**Software architecture**: This process area contains the structure(s) of a system comprised of software components, the external visible characteristics of those components, and the relationships between them. It also includes documentation of a
system's software architecture. This documentation helps in communication between stakeholders, reuse of design components and patterns, and early decisions about high-level design [36].

**Design patterns:** Design pattern refers to a proper way of documenting a solution to a design problem. And pattern language refers to the organized collection of design patterns. Each pattern describes a problem that recurring in an environment and then suggest the basic solution for that problem. Examples include singleton, abstract factory, proxy, decorator, state, strategy. The benefits of design patterns are sharing experience, providing common vocabulary, helping in building complex software architectures [36].

**Architectural styles:** It is a way of classifying architectures that imposes a set of rules on software architecture. Architectural styles examples include client server, centralized vs. distributed, pipes and filters, blackboard, layers, model view controller, monolithic vs. microkernel [36].

**Architecture evaluation:** The purpose of architecture evaluation is to analyse that the system meet the quality requirements, identify weak points in the architecture and paths for improvement [36].

**Architecture views:** Architecture views such as conceptual, code, module and execution help in designing the software architecture in a systematic way. Conceptual view describes the system in major design elements and shows the relationship among them. The main purpose of the module view is to decompose the system into modules and then place the modules on different layers. Code view contains the source code while execution view is about allocation of functional components to runtime entities, handle communication, and synchronization among them [36].

**Software Design:** Software design is concerned with planning for a software solution. When requirements are specified then software developers develop a plan for a solution. It includes algorithm implementation and low-level component design, interfaces design and the design of other features of a software system [66].

**Software design fundamentals:** This sub process area is concerned with the concepts, basic roles and scope of software design [66].

**Design Issues:** During the design of software different key issues are taken into account such as performance, decomposition, managing, and packaging of software components. Other issues that are related to some aspect of software's behaviour such as concurrency, control and handling of events, distribution of components, error and exception handling and fault tolerance, data persistence etc. [66].

**Modeling languages:** There exist many notations and languages which can be used for the representation of software design artifacts. Some are used for the representation of software behaviour while others are used for the structural organization of design. For example the notations/languages used for the representation of behavioural view of software design are activity diagrams, collaboration diagrams, data flow diagrams, decision tables and diagrams, sequence diagrams, state transition and state chart diagrams, formal specification languages, pseudo code and program design languages. Similarly notations/languages used for the representation of structural organization of software design are architecture description languages, class and object diagrams, component diagrams, collaboration responsibilities cards, deployment diagrams, entity relationship diagrams, interface description languages, and structure charts etc.
**Design documentation:** It is a special breed for code generation. Design document does not describe how to write coding for a particular function or even why that particular function exists in the coding. But provides the general requirements that motivate the existence of such a function. A good design document is always short on details but large on explanation.

**Design decision:** It includes all the decisions that are taken about the design of the software product. These decisions include the dimensions such as quality attributes, economic aspects, management aspects, technological aspects and organizational aspects [175, 176, 178].

**Software Design Strategies:** These are different various general strategies that assist to guide the design process. These include data abstraction and information hiding, top-down vs. bottom-up strategies, use of heuristics, use of patterns and pattern languages [66].

**Software Design Evaluation:** It is used for the retaining the quality of software design. For this purpose various tools and techniques are used such as software design reviews, inspections scenario-based techniques, requirements tracing fault-tree analysis, automated cross-checking, performance simulation, feasibility prototype etc.

**Software development:** This process area contains the fundamentals of software development such as minimizing complexity, anticipating change, development languages. Software development (i.e. coding in this thesis) is tightly linked to software design and software testing. The input to this process area is the output of design while the output from this process area is the input for software testing [66].

**Software development process:** It is a structure obligatory for the development of a software product. In this thesis the sub activities in coding are included in this sub process area.

**Development models:** Development models are used for streamlining the development process. There are different development life cycle models are available for the development of software such as waterfall, modified waterfall, incremental, agile development etc. [66].

**Coding:** Source code refers to the collection of statements written in any programming language such as C, C++, Java, Corba etc. It is developed by the programmers in order perform the desired task by the computer [66].

**Programming languages:** It includes all type of communication through which a human prescribe an executable solution to a computer. There are different type of programming languages exist such as configuration languages, toolkit languages and programming languages [66].

**Reusability/ software reuse/COTS:** software reuse also called code reuse is the use of existing coding, or software knowledge, to build new programs/software. Commercial of the shelf components also expedite the development process [66].
**Anticipating change:** software changes over time due to change in environment, requirements etc. The code should be of the degree to anticipate these changes. In order to do changes easily in the code, different considerations should be proper like naming, code layout, use of classes, enumerated types, variables, named constants, use of control structures, code documentation [66].

**Open source software:** These computer programs/software are available in source code form and the users are allowed to study, change, and improve them. These kinds of computer programs/software expedite the work up to great extent. On the other hand closed source software are fully developed in house and the development process can take more time than the open source software.

**Programming paradigm:** It is a fundamental pattern or style of computer programming. Paradigms differ from each other in concepts and each language has a unique programming paradigm. But it is also possible that a language can use multiple paradigms for example a program written in C++ can be purely object-oriented, or purely procedural, or contain elements of both paradigms.

**Verification:** The process in which evaluation of units, models or components of a system take place in order to ensure that whether the artifacts of given development phase fulfils the criteria imposed at initial phase is known as verification [8, 10, 66].

**Inspection process:** It is a proper, thorough, and comprehensively technical review designed to find out problems near to the point of origin as possible [8, 10, 66].

**Validation:** The process in which evaluation of units, models or components of a system during or at the end of development process take place in order to ensure that whether it meets the specified requirements is known as validations [8, 10, 66].

**Unit testing, module testing, or component testing:** It refers to discover defects in logic, data and algorithms and also known as module testing or component testing. It is the lowest level of testing. It is of technical nature [8, 10, 66].

**Integration testing:** It refers to discover interface defects among units by performing test on selected unit of groups. It can be unit integration testing, module testing and system integration testing [8, 10, 66].

**Validation test:** It is also known as system testing. It can be defined as the process of evaluation of components throughout the development life cycle in order to ensure that whether it meets or satisfies the requirements or not. It is mainly used to ensure that the requirements specified in SRS are met [8, 10, 66].

**Regression testing:** It refers to the testing that supplement validation testing to ensure that bugs corrections have not generated new bugs [8, 10, 66].

**Alpha and beta testing:** It is performed by delivering pre-release versions of software to the customers in order to get feedback on specific test scenarios [8, 10, 66].

**Acceptance testing:** It refers to the testing in which customers are actively involved. It is also similar to the validation testing but there is no customer involvement in validation testing [8, 10, 66].

**Installation testing:** It refers to the testing that is performed in target environment according to the hardware configuration requirements after completion of software and acceptance testing [66].

**Conformance/functional testing:** It refers to conformance validation that validates the system behavior according to the specifications [66].
Performance testing: It refers to the verification of performance requirements according to the specified one. Such as capacity and response time [66].

Stress testing: It is performed to check software at high load as well as at extreme point [66].

Back to back testing: These are series of tests are performed on two different versions of same product and results are compared [66].

Recovery testing: It aims to ensure or verify the recovery of software after disaster [66].

Configuration testing: it analyzes software (i.e. to serve different users) under different configurations [66].

Usability testing: It aims to assess the use and learning of software for end users, effectiveness of software functionality regarding support of different end user tasks and at last its capability of fault tolerance [66].

Testing techniques

Ad hoc testing refers to the testing that is carried out based on skills, experience and intuition [66].

Exploratory testing refers to simultaneous learning, designing of tests and executions of test [66].

Specification based techniques

Equivalence partitioning aims to minimize the total number of tests by grouping the data together or test cases that are used to test the same thing and testing one value out of all group[66].

Boundary value analysis refers to choosing test cases on and near the boundaries of underlying domain and rational that many faults might be found near these points [66].

Robustness test is extension of boundary value analysis that is used to test the robustness of program for erroneous inputs [66].

Decision table refers to actions conditions relationships and its combination helps into generation of different possible test cases [66].

Finite state machine based refers to the selection of tests in such a way that can cover the states and transitions on it [66].

Random testing refers to the generations of test randomly [66].

Code based techniques

Control flow based criteria aims to cover all statements or chunk of all statements in a program or specific combinations of them [66].

Data flow based criteria refers to the control flow graph that contains information about how the program are defined, used and killed [66].

Reference models for code-based testing refer to the graphical representation of control structure using a flow graph in code based testing techniques [66].

Fault based techniques

Error guessing refers to the designing of test cases that figure out the most reasonable faults in program by software engineers [66].

Mutation testing refers to the program-modified version under test [66].

Usage based techniques (operational profile) refers to the testing environment that establish operational environment of the
software for evaluation of reliability [66].

**Test related measures:** These are used to provide an evaluation of the program under test based on observed outputs and evaluate the thoroughness of the test set [66].

**Test process:** To perform and integrate testing measures, techniques, methods, concepts and strategies, there is a need of well-defined and control process. It supports activities and setting guidelines for testers, from start to end until tests output in order to ensure that test objectives meet in a cost effective way [66].

<table>
<thead>
<tr>
<th><strong>Software quality:</strong></th>
<th>Software quality means that the software has exact conformance to user requirements, excellent for use, and customers are satisfied[66].</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Software quality fundamentals:</strong></td>
<td>In this sub process area, the concepts, software engineering culture and ethics, models and quality, the value and costs of quality, software characteristics, and quality improvement are included [66].</td>
</tr>
<tr>
<td><strong>Cost of quality:</strong></td>
<td>It includes the cost such as conformance and non-conformance cost. Cost of conformance refers to the amount spent on achieving quality software products. It is further divided into prevention cost and appraisal cost. Prevention cost refers to the amount associated with defects prevention, while appraisal cost contains measuring, auditing and evaluating the software product in order to assure conformance to the performance and quality standards. The cost of non-conformance includes all amounts when the software product does not match to the quality requirements. It is further divided into internal failure cost and external failure cost. The former includes all expenses before the software product is handed over to the customer while the latter refers to the costs that arise from failures at the customer end [66, 321].</td>
</tr>
<tr>
<td><strong>Process quality:</strong></td>
<td>It is the quality of a process that is related to the quality characteristics of the software products that in turn affect quality-in-use as perceived by the customer. Quality of a process also has an impact on the cost and schedule of the software product [66].</td>
</tr>
<tr>
<td><strong>Quality management:</strong></td>
<td>It has three main components: quality control, quality assurance and quality improvement. The aim of quality management is to focus on software quality, and explore means to achieve it.</td>
</tr>
<tr>
<td><strong>Quality improvement:</strong></td>
<td>It is an iterative process and a software product quality can be improved through the improvement in management control, coordination, prevention and early detection of errors, and customer focus [66].</td>
</tr>
<tr>
<td><strong>Software Quality Assurance:</strong></td>
<td>During the project life cycle, SQA ensures the quality of software by continuous monitoring using processes and methods. These are included in standards such as ISO9000 and CMMI [66].</td>
</tr>
<tr>
<td><strong>Risk management:</strong></td>
<td>aims to discover, address, and eradicate software risk items before it become a vulnerable for operation of software or it become a major source that revise the whole software work [17].</td>
</tr>
</tbody>
</table>
Risk Assessment

Risk identification is mainly concerned with the identification of risk items that will definitely greatly affect the outcome of the project. There are number of risk identification techniques such as checklist, comparison with experience, decomposition, and examination of decision drivers [17].

Risk Analysis: it is mainly concerned with the assessment of the loss-probability and loss magnitude regarding identified risk items and the evaluation of dependent risk involved in risk items. Techniques used for risk analysis are network analysis, decision trees, cost models and performance models [17].

Risk prioritization: It is mainly concerned with the prioritization of identified and analyzed risk items. Techniques are Risk exposure analysis, and Delphi etc. [17].

Risk control

Risk management planning: It is mainly concerned with producing plan to address each risk item that contains the risk items plans coordination with one another and with overall project. Techniques are cost-benefit analysis, checklists etc. [17].

Risk resolution: It refers to the creation of situation in which risk items are resolved, mitigated, or eliminated. Techniques are prototype, simulations, benchmarking etc. [17].

Risk monitoring: It refers to the tracking of project progress regarding the resolution of project risk items and taking corrective actions when appropriate. Techniques are top ten risk item list, risk management plan milestone tracking etc. [17].

Initiation and scope definition: Set of activities mainly emphasize on the determination of the software requirements through different elicitation methods and evaluation of the feasibility of project from different angles. Once feasibility has been assessed and established then next requirements specification and validation is done and it contains some change procedures. It contains major activities like [66]
1) Requirements determination and negotiations [66].
2) Feasibility analysis (technical, operational and financial) [66].
3) Review and revision of requirements process [66].

Software project planning: The planning process is based on the scope, requirements and feasibility report. Software development life cycles are evaluated and then most effective one is selected by keeping different aspects of project development in consideration. In project, planning, major tasks are divided into small task and determine deliverables for each task. These are characterize regarding quality and other attributes according to the requirements and then detail effort, schedule and cost is estimated for each task. Both human and non-human resources are allocated to different task. Risk management and quality management are taken into consideration with procedures, roles and responsibilities, schedules [66]. Quality management includes quality assurance, V&V, reviews and audits [66].

It includes major activities [66] are the following
1) Process planning
2) Determine deliverables
3) Effort, schedule and cost estimation
4) Resource allocation
5) Risk management  
6) Quality management  
7) Plan management

**Software project enactment:** The plans are then implement practically and it is ensured that all the activities going to be performed will be according to the plan in such a way that it results into stakeholder satisfaction and achievement of project objectives. It contains activities like measuring, monitoring, controlling and reporting [66].

1) Implementation of plans  
2) Supplier contact management  
3) Implementation of measurement process  
4) Monitor process  
5) Control process  
6) Reporting

**Review and evaluation:** progresses towards achievements of objectives and stakeholders satisfaction are evaluated at critical point in project. It involves following activities[66] such as

1) Determining satisfaction of requirements  
2) Review and evaluation performance  

**Closure:** project closeout is to be take place when all activities associated with process is completed successfully. The evaluation of success criteria is evaluated during this stage [66]. Archival, post mortem, and process improvement activities take place during and after project closure. Main activities [66] are

1) Determining closure  
2) Closure activities

**People management:** It contains team building of stakeholder and managing their expectations management. It also includes the integration of ethical considerations into daily project activities. The knowledge bearing entities within a company are employees and the purpose of people management is that, how to extract the tacit knowledge from them and to make it available for all the employees within a company [1].

**Intellectual capital Management:** The components of Intellectual capital are human capital, relational capital and structural capital. Human capital refers to the capabilities of employees who provide solutions to customers. These include experiences, skills and abilities of employees, knowledge, and collective human ability to solve business problems. The structures and processes within the organization refer to structural capital. Structural capital should be of the mark that it meets market requirements for example trademarks, patents, information systems. Relations of the organization with stakeholders including suppliers, customers, and public are included in relational capital [1, 418, 435].

**Knowledge Management:** KM deals with practices and strategies for the creation, identification, distribution and sharing of knowledge within the organization. The source of knowledge within the organization is employees or organizational practices or processes. KM efforts are spent on organizational objectives such as innovations, competitive advantage, high performance, sharing of lesson learned [419].
**Teamwork:** In software organizations, the development of software is carried out by a team. The effectiveness of the teamwork is high if they work in collaboration that is the team has good communication, cohesion, coordination, balance of contributions, mutual understanding and support and effort [420].

**Stakeholder expectation management:** As there are different stakeholders and each has different desires about the system. With the help of expectation management the stakeholders get to know about each other requests and suggestions. Then though negotiation and prioritization process the most important features are given precedence over others [1].

**Ethical Consideration:** Ethics is the branch of philosophy that focuses morality that is the concepts like right and wrong, good and evil, virtue, justice, etc. In software engineering such code of ethics is the ACM/IEEE Code of Ethics. The contents of this code of ethics cover topics like privacy, confidentiality, intellectual property, fairness, quality of work, liability, fair equality of opportunity, risk disclosure, conflict of interest, and unauthorized access [1].

<table>
<thead>
<tr>
<th>3</th>
<th>Contributions</th>
<th>See Appendix B</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Research type</td>
<td>See Appendix B</td>
</tr>
</tbody>
</table>
Appendix E: Value map of value-based requirements engineering
Appendix F: Value map of value-based architecture
Appendix G: Value map of value-based design
Appendix H: Value map of value-based development
Appendix I: Value map of value-based verification and validation
Appendix J: Value map of value-based quality management
Appendix K: Value map of value-based project management
Appendix L: Value map of value-based risk management
Appendix M: Value map of value-based people management
Appendix N: Value map of value-based software engineering
### Appendix O: Definitions of value dimensions

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Value dimensions</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project value</td>
<td>Project value is created from budget, scheduling and delivery [86]. The project value increases, if it is completed in minimum budget, less time.</td>
</tr>
<tr>
<td></td>
<td>Product Value</td>
<td>Product value can be defined as market value of the product (i.e. exchange value). It is related to product price and is greatly influenced by the non-functional requirements of the software product [81, 86, 94, 95, 117]. The value of the product is directly proportional to its advantages over competitor’s products and vice versa [81, 86, 94, 95, 117]. The important drivers for the creation of the product value are as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The importance of customer in selecting and prioritizing requirements [9, 86, 151].</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Customer satisfaction (Business Perspective) [81, 94, 117]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Software features (Business Perspective) [81, 94, 117]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Business strategy (Business perspective) [81, 94, 117]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stakeholders priority of requirements [1, 78]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Development cost-benefit (Project Perspective) [81, 86, 94]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Resources/competencies [1, 86]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Delivery date/Calendar time (Project Perspective) [81, 86, 94]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Product Price [86]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Differential advantage over competitor product [81, 86, 94, 117]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The party responsible for issuing the requirements [81, 117].</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Status of competitors with respect to the requirements [81, 86, 94, 117].</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Meeting customer’s demands, wishes and expectations [86]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Quality attributes [1, 86]</td>
</tr>
<tr>
<td>1)</td>
<td>Business value</td>
<td>Business value is created from product sales [137, 86, 108], marketing [137], customer orientation [137], strategic alliance [137], integrity [137], sustaining competitive advantage [137], managing requirement process [108], requirements agility [108], contractual innovation [108] and Controlling project risk (i.e. cost and schedule overruns [328], unmet user requirements [328], and system development that is not concerned with business value) generates business value [328]. It is directly proportional to the product sales. Business value is composed of the following value dimensions.</td>
</tr>
<tr>
<td>1.1)</td>
<td>Production value</td>
<td>Production value refers to the collective value of software production process, which involves market requirements value,</td>
</tr>
</tbody>
</table>
physical value and market action value [454, 455]. It ensures the value of development process, requirements and on time and within budget delivery of product.

i. Market Requirements Value: it refers to production value with respect to the market requirements. The product that reflects the market requirements in a better will have a higher market requirements value [454].

ii. Physical value: It refers to the integration of both software process deployment and product’s features for better managing the complexities within the production system. It is used to measure the real added value of production processes and developed product and its implications on the market place [454]. Physical value has the attributes as under:
   - Physical value with respect to time (PVT)- a software product will have higher PVT, if it is evaluated, adjusted and placed in market in shorter developmental cycle [454].
   - Physical value with respect to cost (PVC)- a software product will have higher PVC, if it is developed and marketed within low developmental cost [454].
   - Physical value with respect to quality (PVQ)- a software product will have higher PVQ, if it is developed with higher quality concerned to its final features and development process [454].

iii. Market action value: this attribute of production value is concerned to the strategies of the software product. A product will have higher market action value if it has better strategies to enter a market place [454].

1.2) Differentiation value: it is related to the process of distinguishing the product or offering from others competitive products as well as from the one's own product offerings, in order to make it more attractive to a particular target market [457]. Differentiation value can of the following types.
   - Differentiation with respect to perceived value: It is related to the differentiation of software product based on its features (functional and non-functional) and benefits gained from the product as compared to the competitor’s product [456]. This can be measured through gap analysis and internal value analysis.
   - Differentiation with respect to availability: It is related to the availability of product features in a specified time as compared to the competitor’s product [456].
   - Differentiation with respect to sales and promotion: it is related to the strategies (i.e. low price high quality, high price high quality, using different media) being adopted for the sales and promotion as compared to the competitor products [456].
   - Differentiation with respect to cost and price: It is related to the cost incurred and price of the product as compared to the competitor’s product [456].

1.3) Intellectual capital value: The sum of tangible and intangible assets that a company owns that gives a differential
advantage in the marketplace, including experience and knowledge of the people [418]. In other words, it is used as a key input and tool in development of software today. It determines and covers the value that is provided by employees (human capital), processes (structural capital), products and knowledge existed in relationships between the organization, and external parties (relational capital) [1]. Here organization knowledge means ideas, innovation, creativity, critical thinking, software programs, designs, and processes that can be converted into source of income, creating and establishing value, and give differential advantage to the organization[1]. Four aspects of intellectual capital are intellectual property assets, market assets, human focused assets, and infrastructure assets [24]. The three components of intellectual capital such as human capital, organization capital and customer capital are as follows.

i. **Human capital:** refers to the potential competence capability of individuals who solve problems and provide solutions to the customers. It includes skills and abilities, knowledge (both tacit and explicit knowledge), experiences and joint abilities of human to solve business problems [418].

ii. **Structural capital:** refers to the processes and structures followed inside organization to meet market requirements such as trademarks, information system and patents [418].

iii. **Relational capital:** refers to bilateral relation of organization with stakeholders including customers, vendors, suppliers, and end users [418].

iv. **Intellectual Property.** It refers to intangible value that is created with the help of human creativity and invention, and it comprises of patents, copyrights, and trademarks that are used by the owners to protect their software and other artifacts [1]

**System Value**
Software intensive systems value depends on the balancing of opportunities and risks [335], probability loss is the probability that new development will reduce the value of system, similarly, opportunity exposure for new factors of potential gain in system value equals to probability gain(that enhance system value) – resulting gain[335]. Whereas, risk exposure for any new factor of potential loss of system value is equal to the probability loss – resulting loss. Furthermore system value can be affected by potential sources such as evaluated commercial off the shelf products, reusable units, components and modules, open source repositories, established and mature standards, and strategic alliance [335]. Furthermore, some key factors such as quick time to market, software development life cycle cost, intellectual capital, user interface continuity, complications in vendor support, architectural mismatch, quality requirements, and meeting customer needs, demands and expectations also have greater impact on the gaining or loss of system value[335]. Besides all above-mentioned facts, decisions at all level of system development can be taken in such a way that it must consider and meet all explicit objectives of all stakeholders like sales manager, business manager, marketing manager, requirements engineer, quality engineer, architects, designers, production manager, experts, project manager, product manager and high level management[325].

**Earned Value**
There are two types of earned value i.e. standard earned value and real earned value. 

*Standard earned value* refers to the project management technique that is used to measure progress and performance of project against the planned one, and performs estimation of future performance at specific date [327, 332, 339] but it doesn’t track stakeholder value and business value. However, important point here is that it considers cost, time and risk, which are most important factors at project level. By managing cost in effective way, hitting market window on right time and reducing risk at project level does ultimately generate project value for the company or organization [288].

*Real earned value* is based on value-based approach that considers utility functions or value proposition of different peoples by meeting the actual requirements and deliver expected requirements product. Therefore, it is mainly concerned with stakeholder value and business value [288].

**Minimum marketable features (MMF)**
The breaking down of project requirements into minimum marketable features with intrinsic marketable value and into architecture elements that forms the basis for software value creation [343].

**Intrinsic marketable value**
Comprise of MMFs association with differential advantage, revenue generation, implementation cost effectiveness, projection of brand, and loyalty enhancement [343].

**Product differentiation**
The concept of commoditization is mainly concerned with alike products and owners of undifferentiated products have less power for setting price. Whereas, product differentiation empower software organizations in setting price for the products and enabling them to play monopoly in the market. Product differentiation is totally against of product commoditization. There are number of ways to make a product differential i.e. implementing innovative features, network externalities and easily available to the consumers in terms of competitors etc.

**Technology value**
Innovation can be considered as a fundamental factor that drives technology value [14]. Firstly, idea comes from academia or industry and then developed into technology [33] (i.e it can be methods, tools, techniques etc.). Technology passes through several steps from static validation to dynamic validation utilizing different research methods and improves with passage of time. Usability and usefulness of the Technology is evaluated using industrial practitioners [33]. Cost-benefit analysis, return on investment and comparison in terms of best alternative is assessed in industry. If cost associated with implementation or introduction of new technology is less as compared to other alternatives, provides long-term benefits and generates high return on investment, then it results into financial value, economical value and technology value. Therefore, we can say that innovation is a fundamental factor that creates technology value.

**Cost-benefit analysis**
The detail analysis of costs and benefits plays an important role in the valuation of the software assets and projects. Identification of relevant cost and value drivers are important to perform cost-benefit analysis [1]. While there are different well-established methods for software development cost but the drivers of value and methods, models and frameworks for value creation are missing in software engineering [1]. The evaluation of intangible or soft benefits, influence of time on the value of these cost and benefits and the concerns of uncertainty [1]. Long-term intangible benefits improve monetary terms.
These benefits comprise of flexibility and learning, that plays a key role in long-term significant value creation in software development [1]. Traditional cost-effectives methods/techniques results into only tangible benefits for example reduce efforts results into direct saving [1].

**Intrinsic value**
It may be functionality and quality attributes such as security and usability that is embedded in software known as intrinsic value [29]

**Complementary value**
Complementing a piece of software with another good or service that creates value is known as complementary value [29]. For example, Microsoft word will be much more valuable and worthy, when it is used in an office suite to utilize the functionality and objects of the other applications in that office suite.

**Network externalities**
Software is used in communication and its value is reliant on the number of users that are relevant to the central user. It is subjected to network externalities [29]. For example, employees working in organization and using different applications that are compatible with one another, so they can share all relevant documents and both takes benefits from compatibility.

**Stakeholder value**
A success critical stakeholder is a stakeholder, whose interest is taken into consideration for the success of the project [325]. It is difficult task to involve right person. S-C-S changes throughout the project life cycle. Ignoring the needs, demands, and expectations of any of the S-C-S results into uncertainty of the project. After identification of all internal and external stakeholders then there should be the identification of significance and relative power of each stakeholder. The significance of stakeholder refers to the extent to which project can be successful if needs, demands and expectations are addressed or not. Whereas, relative power means the extent to which stakeholder influence the key and critical decisions. After identifications of the stakeholder significance and relative power then it facilitates to identify success-critical- stakeholders. Those stakeholders who have high significance and relative power would be the success-critical stakeholders in project. Success critical stakeholders often have problem in expressing and compatibility of value propositions especially for new ones otherwise, it can be converted into set of objectives. Value propositions of stakeholders come from experience rather than survey or workshop. SCS often have conflicting needs, demands and expectations. Several effective techniques are used for reconciliation of stakeholder’s value propositions. It can be expectation management, visualization and tradeoff analysis, prioritization, groupware, and business case analysis.

**Economic Value (of the firm)**
The economic significance and importance of a firm is the sum of overall its expected future profits, discounted for time and risk. [1].

**Competitive Position.**
The cost-effective profitability and expansion or growth rate of a particular business unit relative to the competitors in the market, produced by differential position and relative economic costs [1]
**Business Goals**

Non-functional requirements such as reliability, maintainability, usability and cost etc. are generally treated as System qualities. Most of the nonfunctional requirements instigate at the business level, therefore these quality requirements are treated as business goals. Realizing business goals plays an important role in software success. Realizing business goals are crucial for software success. Therefore, it is necessary to scrutinize the change in system’s requirements and to align them with business goals [1].

**Return on Investment (ROI).**

A measure of the profit that an investment generates as the amount of asset’s value used to generate it [1]. It is usually expressed as return (earnings before interest and tax) divided by the Investments [1]. For example, a $100 investment that results into a $10 return has a 10% return on investment.

**Return on capital employed (ROCE)**

Refers to returns at the company level. It is the rate of return (earnings before interest and tax) that total capital (shareholders’ funds plus debt) generates in a business [1].

**Valuation.**

The act of valuing, or of estimate current value or worth of intellectual property for the purpose of acquisition, appraisal, and/or other purposes [1].

**Value Creation.**

Software organizations starts focus on value of different customers and segments or markets when developing product that provide competitive advantage in market globalization and in era of uncertainty. Value creation is mainly concerned with edifying, developing and growing business by creating and delivering of value effectively to the customer [1]. It plays major role in identifying main competencies of the organization and binding these competencies to it’s company future vision. It is very essential to achieve long-term strategic benefits [1].

**Customer lifetime value:**

Customer focused business strategy that is used to maximize profit, revenue, and ensure and manage customer satisfaction is known as CRM [30] (customer relationship management). Customer lifetime value (CLV) is a standard terminology used in CRM system [30]. It can be defined as Total present value during the period in which customer starts to interact and keeps buying relationship with the company [30]. It can be divided into two parts based on present customer. The first part revolves around the profit gained from the customer from starting time till present time. Whereas, second part revolves around the future profit, namely total present profit in addition with potential future profit to be derived from that customer [30]. It can be calculated by determining the present value of the profits gained from customer over the customer lifetime that is estimated from expected number of months or years a customer-company relationship [30].

**Customer’s perceived value**

Also known as use value [31]. It can be defined as the benefits (short term or long-term benefits) derived from the product and are a measure of how much a customer is willing to pay for it [31]. It is greatly influenced by customer’s needs, expectations,
past experience with products and the culture in which customer is [31]. In order to calculate perceived value, divide perceived benefits by perceived price [31], whereas measurement of both benefits and price take place in comparison with competitor’s product. It influences attitudes and choice behavior of the customer. Customer value expectations are a most important factor in the satisfaction of customer while evaluating product [31]. It affects three levels of customer choice such as the choice to purchase or not [31], the preference for product class [31], and the preference for brand [31].

**Customer value drivers**

Value drivers are decision related attributes that play an important role in the choice process of customers [31]. Customers perceive these value drivers. Value drivers depend on the customer’s confidence about the product and the company, consumer motivation and buying situation [31]. The customer’s perception of economic, performance and supplier’s value are the representation of strong beliefs and attitudes [31] that plays major role in creating brand image [31]. Therefore, decision to buy or not to buy is strongly influenced by strong brand image [31].

Five major classes of customer value drivers [31] that have greater impact on customer decision making and behavior are the followings:

1) **Economic-value drivers**: It refers to the buyer’s perception about product or service in terms of cost of acquiring, cost of ownership, cost of installation, and cost of disposals or opportunity cost [31].

2) **Performance/Functional Value**: It refers to the perception of the consumer about the utility that is to be derived from the product or service functionality [31].

3) **Buyer’s Perceptions about the Supplier**: It refers to the supplier status perceived by buyer that plays a major role in enhancing acceptance for a brand. Buyer’s perception about supplier takes long time to change whereas, economic and performance value takes less time to change by introducing change in price and product design [31].

4) **Buyer’s Motivations and Goals**: It refers to the impact of buyer motivation and goal on the decision process that is to be carried out for a particular purchase. Factors that affect the buyer’s motivations and goals are recognition, self-esteem, visibility, to be known as problem solver, good decision taker and good dealer etc. [31].

5) **The Buying Situation**: It refers to the relationship of the buyers purchase with the situational context. Sometime situational context become facilitative one or some time as a hurdle in purchase and sometime remains neutral. Some of the key situational factors that have greater impact on the behavior such as buyer’s task requirements, buyer’s resource capabilities, and buyer’s past experience, and organizational social influence on buyers [31].

**Fair value**

The amount that would reimburse the owner when unwillingly deprived of the usage of the asset [1]. It is difficult to determine the fair value of an intangible asset.

**Market value**
The feasible pay that at which buyer shows willingness to buy an asset on the open software market place with respect to the competitor’s product [1]. It is difficult to determine the market value of an intangible asset.

**Acquisition value:**
The amount that a purchaser pays to get the rights of usage, selling, or distribution of the asset on the open marketplace [1]. It is difficult to determine the acquisition value of an intangible asset.

**Insurable value**
The amount of insurance that is specifically used for the replacement of an asset with a like functionality and revenue producing capability [1].

**Collateral value**
“The amount that a creditor would advance with the asset serving as collateral for the loan” [1]. But, it is difficult to carry out this task in case of software industry because book value of software cannot be used always as an indicator to determine its worth to software organization.
**Appendix P: Kappa Statistics - Research Type**

*Researcher_1 * Researcher_2 Crosstabulation*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Researcher_1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>1. Evaluation research</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2. Validation research</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3. Solution proposal</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4. Experience report</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5. Philosophical research</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.796</td>
<td>.136</td>
<td>6.032</td>
<td>.000</td>
</tr>
</tbody>
</table>

| N of Valid Cases     | 20    |                   |           |              |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix Q:** Kappa statistics - Value-based contribution (disagreements)

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th>Count</th>
<th>Researcher_2</th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Researcher_1</td>
<td>1</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Approx. T&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>-0.318</td>
<td>0.083</td>
<td>-1.832</td>
<td>0.067</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Not assuming the null hypothesis.

<sup>b</sup> Using the asymptotic standard error assuming the null hypothesis.
### Appendix R: Kappa statistics - Value-based contribution (agreements)

#### Researcher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th>Researcher_1</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5.1. Recommendations</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5.2. Model</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5.3. Method</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5.4. Tool</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5.5. Framework</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>5.6. Approach</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>20</td>
<td>5.7. Metric</td>
</tr>
</tbody>
</table>

#### Symmetric Measures

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Approx. T&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.812</td>
<td>.100</td>
<td>7.671</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Not assuming the null hypothesis.

<sup>b</sup> Using the asymptotic standard error assuming the null hypothesis.
### Appendix S: Kappa statistics - VBSE process areas

Researher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th>Researcher_2</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher_1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>1. Value-based requirements engineering</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2. Value-based architecture</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3. Value-based design</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>4. Value-based development</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>5. Value-based verification &amp; validation</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>6. Value-based quality management</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>7. Value-based project management</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>8. Value-based risk management</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>9. Value-based people management</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

#### Symmetric Measures

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Asympt. Std. Error</th>
<th>Asym. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.791</td>
<td>.057</td>
<td>16.497</td>
</tr>
</tbody>
</table>

* N of Valid Cases: 60

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
### Appendix T: Kappa statistics - empirical basis of need (disagreements)

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>1. VBSE agenda</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>2. Statement only</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>9</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error(^a)</th>
<th>Approx. T(^b)</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.010</td>
<td>.219</td>
<td>.045</td>
<td>.964</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a. Not assuming the null hypothesis.
- b. Using the asymptotic standard error assuming the null hypothesis.
### Appendix U: Kappa statistics - Empirical basis of need (agreements)

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher_1</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>10. VBSE agenda</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>6. Statement only</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4. Nothing</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.754</td>
<td>.133</td>
<td>4.646</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
Appendix V: Kappa statistics - Application validation method

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th>Researcher_2</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher_1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

**Legends**
- 1. Case study
- 2. Interview
- 3. Survey
- 4. Experiment
- 5. Observation
- 6. Prototyping
- 7. Conceptual analysis
- 8. Example driven
- 9. Not applicable

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.878</td>
<td>.079</td>
<td>9.530</td>
<td>.000</td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.
Appendix W: Kappa statistics - Application validation Design

Researcher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

Symmetric Measures

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Approx. T&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.714</td>
<td>.125</td>
<td>5.147</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Not assuming the null hypothesis.

<sup>b</sup> Using the asymptotic standard error assuming the null hypothesis.
Appendix X: Kappa statistics - Application validation Results

Researcher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher_1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1. Statement only</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>2. Qualitative results</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>3. Quantitative results</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>4. Qual + Quan results</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>11</td>
<td>5</td>
<td>3</td>
<td>20</td>
<td>5. Nothing</td>
</tr>
</tbody>
</table>

Symmetric Measures

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.672</td>
<td>.153</td>
<td>4.433</td>
<td>.000</td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix Y: Kappa statistics - Usability**

*Researcher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>Total</td>
<td></td>
<td>Legends</td>
</tr>
<tr>
<td>Researcher_1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1. Statement only</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3. Quantitative results</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>12</td>
<td>14</td>
<td>5. Nothing</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.691</td>
<td>.167</td>
<td>3.983</td>
<td>.000</td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.
Appendix Z: Kappa statistics - Usefulness (disagreements)

Researcher_1 * Researcher_2 Crosstabulation

<table>
<thead>
<tr>
<th>Count</th>
<th>Researcher_2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Researcher_1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
</tr>
</tbody>
</table>

Symmetric Measures

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.593</td>
<td>.130</td>
<td>5.045</td>
<td>.000</td>
</tr>
</tbody>
</table>

N of Valid Cases | 20 |

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix AA: Kappa statistics - Usefulness (agreements)**

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th>Researcher_1</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>1. Statement only</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2. Qualitative results</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3. Quantitative results</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>4. Qual + Quan results</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>5. Nothing</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.864</td>
<td>.090</td>
<td>7.202</td>
<td>.000</td>
</tr>
</tbody>
</table>

- a. Not assuming the null hypothesis.
- b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix BB: Kappa statistics - systematic map pilot selection (disagreement)**

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Researcher_1 1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>19. 1. Development and management process areas</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>19. 2. Research types</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>18. 3. value-based contributions</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>16. 4. Value dimensions</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>2</td>
<td>27. 5. Peer reviewed</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30. 6. Full text</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>10</td>
<td>51. 7. Others</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>18</td>
<td>20</td>
<td>13</td>
<td>28</td>
<td>30</td>
<td>56</td>
<td>180</td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error a</th>
<th>Approx. T b</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.413</td>
<td>.048</td>
<td>12.614</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>180</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix CC:** Kappa statistics - systematic map pilot selection (agreement)

**Researcher_1 * Researcher_2 Crosstabulation**

<table>
<thead>
<tr>
<th></th>
<th>Researcher_2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
<th>Legends</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Researcher_1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>24. 1. Development and management process areas</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>23. 2. Research types</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>23. 3. value-based contributions</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>22. 4. Value dimensions</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>2</td>
<td>27. 5. Peer reviewed</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30. 6. Full text</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>10</td>
<td>31. 7. Others</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>22</td>
<td>25</td>
<td>21</td>
<td>28</td>
<td>30</td>
<td>32</td>
<td>180</td>
</tr>
</tbody>
</table>

**Symmetric Measures**

<table>
<thead>
<tr>
<th>Measure of Agreement</th>
<th>Value</th>
<th>Asymp. Std. Error</th>
<th>Approx. T</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.720</td>
<td>.037</td>
<td>23.492</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>180</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.
**Appendix DD: Missing value dimensions**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Value dimensions</th>
<th>S. No.</th>
<th>Value dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intrinsic value</td>
<td>18</td>
<td>Human capital value</td>
</tr>
<tr>
<td>2</td>
<td>Producer value</td>
<td>19</td>
<td>Structural capital value</td>
</tr>
<tr>
<td>3</td>
<td>Internal value</td>
<td>20</td>
<td>Customer capital value</td>
</tr>
<tr>
<td>4</td>
<td>Complementary value</td>
<td>21</td>
<td>Innovation value</td>
</tr>
<tr>
<td>5</td>
<td>Network externalities</td>
<td>22</td>
<td>Value of technology</td>
</tr>
<tr>
<td>6</td>
<td>User experience value</td>
<td>23</td>
<td>Production value</td>
</tr>
<tr>
<td>7</td>
<td>Customer lifetime value OR</td>
<td>24</td>
<td>Physical value</td>
</tr>
<tr>
<td>8</td>
<td>Share holder value OR</td>
<td>25</td>
<td>Physical value with respect to time (PVt)</td>
</tr>
<tr>
<td>9</td>
<td>Production value OR</td>
<td>26</td>
<td>Physical value with respect to cost (PVc)</td>
</tr>
<tr>
<td>10</td>
<td>Physical value</td>
<td>27</td>
<td>Physical value with respect to quality (PVq)</td>
</tr>
<tr>
<td>11</td>
<td>Market action value</td>
<td>28</td>
<td>Market action value:</td>
</tr>
<tr>
<td>12</td>
<td>Differentiation value</td>
<td>29</td>
<td>Real earned value</td>
</tr>
<tr>
<td>13</td>
<td>Differentiation value with respect to perceived value</td>
<td>30</td>
<td>Intrinsic marketable value</td>
</tr>
<tr>
<td>14</td>
<td>Differentiation with respect to availability</td>
<td>31</td>
<td>Customer lifetime value</td>
</tr>
<tr>
<td>15</td>
<td>Differentiation with respect to sales and promotion</td>
<td>32</td>
<td>Acquisition value:</td>
</tr>
<tr>
<td>16</td>
<td>Differentiation with respect to cost OR Price</td>
<td>33</td>
<td>Insurable value</td>
</tr>
<tr>
<td>17</td>
<td>Intellectual capital value</td>
<td>34</td>
<td>Collateral value</td>
</tr>
</tbody>
</table>
**Appendix EE: Value dimensions perspectives**

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Frequency</th>
<th>Value considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>90, 119, 131,</td>
<td>Business value 70, 81, 86, 90, 91, 92, 101, 103, 108, 110, 116, 119, 131, 137, 141,</td>
</tr>
<tr>
<td>Project</td>
<td>91, 101, 103, 110, 116, 141,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>70, 92,</td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td>81,</td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Product+organization</td>
<td>137,</td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Frequency</th>
<th>Value considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>89, 117, 133,</td>
<td>Product value 81, 86, 89, 92, 94, 95, 117, 133</td>
</tr>
<tr>
<td>Project</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>81, 94, 95,</td>
<td></td>
</tr>
<tr>
<td>Project+project</td>
<td>81,</td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Product+organization</td>
<td>137,</td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Frequency</th>
<th>Value considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>101</td>
<td>Project value 69, 81, 86, 101</td>
</tr>
<tr>
<td>Product</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Project+project</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>71, 74, 87, 102, 107, 140, 143,</td>
<td>Customer value 71, 74, 78, 86, 87, 97, 102, 105, 107, 140, 143,</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Project</td>
<td>78, 105,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td>86,</td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td>97,</td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>112, 114, 125, 130, 143,</td>
<td>User value 78, 105, 112, 114, 125, 130, 143,</td>
</tr>
<tr>
<td>Project</td>
<td>78, 105,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>71, 82, 107, 113, 127,</td>
<td>Market value 71, 82, 106, 107, 113, 127,</td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>130,</td>
<td>System Value 69, 91, 126, 130</td>
</tr>
<tr>
<td>Project</td>
<td>69, 91, 126,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entity Type</td>
<td>Entity Value</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Product</td>
<td>83,</td>
<td>Stakeholder value 77, 80, 83, 88,</td>
</tr>
<tr>
<td>Project</td>
<td>77, 80, 88,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>76, 89, 115, 118, 128,</td>
<td>Value 76, 79, 85, 89, 99, 100, 111, 115, 118, 120, 121, 122, 128, 134,</td>
</tr>
<tr>
<td>Project</td>
<td>79, 100, 111, 122, 134,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>85,</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>90, 129,</td>
<td>Feature value 90, 91, 129,</td>
</tr>
<tr>
<td>Project</td>
<td>91,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product+organization</td>
<td>Project_product+organization</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Product</td>
<td>82, 107, 138,</td>
<td>Requirements value 82, 107, 132, 138,</td>
</tr>
<tr>
<td>Project</td>
<td>132,</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>73,</td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td>85, 98,</td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td>75, 439, 440,</td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td>75, 439, 440,</td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unable to identify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>84,</td>
<td>Economic value 84</td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product+project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project+organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project_product+organization</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

216
<table>
<thead>
<tr>
<th>Not stated</th>
<th>Unable to identify</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Value of technology 101, 135,</td>
</tr>
<tr>
<td><strong>Project</strong></td>
<td>101, 135</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product+project</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project_product+organization</strong></td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td></td>
</tr>
<tr>
<td><strong>Unable to identify</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project</strong> +product+ organization</td>
<td>Relationship value 86,</td>
</tr>
<tr>
<td>product</td>
<td>139</td>
</tr>
<tr>
<td><strong>Project</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product+project</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project_product+organization</strong></td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td></td>
</tr>
<tr>
<td><strong>Unable to identify</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>Utility value 104</td>
</tr>
<tr>
<td><strong>Project</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Product+organization</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project_product+organization</strong></td>
<td></td>
</tr>
<tr>
<td>Not stated</td>
<td>104</td>
</tr>
<tr>
<td><strong>Unable to identify</strong></td>
<td></td>
</tr>
</tbody>
</table>