Developing framework for quantifying modernization opportunity

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Abstract

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Information technology development and management literature have an abundance of instructions, guidance and management models to guide making decisions on creating new information management systems and managing operations of information systems, but there are fewer practical insights and guidance on how to survive with ageing systems, and how to make decisions on modernising or retiring critical legacy systems.

This thesis project takes a non-exhaustive look at previous and current research on system modernisation and it-management literature and included 14 free-form interviews and 19 structured questionnaire responses to produce a contemporary view of how people in organisations make decisions on system modernisation.

As an outcome, this thesis project presents a simple way to identify and quantify the need to modernise IT systems in organisations. The model builds on top of tools and ideas presented in previous research on identifying legacy systems but proposes a simple quantification mechanism to make legacy systems' inherent risks visible.

The model comprises four distinctive phases: identification of the primary business driver, capabilities that the organisation needs, assessment of the portfolio state and quantification of the change.

The core idea of the portfolio assessment is to focus analysis on two components: costs and risks. Costs include all the costs related to operating the service efficiently, and risks include all the relevant risks that could have a business impact with some probability. Transforming operational, technical or other quality problems into risks forces the organisation to understand that lack of maintenance or quality is a business risk that needs to be accepted or controlled.

To assess modernisation opportunity or alternatives to the current state this thesis proposes quantifying modernisation improvement value in six distinctive categories: how it increases revenue, how it protects existing revenue, how it reduces costs currently accrued, how it avoids future costs not yet accrued, how it decreases previously quantified risk profile and how the change enables achieving some larger strategic goals in the organisation.

Keywords
Modernisation, information technology, decision making, digital transformation, business value, devops

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1 Introduction

We live in an age where the application of information technology and software systems are pervasive in almost every facet of our lives and in all sectors of society. Information technology provides a stable foundation for business execution, but as organizations and business needs evolve, older systems could become a liability and slow the organization down.

If those systems are still otherwise viable, working, and providing value – it can be challenging to make the decision to replace or modernize them. The puzzle of recognizing that moment and enabling organisations to act in a timely manner is the crux of this thesis.

The need for this research is born out of commercial needs witnessed in the information technology services field where consultants have been advising organisations on information systems lifecycle decisions. Even though some organisations have years or even decades of history in managing operations and information systems, many of those organisations struggle in making sense of how and when to modernise their information systems, processes, and ways of working.

The issue has been addressed in multiple fields of study, including information economics, IT governance, IT management, enterprise architecture, information systems research, software development, software architecture literature, and, lately, digital transformation literature. But there still seems to be a gap in if and how those ideas and tools are applied in the professional field.

In this thesis, I focus on the specific problem of quantifying the need to modernize existing systems to enable organizations to make well-timed decisions about system modernisation efforts with a holistic and context-dependent business value in mind. This research takes a non-exhaustive look into the topic through the lenses of multiple research perspectives and defines a sensemaking model organizations could use while deciding on their modernisation efforts.

Therefore, both the intended academic and commercial impact of this work is deeply intertwined: getting good insights from existing research to help practitioners who make future decisions in their field.

The thesis and related research was done inside an IT services company Siili Solutions to serve the current and future business needs of Siili Solutions and its customers in modernisation decision-making.

2 Objectives

This section defines the objectives and research questions for the research.

2.1 Expected outcomes

The objective of this thesis is to produce a practical model to be used in sense-making inside organizations. What are the concepts related to modernization and what decision-makers should consider and focus on while making decisions on modernization efforts? Emphasis is on the word **practical.** Hence exhaustive systematic literature review of the full existing body of knowledge is not needed.

This goal is reached through two distinctive objectives:

1) Research backed sense-making framework to identify the most critical elements to define business need or opportunities for modernisation

2) Way to quantify different perspectives in a single model to make decisions on modernization

These objectives are reached by answering the following research questions.

2.2 Research questions

Q1) Based on literature: how modernization need can be identified

Q2) Based on literature: how modernization need can be quantified

Q3) How are organizations in the marketplace currently identifying and quantifying the need for their modernization efforts

Q4) Based on literature and market research findings, how should modernization need be quantified to help decision making

2.3 Scope

Q1 and Q2 are answered with a literature search. Within the literature search, I'll try to define key concepts relevant to the thesis questions and define the dynamic between concepts.

Q3 is answered via interviews and a questionnaire sent to people who have participated in modernization efforts or have been responsible for making decisions on modernization project initiations.

Q4 is answered by providing a synthesis of good practices described in existing literature and responses collected in this research.

This work is scoped to be practical in modernization or transformation projects inside medium-sized enterprises and, to some extent, even large enterprises. This work primarily excludes large top-down transformation efforts led by enterprise top management, as such ventures can play with different rules and face other change management challenges.

This scoping allows the work to stay practical and focused on how practitioners inside organizations can apply it in the marketplace. And practitioner is defined in this study as IT or business-focused workers or managers responsible for making or influencing IT system decisions. This often excludes executives who are already further away from analysing and making decisions between options.

3 Methodology

As the research goal is to produce practical tools and approaches to be used inside a consulting company, it was seen appropriate to do the research as an action research process, where the author, as a researcher, is also interacting intensively with the organisation and adjusting the research-process based on continuous new learnings done in the process.

During the research, the author was employed by Siili Solutions as a consultant, participating in active modernisation cases. This provided a highly informative and dynamic context in which the author was interacting in project work with other experts and was able to observe and learn different perspectives as they were applied.

The research project was started inside the company alongside ongoing project work to provide context for the research and for larger sense-making around topics and themes that relate to modernisation decision-making. Experts and stakeholders were invited to participate in the research context and to contribute their insights and reflections.

Project work and research work were kept separate. Developed models were not tested in ongoing projects, and people were not included in research activities without their explicit understanding and approval that they are contributing to research. As the research time cycle is short compared to enterprise modernisation projects and decision-making, it is also natural and practical that the research is not yet put into action in actual customer projects but rather in how experts think, understand, and make sense of modernisation decision making.

3.1 Research process

The research process was planned to have a flexible amount of research cycles that could be implemented alongside ongoing work in three different phases: literary research, data collection and analysis. In each of these phases, work would be done in multiple iterative cycles.

Research would start with a literary search. The literary review would continue throughout the whole study process if new materials and viewpoints would emerge based on insights gained in the process. Materials would be actively debated and reflected against other industry insights and practices inside the modernization team in Siili Solutions.

Based on the initial understanding gained in literary research, data collection from the marketplace was planned to be done mainly through interviews. Interviews were selected as the tool to provide the opportunity for the researcher to gain deeper and honest insights from people who participate in these decisions and to be able to potentially identify themes and ideas that have not come

across in the literary review. Interviews were thought to also provide better initial insights into what people prioritize in decision-making through frank conversation rather than through questionnaires where questions and available options can accidentally create biases in responses. If needed, additional data would be collected with a structured questionnaire.

The analysis phase was then planned to be the last step, where data and insights collected from different sources are merged to answer the presented research questions. And to finalise the research report.

Though phases can be planned and presented here as separate, they were, from the start, thought to be interlinked. Researched and reviewed literature was analysed, and potential models were already created during the early phases of the research to also make better sense of the material. Similarly, interviews and insights gained from there caused the need to re-review some materials and reassess previous thoughts.

3.2 Research plan

The thesis topic was selected in December 2021, and an initial literature review of the research topic was started to help to form a deeper understanding of the subject matter and to clarify the research questions. The research plan, as presented in February 2022, was as follows:

February: Literature review and construction of the theoretical model for the research.
March: Interviews. Creation of the survey for data collection and revisions to the model.
April: Data collection and analysis of survey results. Revision to the model.
May: Thesis finished.

This plan was then constantly iterated and adjusted as the work progressed.

The literature review structure and results, as well as how the research was done, are described in the next chapters.

4 Literary review

This section defines the theoretical framework used and how literature research has guided the investigation into the proposed model.

As proposed in the introduction, I postulate that there is a gap in management practice in identifying and quantifying modernization needs. Even though there already is a cornucopia of frameworks, models, and research in different fields of study on the subject - there is less widely accepted and applied practical information and guidance on how actually to make such quantifications.

Advances in the practice are not often documented in academic publications or research until later. Hence current best practices and ideas can be documented better in trade publications, books, conference presentations, and models created by industry leaders. Similarly, based on anecdotal evidence, practitioners mostly follow trade publications, books, and information – compared to academic research on subjects.

For the research, this is a major scoping challenge as the aim is to get a holistic view from multiple fields of study in the scope of a single study. And any inclusion and exclusion of resources can open the research to other criticism.

The fundamental meta-model for the research is the model about making a decision. Though decision-making theories and psychology provide alternative views to decision-making, this thesis takes the perspective of rational analysis that IT investment options can be analysed with respect to their value, cost, and risks (Parker et al., 1988: 5).

As decision-making happens inside a larger organization, this problem needs to be examined from different perspectives. This research takes a non-exhaustive look into the literature in various domains that can reflect decision-making and influence those making or influencing modernization decisions inside organizations. Figure 1 depicts a conceptual model of relevant themes present in this study to answer the questions before literature research is done.

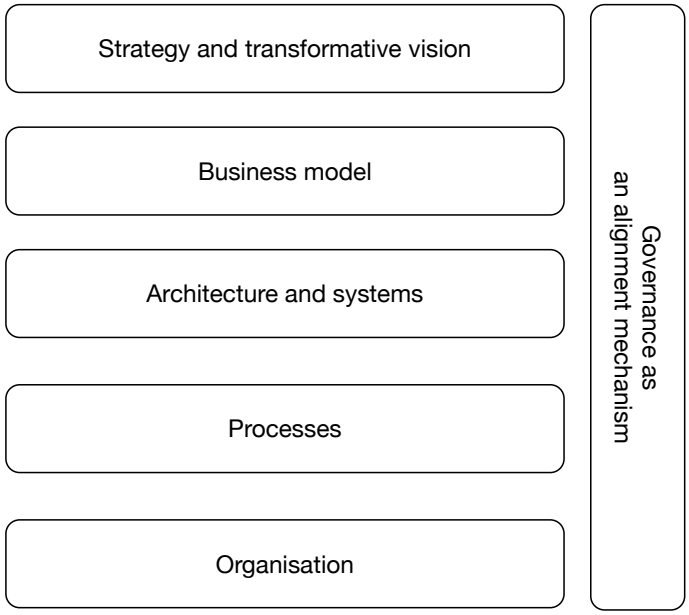


Figure 1: Mental model of organizational themes of this study

Above in the diagram is the organizational strategy and vision that, to some extent, guides behaviour and actions inside the organization. The business model defines how the organization produces and captures value from its interactions in the marketplace. Architecture and systems cover all the relevant structures and systems that support running the operations of said business model. Processes and ways of working are how the actual organization then makes those visionary promises real. Alongside feedback loops and governance mechanisms provide alignment throughout the organization.

The author recognizes that there are other relevant fields of study that provide poignant and exciting perspectives to the discussion. These fields of study were selected as they were already well-established and documented in the literature, and the author was aware of their existence.

Transformation literature - and specifically literature about digital transformation - will be studied to understand how the understanding of digital capabilities can change strategic choices that the organization takes and their impact on to need to renew and modernize systems and processes.

Enterprise architecture literature is studied to understand how enterprise architecture provides guidance, structure, and alignment to decision-making and if existing frameworks provide any help in the identification and quantification of the need to change.

Software development literature will be studied regarding system evolution and modernization decision-making.

In IT-service management literature focus will be on identifying how service management processes provide signals, data, and insights to modernization initiatives.

IT-governance literature will be studied about how governance processes and practices can affect modernization decisions and understanding.

This initial perception of the multidisciplinary nature of the problem dictates that the literature review will be more about breadth than depth in all the selected domains. The hypothesis is that the value of this thesis will be generated by providing a novel synthesis over these separate fields of study.

4.1 How the literary review was conducted

The literature review was conducted by starting with a preselected list of well-known books or articles in each domain and then adding materials with additional forward and backward searches from databases based on authors, references, and themes picked up from the selected start material. The review aims to summarise and synthesize what is written about each topic in three steps: literature gathering and screening, processing, and finally producing the output (Levy and Ellis, 2006).

Because of the broad scope of the work, most of the papers screened were excluded from further analysis. Many papers on the topic went deeper into domain specifics and did not seem to contradict the high-level understanding or concepts presented in other materials. It is possible that further study into the details of each domain could show additional nuances that could change the results of the research and interpretation of the state of thinking and practices. But within the scope and timeframe of this work, it is not possible to go both wide and deep.

The literature review started from the domain of software and systems development domain, as it has the largest body of knowledge related to the actual modernisation of information technology systems and processes. Computer science and systems management literature is the foundational field for thinking about system lifecycle management and understanding costs and risks related to the technology lifecycle.

The second domain for the study was transformation literature, focusing on digital transformation and the usage of digital capabilities. This body of knowledge provides guidance and thinking on how emerging and new digital capabilities change how organisations could and should approach their visions about their raison d'être.

The third domain for the study was enterprise architecture, which is its distinctive field of study that has clear links to organizations' business strategies and the field of information technology governance. Enterprise architecture relates to how information technology and capabilities can be used to achieve business goals - and lead the development of such capabilities holistically.

The fourth domain for the study was IT governance. The focus was on decision-making structures and decision-making to drive business benefits from the usage of information technology inside organizations.

The fifth domain was IT service development and management literature, which complements other domains by taking the business service perspective and service lifecycle management perspectives to the acquired and operated capabilities.

Literature review materials and search terms used are described in Appendix 1 and Appendix 2.

4.2 Literary review overview

A surprising discovery during the literature review was that there was very little written and guidance given on how and when to make decisions on modernizing or replacing working and value-producing information systems. Though management models and frameworks reference and reflect that system lifecycle management includes system retirement once the service or system no longer fulfils defined key performance indicators – there is less practical consideration and guidance on that.

And the problem is not new. Bennett (1995) wrote almost three decades ago about the challenges of managing software evolution as legacy systems continue to do valuable work, but management does not take action on them.

During the multidisciplinary literary review, six themes were identified:

1. how information technology is seen to produce value
2. how information technology is managed for value
3. understanding of the evolution of software systems
4. digital transformation as a cross-cutting concern to modernize organisations
5. software delivery capability as an enabler
6. business agility as the goal for modern companies

These themes provide the theoretical backdrop for understanding how to make decisions about system modernizations.

4.2.1 Value of IT

Information technology can be valuable to the business. Researchers and practitioners agree that technology provides value, though there are different conceptualizations of what the value is and how value is provided. Differences also exist inside organizations in how members of the organization perceive and make sense of how IT produces value.

Senior executives may not be able to cite specific effects for individual applications but, at a process level, they may be able to give general insights into whether IT has allowed their firm to improve sales by customizing products and services or whether IT has allowed the firm to lower costs through greater quality control (Tallon, Kraemer 2007).

Bayer (2021) conceptualized in his dissertation that IT creates value through three inherent capabilities: transactional, exchange, and codification capabilities – and that those capabilities can be regarded as moderators of the relationship between IT and competitive advantage.

> Transactional: The ability to automate existing business processes and process, interpret, and synthesize information.
>
> Exchange: The ability to exchange information within and across firms, enabling fragmented entities to connect, communicate, and collaborate seamlessly.
>
> Codification: The ability to capture and integrate information by making it easy to collect, organize, store, and access across the organization

These three capabilities then contribute to the factors of competitive advantage: efficiency, quality, innovation, and customer responsiveness.

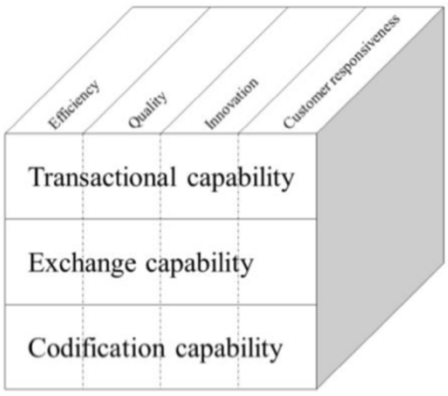


Figure 2: Information technology value creation cube (Bayer,2021)

On a more concrete level, Seufert et. al (2021) summarises research literature to have the following well-established components in the definitions:

- IT business value can be defined as the impact of IT on organizational performance
- impact can be at the intermediate process level and the organization-wide level
- comprising both efficiency impacts and competitive impacts
- efficiency refers to internal impacts such as productivity enhancement, product quality, profitability improvements, or cost reduction
- competitive refers to external impacts such as competitive advantage or market expansion

Seufert et al. (2021) constructed from the existing IT impact and value catalogues a meta-IT Value framework that aggregates and combines over 600 different IT impacts into a hierarchical structure in the following clusters: LOG (logistics), OPS (operations improvements), M&S (marketing and sales), SER (service), proc (procurement), COA (cross-organisational activities), TD (technology development), HR (human relationship impacts). These clusters are listed in table 1.

ID	Aggregated values	Examples of impacts
COA1	Operational time and cost savings at firm-level	Labor cost reduction, Cost reductions, Productivity Improvements, Overall operation efficiency and effectiveness, Speed up transactions or shorten product cycles, Reduced planning times, Enabling faster access to information
COA2	Immediate improvements in management process	Improving information accuracy, Availability of new, better or more information providing opportunity to compete more effectively, New Reports/Reporting Capability, Improved ability to coordinate and integrate, Increase the flexibility of information requests, Better asset management
COA3	Development of new business fields	Business growth with increased employees, new policies and procedures, Improved capture of design and construction decisions, Development of new business fields, Better research/development planning
COA4	Improved market positioning of the company	Enable new market strategy, Help establish useful linkages with other organizations, Improved strategy formulation and planning, Strategic competitive advantage
COA5	Improved corporate growth (and reporting)	Business growth in transaction volume, processing capacity and capability, Reporting, Business growth in new markets
COA6	Increased flexibility to adapt to future changes	Global resource management, Expandable to a range of applications, Improved organizational culture, Improved change management , Increased business flexibility, Reduced technology risks
COA7	Growth management	Build cost leadership, Increased market share, Leverage Size, Revenue increases through product differentiation
COA8	Creating/defending competitive advantages	Enable the organization to catch up with competitors, Improved relations with external parties that are neither customers, competitors nor suppliers, Negating existing entry barriers, Creating new entry barriers

COA9	Improved integration and information flow	Improved communication, Make use of extensive user feedback, Fewer information bottlenecks, Enabling easier access to information, Smoother work flow, Business integration, Information processing efficiency
COA10	Improved employee satisfaction and performance	Greater employee involvement in business management, Increased employee satisfaction with better decision making tools, Satisfied employees for better employee service, Creativity
COA11	IT-Investment costs	Acquisition and implementation costs, Personnel costs for training and instruction, indirect investment costs
COA12	Time savings in daily business operations	Labour time saving, Fewer phone calls, Fewer letters
HR1	Staff reductions	Save money by avoiding the need to increase the work force, enhances effectiveness in the job, Reduced staff requirement, Personnel Reduction
HR2	Improving employee skills	Shorten learning time, Improved learning and/or increased knowledge of persons in the organization, learning through the presence of IS, Enabling of cross-functional teams
LOG1	Reduced inventory and better inventory management	Inventory Reduction, Higher turnover inventory, Increasing the speed of distribution, Improved delivery scheduling
LOG2	Improved inventory control	Better inventory management, More precise production planning, control and monitoring, Improved operational decisions
M&S1	Improved Marketing & Sales capabilities	Multi-currency capability, Improving external access to stock levels and price information, Ability to provide instant price quotations to clients
M&S2	Improved customer retention	Improve customer relations, Customer loyalty
M&S3	Increased Sales	Provide new products or services to customers, Increased Sales, Customer Responsiveness
M&S4	Time savings in Marketing & Sales and product delivery	Sales Automation, Faster invoicing, Easily find the best offer, Faster and more secure checkout processing
M&S5	Leveraging marketing and sales capabilities as competitive advantages	Improved company image, Easier decision making for buyers due to improved evaluation of sources of materials, Better marketing information, More detailed market analyses
M&S6	Improved sales management	More precise sales planning, control and monitoring, More precise assortment analysis, Faster and more costeffective information on the success of marketing measures
OPS1	Improved production processes	Reduced construction time, Manufacturing performance, improved outcomes or outputs, Reducing operating costs, Throughput
OPS2	Improved product and production quality	Quality improvement, Higher degree of standardization of operations, Contribute to high quality
PROC1	More efficient procurement of materials	Improved supplier relations, Procurement Cost Reduction, Faster response to supplier quotations, Cost reduction in the area of raw materials
PROC2	Strengthening the company's position towards suppliers	Better supplier selection, Strengthening negotiating power with suppliers

SER1	Improved quality and delivery of customer services	Faster delivery of services, Improved delivery of products/services, Improved quality of products/services, Better customer service, Providing customized product or services, Improved focus on client requirements, Better service to customers, Establish 24 × 7 customer service, Contribute to superior customer service
TD1	Improved IT- Infrastructure support	Save money by reducing system modification or enhancement costs, Mainframe or hardware replacing, Provide the ability to perform maintenance faster, Integration of new functions, Increasing system stability
TD2	Improved R&D and Life Cycles	Continuous improvement in system process and technology, Allow other applications to be developed faster, Speeded up by product life cycle by shortening the development process, Making new businesses technologically feasible

Table 1: Meta IT-value catalogue (Seufert et al., 2021)

Intel's Global IT innovation director Martin Curley (2008) defined in his dissertation value impacts on business value as revenue (growth), costs (efficiency), assets (productivity), risks (continuity), and expectations (P/E multiple). Shareholder value is primarily increased through growing revenue, improving operating margin (achieved through improved efficiencies), improving asset efficiency, managing risk, and improving expectations which can be a key driver of total shareholder value as manifested by the P/E ratio for publicly quoted companies. Total shareholder return is a function of 3 key factors: profit growth, free cash generation, and multiple expansion is a good overall measure of value generated. Investments in IT and IT capability should ultimately be targeted to influence at least one of the three key measures. (Curley, 2008)

The information technology capability management framework defines value as: "the contribution that IT-based resources and capabilities make to helping an organization achieve its objectives. Those objectives may be internal or external to the IT function" (Kennealy et al., 2017)

And practitioners Schwartz and Kim (2016) postulated in the aptly named book "The Art of Business Value" that business value is a hypothesis held by the organization's leadership as to what will best accomplish the organization's ultimate goals or desired outcomes.

As IT has become indispensable to every business of any size, the inevitable result has been the increasing importance of showing value (Hunter, Westerman 2009). Multiple authors, like Harris, Herron, and Iwanicki (2008), have argued for rigorous measurement of IT performance and communication of value created. Gartner analysts (Naegle, R. Ganly, C., 2020) also stated that measuring and communicating the business value enabled by IT represents a unique and often uncomfortable challenge for many CIOs and suggest nine rules demonstrating and communicating business value.

1. Value is always determined by the consumer, not the producer/provider.

2. Value is measured by business outcomes and impact to the mission or consumer.
3. For value to be measured, a transaction is required.
4. The language of value must be that of the consumer (outcome/product) not the producer (parts/process).
5. Cash savings is generally better than efficiency gains.
6. Prioritization of projects and IT spend must be a function of relative value to the organization.
7. Value reporting or communication needs to be easily and quickly understood.
8. If the people with the money do not understand the value, they will never become advocates of IT, and may not approve funding (even when there is user value).
9. All IT funding requirements must be grouped into one of two categories: operate or change.

For modernization decisions and considerations, this notion of how value is defined, communicated, and understood is at the core.

4.2.2 Managing IT for value

Fundamentally, most information technology management practices and concepts exist to drive organizational value from IT investments and the usage of IT assets. As an industry, we have evolved and developed practices and processes to manage the growing complexities of information technology usage and link IT management to the larger management and governance models inside organizations.

4.2.2.1 IT-Governance

IT governance can be defined as specifying the decision rights and accountability framework to encourage desirable behaviour in the use of IT (Weill, Ross 2004). Or, as in IT Portfolio Management (Maizlish, 2005), IT governance is presented as: "the system by which an organization's IT portfolio is directed and controlled. IT Governance describes (a) the distribution of IT decision-making rights and responsibilities among different shareholders in the organization, and (b) the rules and procedures for making and monitoring decisions on strategic IT concerns".

In their research, Weill and Ross (2004) showed that top-performing enterprises that had good governance practices generated returns on their IT investments up to 40 per cent greater than their competitors. Good IT governance mechanism has been seen to impact IT-enabled dynamic capabilities positively, that positively impacts agility and innovative capability, in turn, supports the firm to achieve firm performance (Ilmudeen, 2021).

Joshi et al. (2022) noted that mature IT governance impact on company performance is not direct but mediated by good IT performance. Good governance processes and practices are an enabler, but IT and business executives need to establish the IT processes to deliver consistent IT value and services to achieve customer and financial IT goals – and implementation of IT metrics to measure and monitor IT investments is key to avoiding IT failures and ensuring IT resource investments contribute to business needs (Joshi et al., 2022).

In his dissertation, Hiekkanen (2016) highlighted that IT governance contributes to tactical and operational alignment by advocating formal processes and mature practices, but to have an impact on the strategic level, it requires top management to understand the strategic value of IT. To successfully avoid the “alignment trap” (Shpilberg et al., 2007), top leadership should understand how technology impacts the business.

4.2.2.2 Enterprise architecture

Ross et al. (2006) connect top management strategic thinking, operating model, and enterprise architecture to define the foundation for execution. In short, a foundation for execution is the IT infrastructure and digitized business processes automating a company’s core capabilities. The key to effective enterprise architecture is to identify the processes, data, technologies, and customer interfaces that take the operating model from vision to reality. (Ross et al. 2006)

Creating and exploiting the foundation for execution

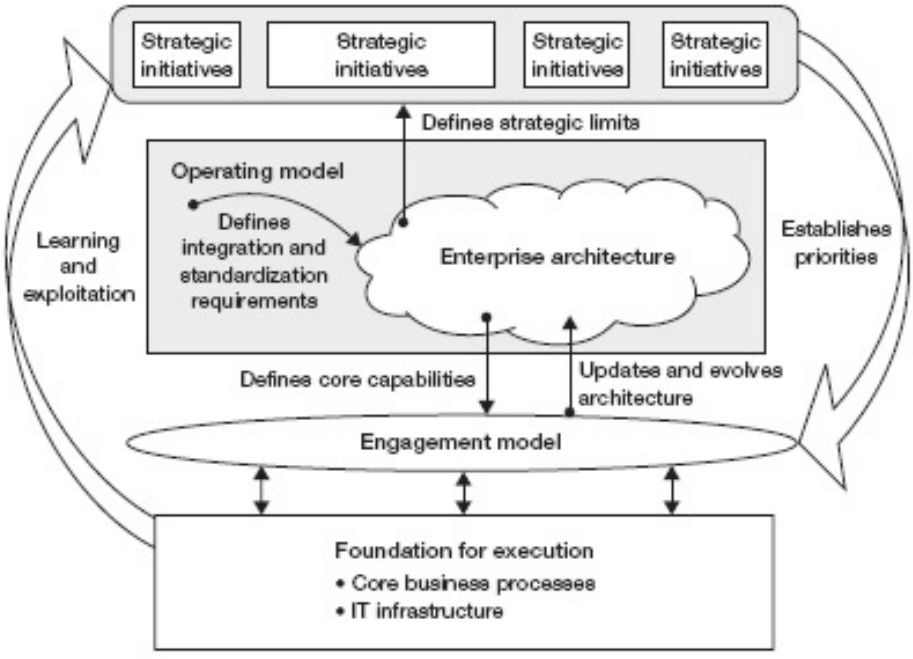


Figure 3: Enterprise architecture as the foundation for execution (Ross et al. 2006)

Bente et al. (2012) define enterprise architecture as the representation of the structure and behaviour of an enterprise's IT landscape in relation to its business environment. It reflects the current and future use of IT in the enterprise and provides a roadmap to reach a future state.

Niemi (2016) synthesizes based on previous research that, in practice, EA is an approach to support organizational transformation by translating organizations' strategies and operating models into concrete development initiatives and aligning organizations' resources for the enactment of the strategies as postulated previously, among others Ross et al. (2006) and Tamm et al. (2011). And rather than focusing on only a subset of organizations' resources, Enterprise architecture provides a holistic view of all of the capabilities and resources of the organization, including business processes, systems, information, and technology (Kaisler et al., 2005).

In organizations, EA can be conceptualized as an architecture product or artefact that provides an abstract representation of the organization and a plan guiding its implementation, accompanied with services to support their realization and with creation, maintenance, and governance of EA through EA processes (Niemi, 2016).

But the research evidence on the positive impacts of enterprise architecture is scarce. Many studies have focused on hypothetical or potential benefits of EA, not on concretized benefits (Niemi, Pekkola 2019). In his dissertation, van den Berg (2019) found three case examples where EA contribution was perceived as valuable. Successful support of IT decision-making depends on how the role of EA is tailored to the specific IT decision-making context (van den Berg, 2019). Similarly, Pekkola's and Niemi's (2019) research indicates that EA benefits stem from solid EA processes, as well as from the appropriate use of EA products and services and that social and cultural factors also play an important role in the process.

Inside industry and vendor reports enterprise architecture practice and tools users do report gaining benefits from EA, see figure 4.

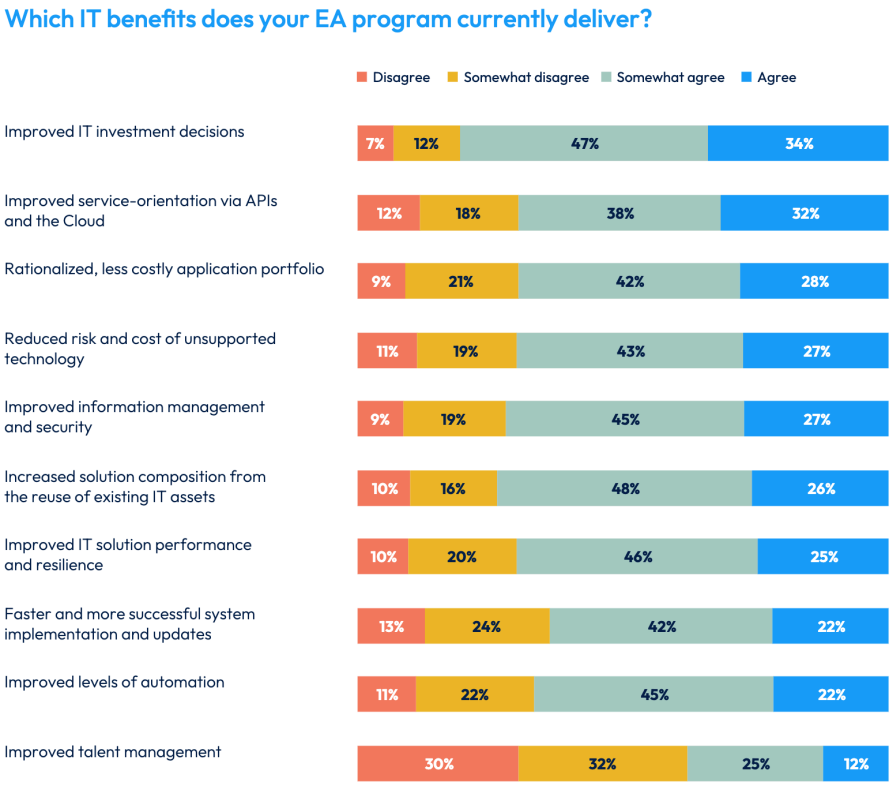


Figure 4: Reported benefits of enterprise architecture program (BiZZdesign 2022)

Though not explicitly using the terms enterprise architecture, Murer and Bonati (2014) describe the Credit Suisse banking platform's strategic evolution and management with managed evolution model, which aligns business and IT and combines the continuous delivery of new business value with the continuous improvement of agility.

According to Murer and Bonati (2014) managed evolution is essentially about steering a portfolio of modifications for the very large system in a coordinated way:

> "Portfolio management have a massive influence on how budgets are allocated and finally lead to a new business-IT alignment, both on the strategic and on the operational level. A decisive part of this business-IT alignment is the alignment of business and IT strategy. During each information technology strategy cycle all applications in the application portfolio and all infrastructure technologies in the technology portfolio are reviewed and assessed for architectural health and appropriate business functionality, domain by domain. This result is then compared with expectations about future business requirements ("Fit-for-Future") as derived from the business strategy. The results of the evolution of the very large information system must be measured and tracked. Deviations of the desired evolution strategy must be identified and corrected. " (Murer, Bonati 2014)

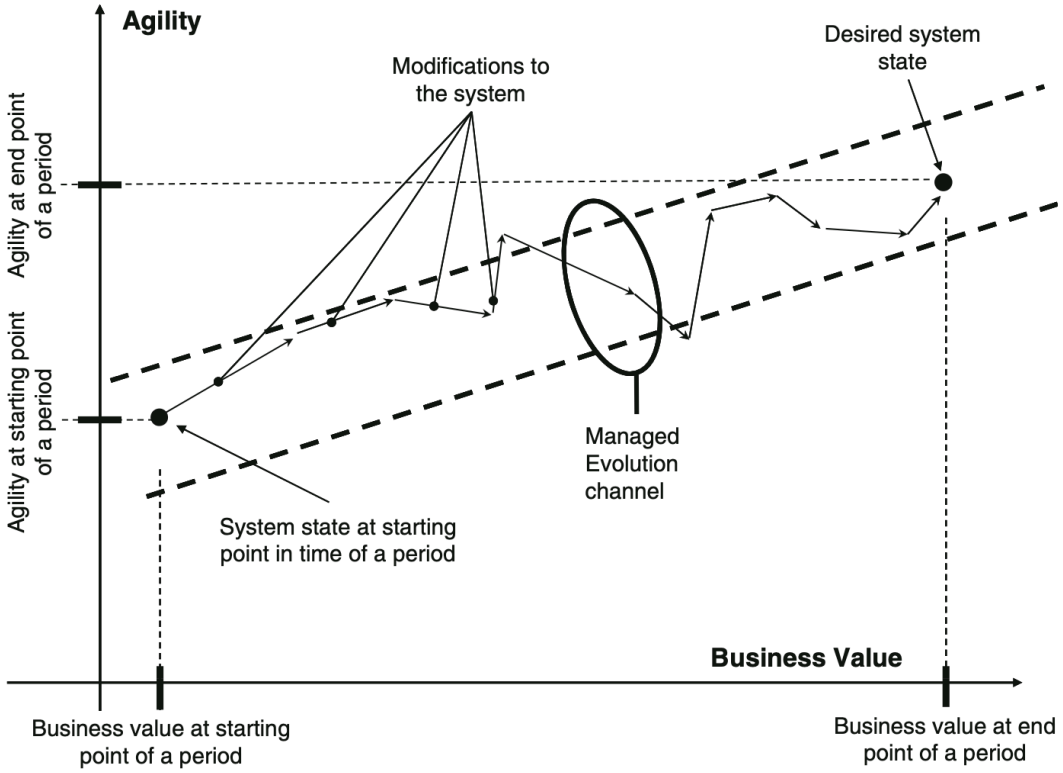


Figure 5: Managed evolution (Murer, Bonati 2014)

As Murer and Bonati (2014) describe the evolution of a ‘very large information system’, they are essentially describing the evolution of a whole operational IT platform of a bank that employs over 40 thousand employees in multiple continents. But as the business is connected, so is the platform too - and the whole platform can be inspected as a single large system.

This system of system perspective is present also in other literature and research. For example Poutanen and Pulkkinen (2021) express it in their case study where they observe new agile capability development in two organisations with existing enterprise architecture management practices. This is in similar vein as Abraham et al. (2013) have stated Enterprise Architecture and EA management relate to the systems nature of enterprises and enterprises as “hierarchical, multilevel systems.

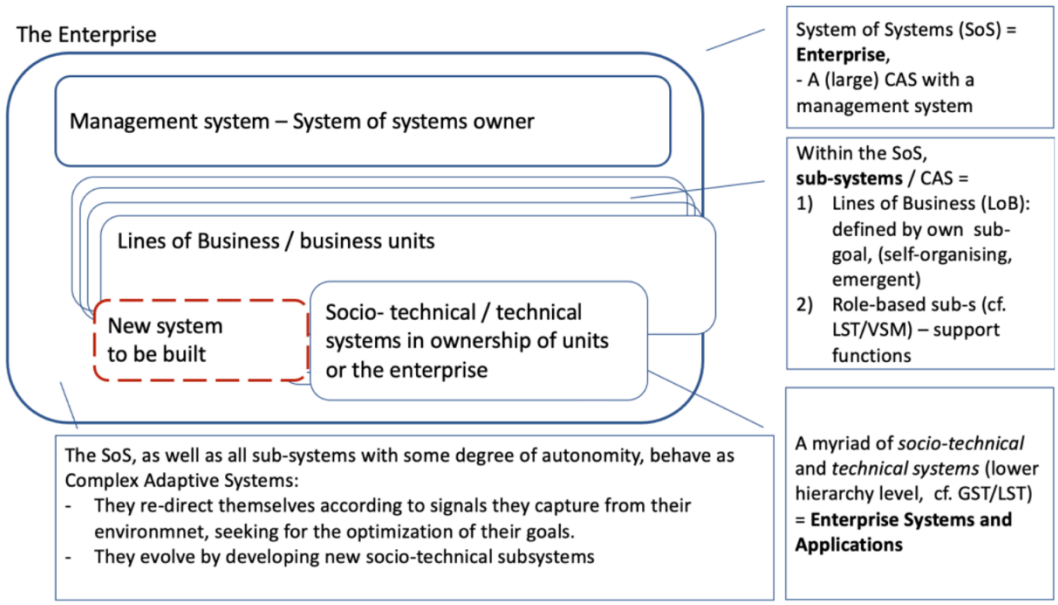


Figure 6: Enterprise as a system of systems view (Poutanen, Pulkkinen 2021)

4.2.2.3 Managing IT service portfolios

IT-Governance or enterprise architecture models and practices do not influence how services are operated or managed, and separate practices and fields of studies have evolved to provide guidance and good practices on how to tackle increases in IT systems complexity and manage reliable and effective service delivery. In the IT service management literature review, Serrano et al. (2021) identified the following 13 key benefits described to be achieved with ITSM-practices:

1. Better processes control/documentation
2. Tangible improvements in process metrics (i.e., incident resolution times, change implementation time, predictable failures)
3. IT service quality improvement
4. Increase of customer satisfaction
5. Decrease in IT expenses
6. Higher efficiency/performance
7. Better IS-business alignment
8. Efficiency in the internal communication process/information sharing efficiency
9. Increase of organizational competitiveness
10. Mature processes
11. Increase of organization revenue
12. Better employee satisfaction

13. Reduction in staff

These benefits are interlinked to each other by the logic expressed in picture 7. In the picture arrow points to the effect that follows from achieving the other benefit, for example better process control and documentation leads to efficiency in internal communication.

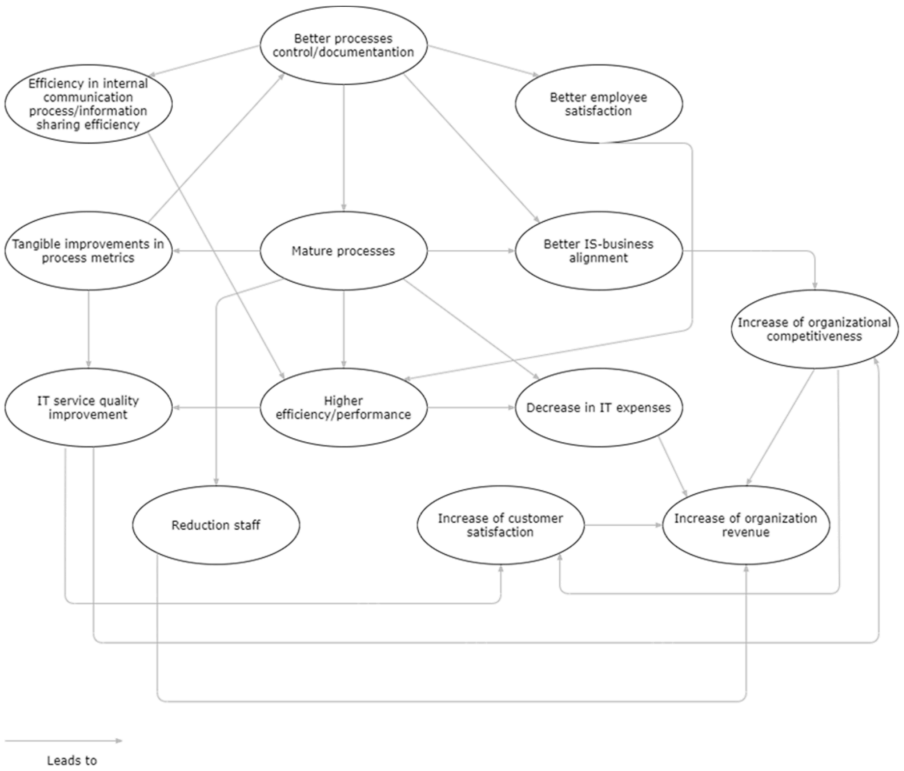


Figure 7: ITSM benefits conceptual model (Serrano et al., 2021)

Information and technology are becoming more thoroughly integrated with other organizational capabilities, silos are breaking down, and cross-functional teams are being utilized more widely. Service management is changing to address and support this organizational shift and ensure opportunities from new technologies and new ways of working are maximized (Axelos,2019).

Multiple different frameworks and models exist in the marketplace, and organisations also implement sufficient service management systems even without the help of frameworks or without following religiously defined roles and practices.

Typically, frameworks have some holistic model for understanding and managing the big picture, and then from those high-level principles and ideas derive a set of processes or practices that link together to provide a complete system with clearly defined roles, responsibilities and interfaces between different roles. Here we will briefly take a look at four different models: ITIL, IT Capability management framework, Business Technology Standard and Scaled Agile Framework.

ITIL has led the ITSM industry with guidance, training, and certification programmes for more than 30 years. ITIL 4 brings ITIL up to date by re-shaping much of the established ITSM practices in the wider context of customer experience, value streams, and digital transformation, as well as embracing new ways of working, such as Lean, Agile, and DevOps. (Axelos,2019).

ITIL 4 service value system builds around 5 core components: the value chain, common practices, guiding principles, governance, and continuous improvement model – as seen in figure 8.

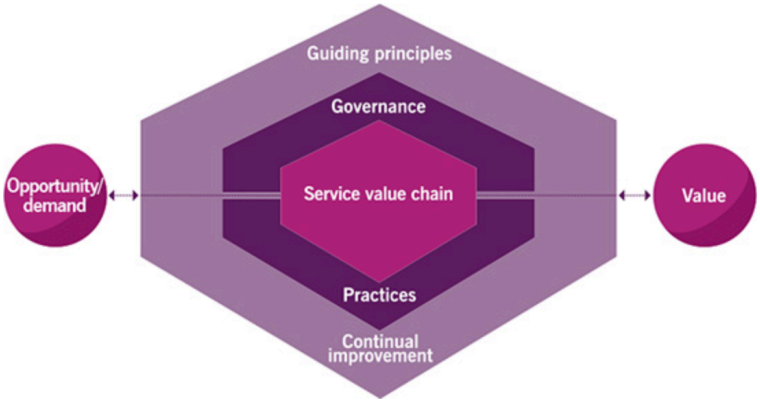


Figure 8: ITIL 4 service value system (Axelos,2019)

ITIL service value chain includes 6 core activities that define the whole lifecycle of the service. The six value chain activities are: plan, improve, engage, design and transition, obtain/build and deliver and support.

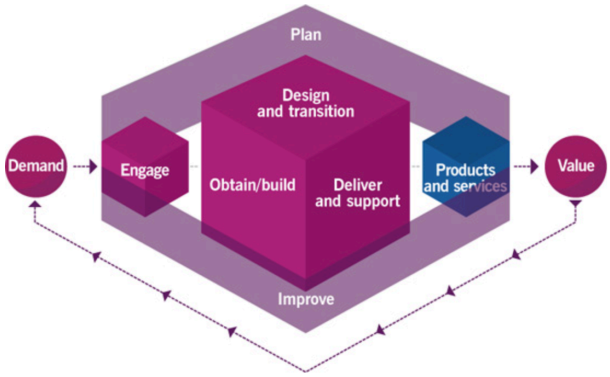


Figure 9: the six ITIL value chain activities (Axelos,2019)

These activities represent the steps an organization takes in the creation of value. Each activity transforms inputs into outputs. These inputs can be demanded from outside the value chain or outputs of other activities. All the activities are interconnected, with each activity receiving and providing triggers for further action. (Axelos,2019)

IT capability management framework is a less known holistic IT value management framework that is governed by Innovation Value Institute at Maynooth University in Ireland. The framework was initially developed inside Intel corporation and eventually shared with the world. Framework's creator also wrote his PhD dissertation about the subject (Curley, 2008).

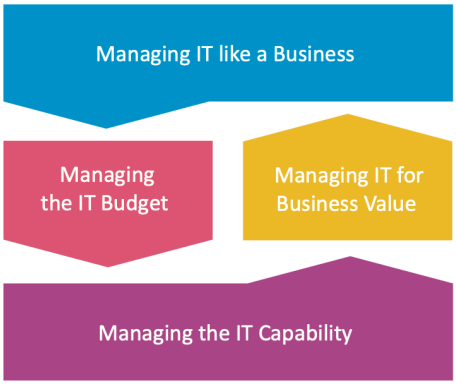


Figure 10: IT capability maturity framework macro-capabilities (Kennealy et al., 2017)

IT-CMF defines 4 core macro capabilities that include 36 core capabilities that the organisation should manage. The other side of the model is a CMMI inspired maturity model, that reflects different levels in evolution of organisational capability to manage It for business value.

Figure 11: Major strategies of IT capability maturity framework's macro-capabilities (Kennealy et al., 2017)

Business Technology standard is an open-source management framework to plan, build and run information technology. The framework includes a comprehensive capability model of enterprise

capabilities that the organisation should have for organising and coordinating technology management across the entire enterprise.

Figure 12: Business technology standard capability model (Business Technology Forum, 2021)

Besides defining capabilities, the framework defines also an operating model and organisational roles with specific responsibilities. The model provides novel separation for different types of technologies used in the enterprises by separating customer-facing digital frontline technologies and internal technology backbone from each other as the value drivers and measurements are different.

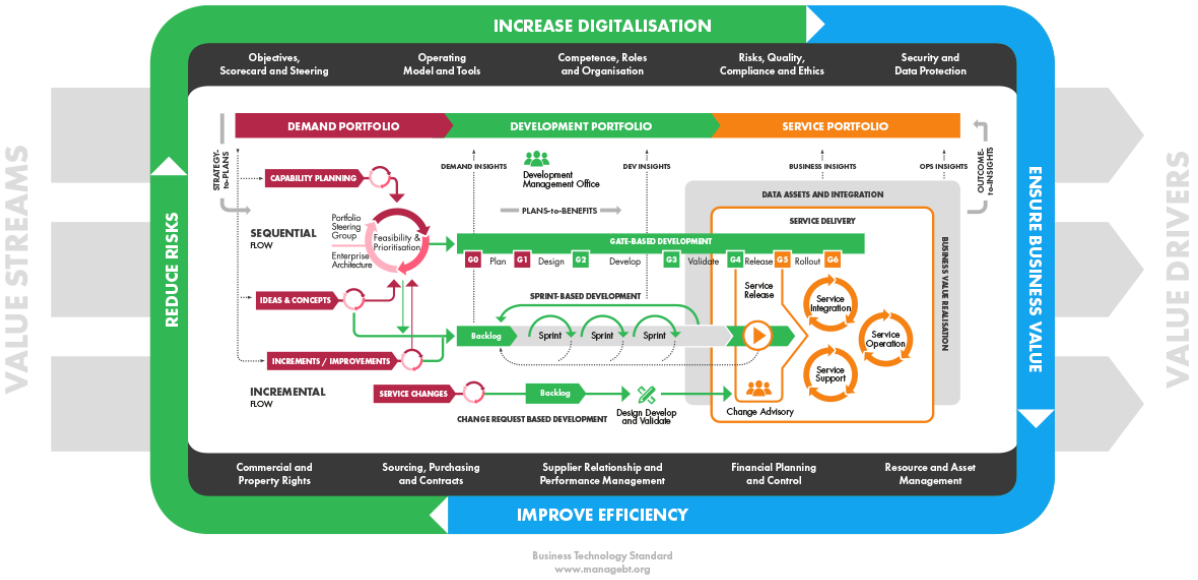


Figure 13: Business technology standard operating model (Business Technology Forum, 2021)

The Scaled Agile Framework is a massive development framework mostly known as a model for managing large-scale agile development in large enterprises. But besides being an agile development framework, the model is also a lean management framework to manage operational value streams.

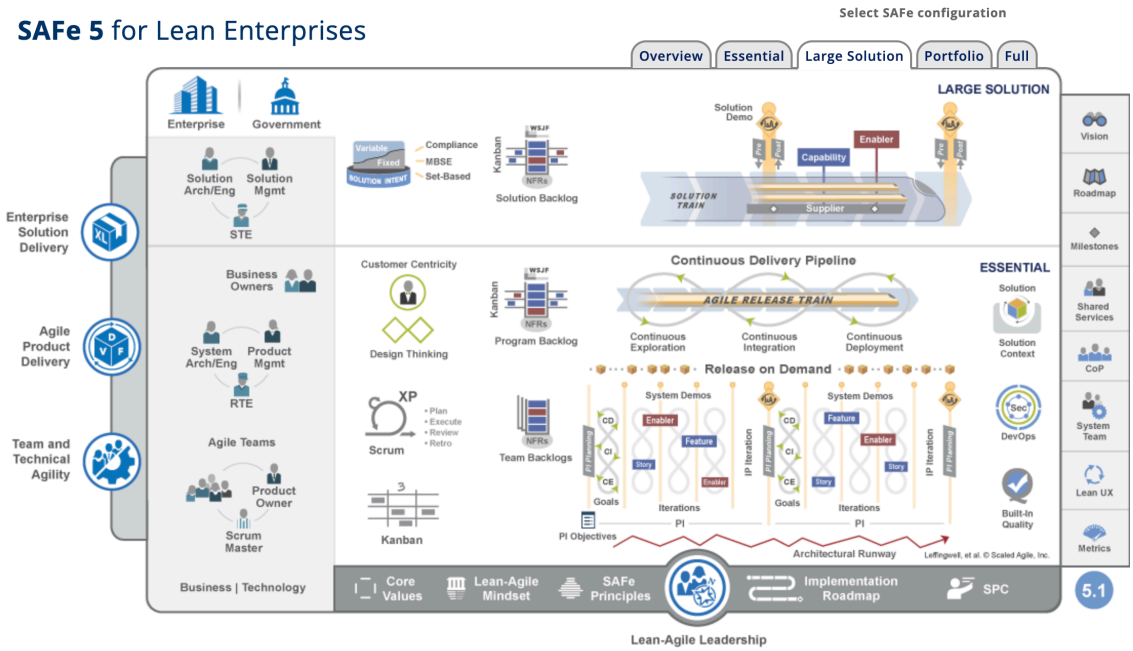


Figure 14: Scaled agile framework large solution overview (Scaled Agile Inc., 2021)

In the Scaled Agile framework terminology development value streams are value streams that produce new solutions and solution increments for the enterprise to be used in the operational value streams that produce measurable value to the end user.

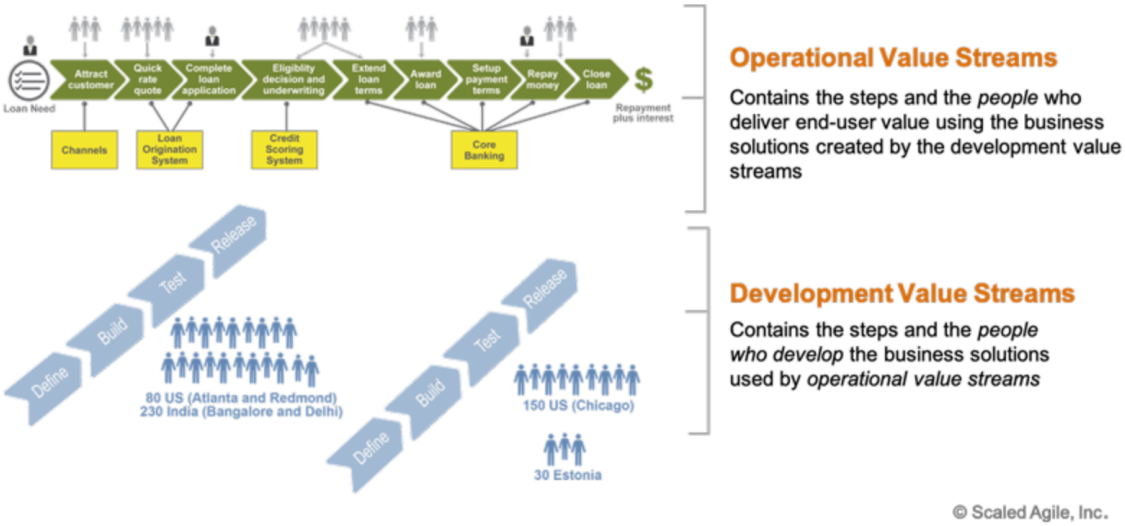


Figure 15: Operational and development value stream explained (Scaled Agile Inc., 2021)

These four frameworks and models have large differences in how they guide the adoption and what specific processes they suggest organisations have, but for the purposes of this thesis, they share a similar philosophical foundation of understanding and managing for the flow of value. A common theme in these four frameworks is that the following things need to happen in a controlled way: the business identifies the value that it wants to get from a service, business metrics are agreed upon to monitor value realisation and performance, and the lifecycle of the service is managed all the way to the retirement of the service. This theme is poignantly captured in Business technology standard's business value realisation capability (see figure 16).

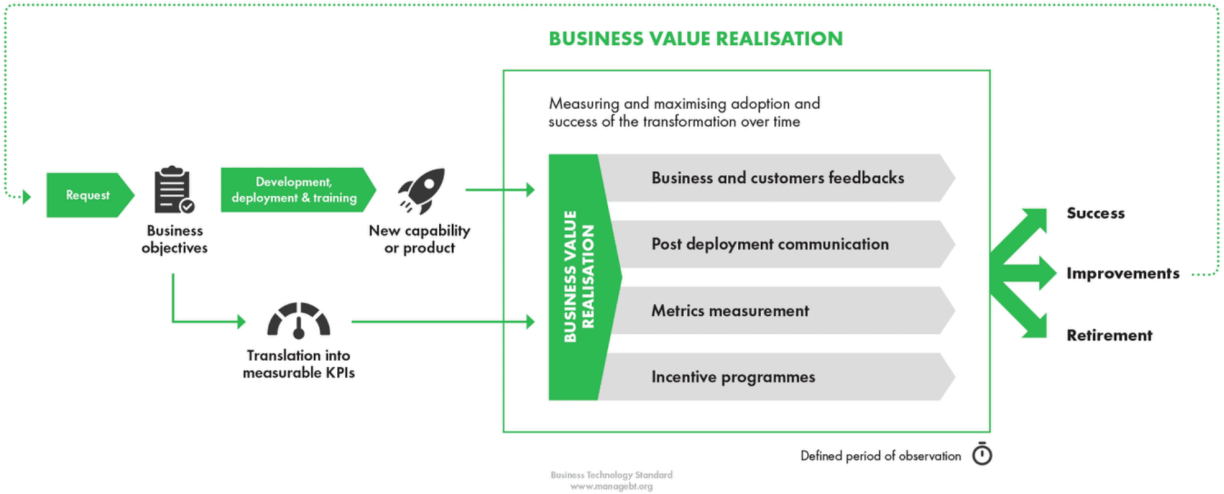


Figure 16: Business value realisation capability in the business technology standard (Business Technology Forum, 2021)

This business value realisation, in theory, is the core process that should produce KPI data and performance insights about elements in the service portfolio or solutions in the value chain to make well-timed and proactive business-value-driven decisions on when to make evolution decisions about the existing systems.

4.2.3 Evolution of software systems

Software evolution as a concept is not new, as it has been identified as a phenomenon in the literature already in the 1960s and has been considered important as means for continuous and progressive change (Lehman and Ramil 2003). Vocabulary and concepts of how researchers and practitioners see software system evolution and actions inside the lifecycle have also evolved. See figure 17.

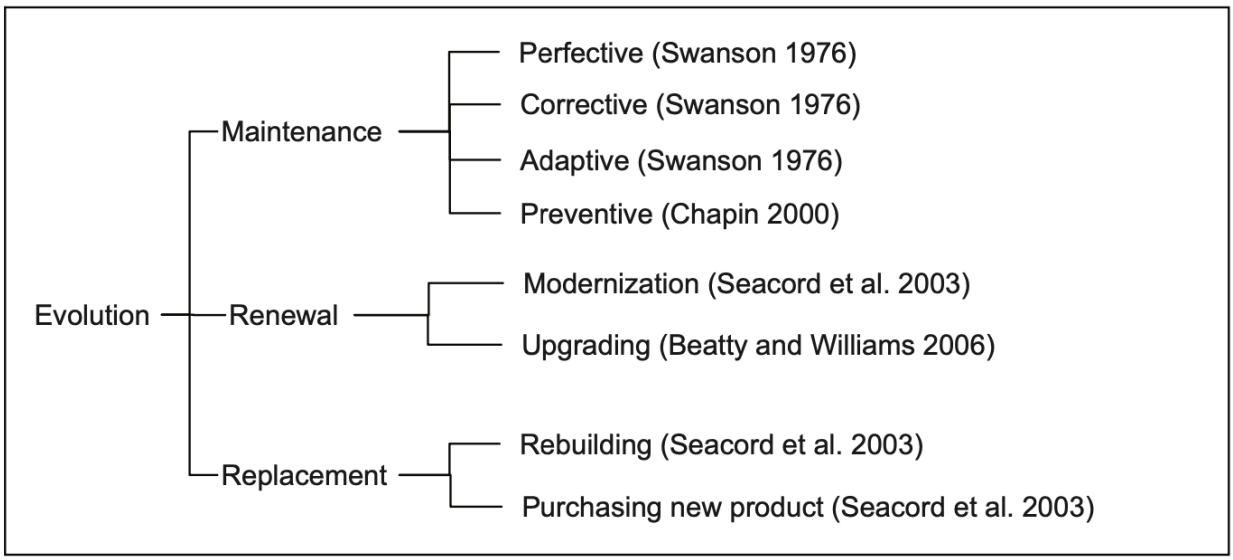


Figure 17: taxonomy of IT artefact evolution (Kankaanpää, 2011)

Continuous evolution is necessary in order to maintain a system's ability to respond to the requirements of its environment (Lehman 1998). As systems age maintaining them will incur increasing difficulties and organisations often face a legacy dilemma (Bennett 1995). Systems with long lifetime are business critical, but will start to require extensive resources and face increasing difficulties due to obsolete technologies (Bennett 1995). But making decisions about system modernisation or replacement is challenging, and decisions are often made informally and largely based on intuition (Saarelainen et al. 2006).

Software development literature recognises these days not only software lifecycle and evolution, but more importantly intertwined socio technical system which considers the human system where the software is used (Kankaanpää, 2011). The life cycle of a socio-technical system is perceived as a continuously evolving system, similar to WSLC model (Alter 2008a).

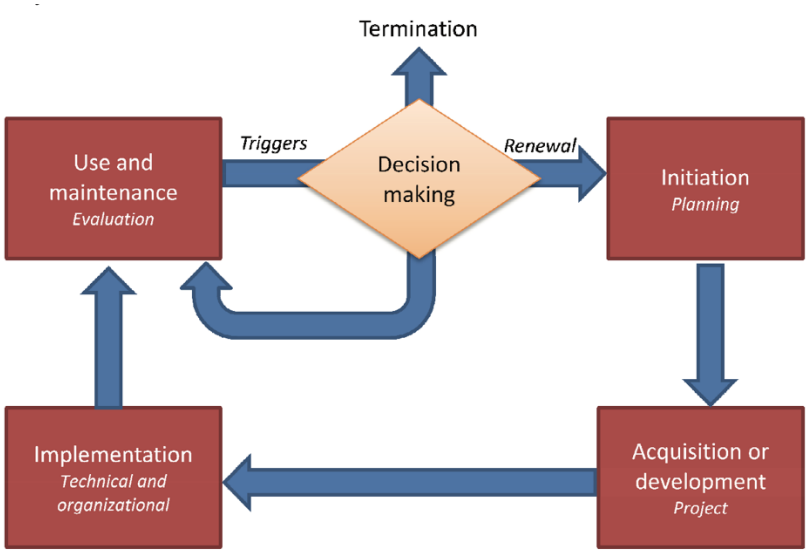


Figure 18: Modified IS Life cycle as (Kankaanpää, 2011)

Modernisation definition in this study loans the definition from previous academic authors and uses Khadka's (2016) definition as a base: "the process of evolving existing software systems by replacing, redeveloping, reusing, or migrating the software components and platforms, when traditional maintenance practices can no longer achieve the desired system properties".

Based on the above, modernisation in this study is thought of as a change that is needed to the business process, capability, or systems in the enterprise. This required change is something which can't happen within a regular, continuous improvement effort of that work - and hence requires additional investments and related decisions. This definition intentionally does not focus on modernisation to only cover an IT system or asset modernisation but rather takes a more holistic view of the work system.

4.2.3.1 Identifying the need to modernise

Legacy systems never started or were envisioned as legacy systems but are basically the result of management inaction rather than technical deficiency (Bennett, 1995). Based on small comparative study in Finland by Kankaanpää et al. (2007) the most common initiatives for modernization are business development, the system's old age and obsolete technology – while the most

common initiatives for system replacement are the old age of the existing system, the end of vendor's support and system's inability to respond to company's business needs.

Kankaanpää (2011) identified in her dissertation three core determinants for IT artefact (system) renewal: triggers, benefits and timing. Triggers stem from technology, business, vendor or otherwise from the external environment. Benefits include economic benefits as well as intangible benefits. And timing which includes business interests and business calendar, vendor timetables and timing of strategic IT updates or project deliveries. These determinants also have an interplay where each can affect another.

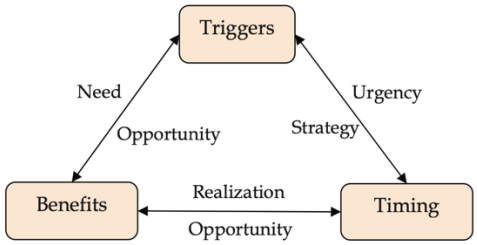


Figure 19: Interrelation of artefact renewal determinants (Kankaanpää, 2011)

Researchers and practitioners have created different heuristics and models to evaluate and decide when a system would be ripe for modernisation. And even though models were developed for different times and technical environments, they still have many applicable qualities and characteristics for decision-making even today. This section goes briefly through previous works without going into the details of any model.

Bennet (1995) identified useful symptoms for legacy systems and the need to act on them. Khadka (2014) interviewed professionals' perceptions of working with legacy systems and identified four core drivers for modernisation: the need to stay agile, high maintenance costs, lack of knowledge and proneness to failures. Eventually, Khadka defined legacy systems as "any system that cannot be modified to adapt to constantly changing business requirements and is still valuable to its stakeholder such that its failure can have a serious impact on business" (Khadka, 2016)

With the SABA model Bennet, Ramage and Munro provided an analysis method that takes into account organisational evolution scenarios and then technical scenarios that fit created business scenarios (Bennett, K.H., Ramage, M. and Munro, M. 1999). Lewis et al. (2005) created SMART-model to guide organisations in analysis in identifying services in legacy systems and how to transform them into SOA services in some new target architecture. Warren and Ransom (2002) defined Renaissance model to assess and evaluate different strategies to improve system evolvability.

Ahonen et al. (2006) described a lightweight process to collect and analyse relevant qualitative and quantitative data for renewal decision-making and noted that a structured process surfaced a better understanding of the quality and value of the system based on objective data and user perception in a way that was contradictory to the original perception that decision makers and management had.

Tilus (2006) created in his thesis work a simple framework - MODEST - to estimate modernisation pressure towards a system through a lightweight process that can be used effectively and continuously inside organisations to measure the evolution of the modernisation pressure. The research group also produced a straightforward checklist-based decision-making framework VERDE to support decision-makers in evaluating what needs to be thought and if all the relevant aspects had been sufficiently covered (Koskinen et al. 2006).

De Lucia, Fasolino and Pompelle defined decision framework that includes assessment model with technical and business dimensions, and then has 5 step process starting from goal definition, followed by gap analysis, portfolio analysis, alternative definitions and conversion strategy definitions for systems that need major changes (De Lucia, Fasolino and Pompelle, 2001).

Attribute	Variable	Metrics
Business Value	Economic value	Market value, Profitability Index, Internal Rate of Return
	Data Value	Percentage of mission critical archives, Percentage of application-dependent archives
	Utility	Business function coverage rate, actual usage frequency, customer satisfaction metrics
	Specialization	Percentage of highly specialized functions, Percentage of generic functions
Technical Value	Maintainability	LOC, FP, Control Flow Knots, Cyclomatic Complexity, Dead code rate
	Decomposability	Architecture modularity, percentage of modules with separation of concerns
	Deterioration	Backlog increase, defect rate increase, response-time increase, maintenance time per request increase
	Obsolescence	System age, operating system version, hardware version, technical support availability

Figure 20: Assessment categories (De Lucia, Fasolino and Pompelle, 2001)

Bakar and Razali (2013) compared how ISO standard defined quality attributes map with assessment characteristics defined in some of the previously defined and published models that had well published and available descriptions for their characteristics. Crotty and Horrocks (2017) merged in

their work and case study inside a financial institution legacy assessment meta-model attributes from three previous authors: Alkazemi et al. (2013), De Lucia et al. (2001) and Ransom et al. (1998).

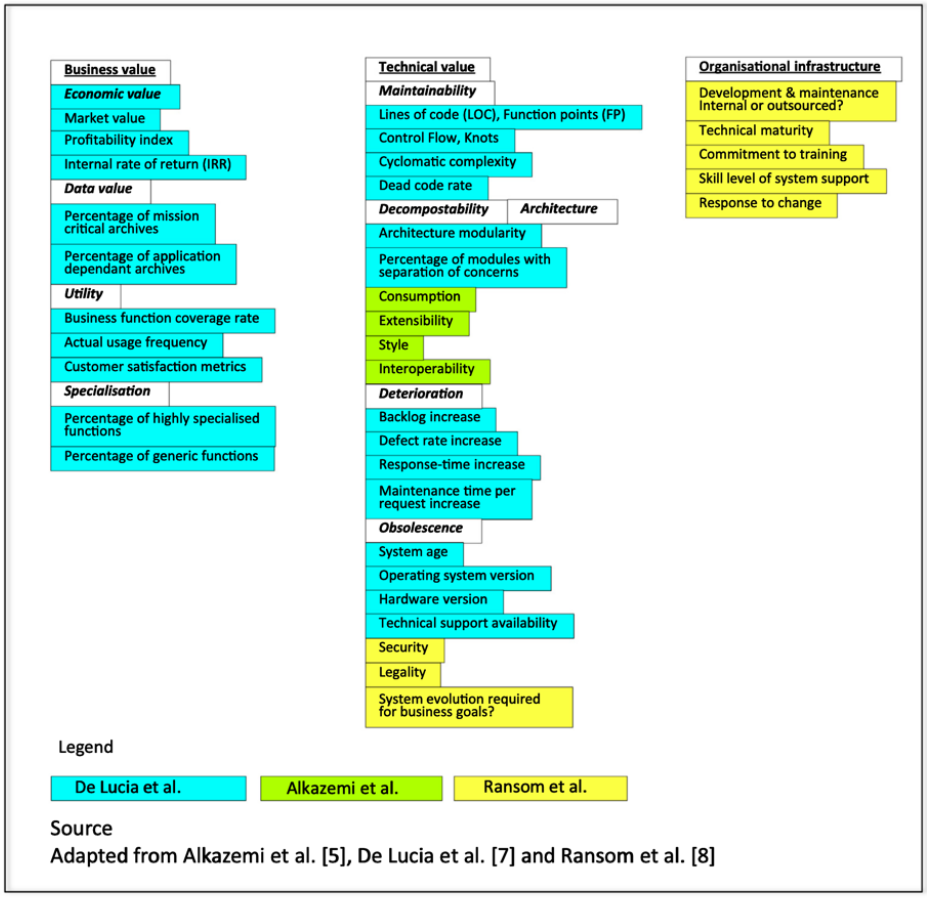


Figure 21: Legacy system assessment meta model attributes Crotty and Horrocks (2017)

Bellotti (2021) provides in her book practical practitioner heuristics to identify systems for modernisation:

- The code is difficult to understand.
- It references decisions or architectural choices that are no longer relevant, and institutional memory has been lost
- Qualified engineering candidates are rare
- Hardware replacement parts are difficult to find
- The technology can no longer perform its function efficiently
- System has performance issues
- System has stability issues

Besides academic researchers and practitioners, also industry analysts have added to the body of knowledge of modernisation needs evaluation. Forrester's Gerush and West (2011) defined a goal-question-metric model-based evaluation model to drive business performance in application portfolio: are resources invested to things that produce the most business value, are solutions delivered with required quality and are operations efficient and effective (see figure 22).

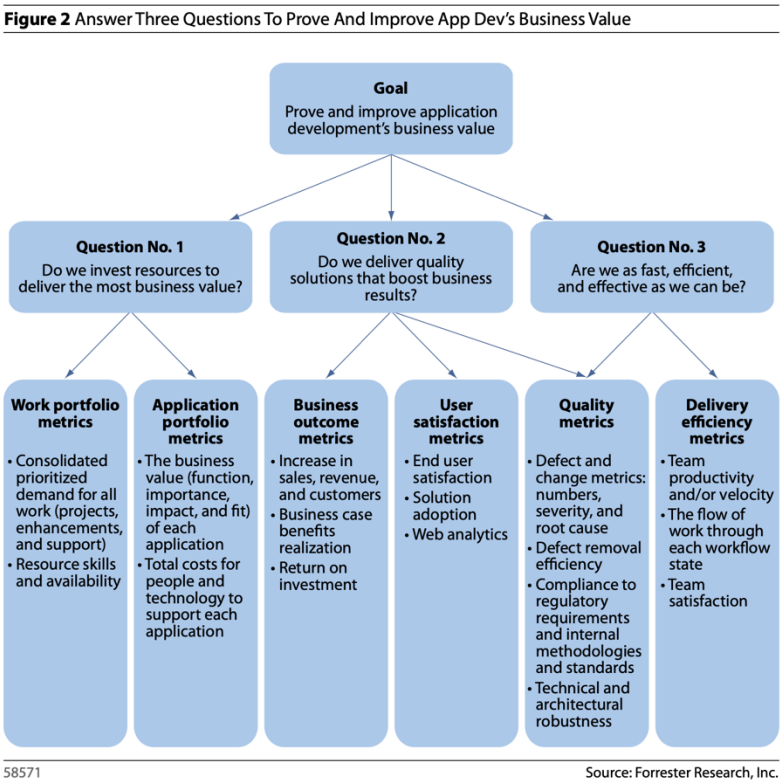


Figure 22: Six most meaningful questions to prove and improve application development's business value (Gerush, West 2011)

Gartner (2019) identified 6 drivers for identifying legacy systems for modernisation, three from the business perspective (business fit, business value and agility) and three drivers from the IT perspective (cost, complexity and risk). If the application is not meeting the new requirements imposed by digital businesses, it needs to be modernized to fit properly and should be updated to provide greater business value. Applications that lack the agility to keep pace with the demands of digital business may be a cost or risk liability. If the total cost of ownership is too high, the technology too complex, or security, compliance, support, or scalability are being compromised, it's time to modernize. (Gartner, 2019)

For decision making common tool in literature has also been a decision or portfolio matrix. Such has been presented with slight variations by Ransom et al. (1998), De Lucia et al. (2001), Seacord et al. (2003), Crotty and Horrocks (2017) and Gartner with the mnemonic TIME (Tolerate systems

with high technical quality, but low business value. Invest in systems that have high value and high quality. Migrate systems that have high value, but low quality. Eliminate those which have low quality and value).

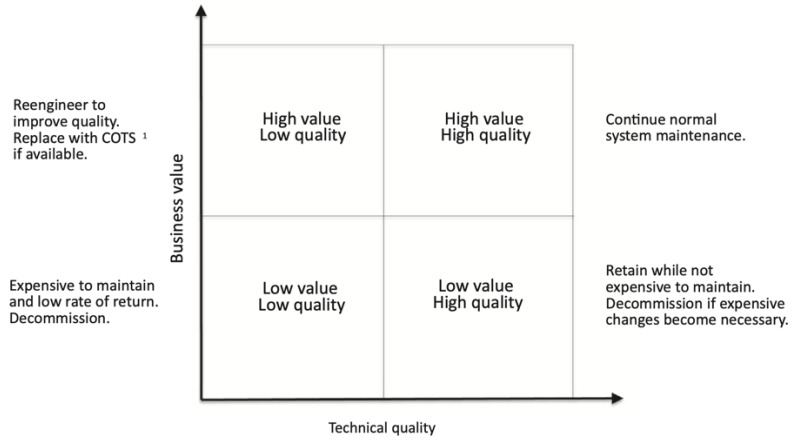


Figure 23: Portfolio decision matrix as described by Crotty and Horrocks (2017)

Crotty and Horrocks (2017) assert that there is consistency in the legacy system literature in recognising that a decision on the best option to manage such systems should be based on a structured assessment incorporating economic and quality factors and that decisions must be taken and supported by a broad range of stakeholders within the organisation and not limited to technical considerations alone.

As intended benefits, researchers and practitioners have identified different categories of benefits. Khadka (2015) identified from the literature the following intended benefits for modernisation efforts: cost reduction, increased reusability, increased agility, increased flexibility, improved performance, increased maintainability, competitiveness, increased availability, faster time to market and increased interoperability.

4.2.3.2 Modernisation investment evaluation

The challenge of making a business case and valuing IT investments is not new. Both academic and professional literature offers different kinds of methods for estimation and valuation.

Koskinen et al. (2004) evaluated 12 different modernisation evaluation frameworks (6 generic strategic level decision-making frameworks, 2 risk evaluation frameworks and 4 cost estimation models) regarding their suitability to use, but unfortunately, empirical validation for most of those models was non-existent. Renkema and Berghout (1997) listed over 50 valuation methods ranked into

four categories: financial methods, multi-criteria methods, ratio methods and portfolio methods. Verhoef (2002) presented a whole set of methods to practice quantitative IT portfolio management. But as Nijland (2004) studied in his dissertation IT-evaluation methods in a case study in an insurance company, he concluded that managers and decision-makers are not using more advanced methods. Managers only use methods they intuitively understand.

Kankaanpää et al. (2007) recognised challenges with different economic assessment methods in relation to making decisions on software evolution and proposed a decision-tree-based model to select appropriate valuation methods. Similarly, Silvius (2008) created a conceptual model for helping to select appropriate valuation methods for IT investments based on three dimensions: impact, the certainty of revenue and tangibility of revenue.

But outside academia and outside these researchers' case studies, created frameworks seem to be rarely, if ever, used. For example, created ISEBA model (Kankaanpää et al. 2005) has not received any further usage in the industry nor in research, based on a lack of citations in academic and practitioner literature. While academia and scientists are developing more sophisticated instruments, practitioners are clinging to the simpler options they have available.

As challenges in estimating projects and valuating IT investments is well known, some organisations have tried to partially avoid some of the problems related to regular budgeting and investment proposal valuations and adopt more agile practices with lean budgeting and funding of value streams as in Scaled Agile Framework (Scaled Agile Inc., 2021).

4.2.4 Digital transformation imperative

Andreessen (2011) wrote prophetically that software is eating the world and that companies in every industry need to assume that a software revolution is coming. Digitalization, digital transformation, and digital disruption have become terms used almost interchangeable in the professional literature. Even academic researchers have faced challenges in providing clear and concise definitions that sufficiently capture these emerging phenomena.

Researchers have tried to synthesise conceptual definitions for digital transformation. Vial (2021) defined digital transformation as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies". Gong and Ribiere (2021) synthesised their definition based on 124 individual definitions as: "A fundamental change process enabled by digital technologies that aims to bring radical improvement and innovation to an entity [e.g., an organization, a business network, an industry, or society] to create value for its stakeholders by strategically leveraging its key resources and capabilities." (Gong and Ribiere, 2021)

Verhoef et al (2021) identified strategic imperatives in terms of digital resources and capabilities, organisational structures, and metrics to successfully transform digitally. Verhoef et al. (2021) emphasise that digital agility is needed to recombine digital assets with other organizational resources in order to change the way of doing business. By continuously sensing and seizing market opportunities, digital agility fosters the recombination and development of new products, services and business models that enhance the value created for the customer. Organisations need to have agile organisational ways of work, implying short cycles to quickly test and update market assumptions via trial and error (Verhoef et al., 2021). And the IT function itself needs to transform from a line function focused on enabling communication or data flows into a more proactive and orchestrating role supportive to digital value creation via fast and explorative responses (Verhoef et al., 2021).

To realize the full potential of digital transformation, digital firms need to measure performance improvements on key performance indicators (KPIs) to facilitate learning and finetune the business model. Overall outcome-related metrics, like ROI, profitability, and revenue growth, typically remain relevant for firms that engage in digitization and digitalization. (Verhoef et al., 2021)

Strategic management literature authors like Weil and Woerner (2018) focus on enabling management to understand what their business model will be with regards to two dimensions: knowledge of the customer (partial vs complete) and business design (part of value chain vs. ecosystem), and to understand what will be their source of competitive advantage in that model (content, customer experience, platform).

Practitioners and researchers that come from information system and innovation perspectives emphasise not only how technology is an important enabler, but that technology should be at the core of the organisation and the organisation as a whole needs to have the capability to adapt with the speed of the market. For example, Bosch (2016) argues that to survive and thrive in the software-driven world, organisations need to improve their capabilities in software development value delivery speed to enable R&D as an effective innovation system, need to improve the usage of data to drive the organisation to be an evidence-based organisation and effectively have strategic multi ecosystem engagement model.

Based on their research Bosch (2019) argues that digitalisation causes a fundamental shift in the operations of digital companies compared to traditional organisations. Digital organisations are different in at least eight aspects: data-driven decision-making, relentless experimentation, short feedback cycles, decision-making pushed down in organisation, strategic data collection, unified data warehouse, pervasive automation and new job descriptions.

	Traditional	Digitalized
Business	Transactional model where customers buy products periodically (typically every couple of years)	Continuous value delivery model based on services; monetization through KPIs and expectation of continuous improvement
Ecosystem	One dimensional value network from suppliers to product company to customer.	Multi-dimensional business network with multiple avenues for monetization using products, data and other assets.
Architecture	Deeply integrated architecture optimized for minimal bill of material cost. Focus is on freezing the architecture after design and a "big bang" release.	Modularized architecture separating parts that evolve at different frequencies through APIs (mechanics, electronics, software). Focus is on facilitating continuous evolution and release.
Process	Process dictated by mechanical design and manufacturing constraints. Focus on planning and prediction in order to minimize cost due to late changes and quality issues.	Process focused on fast feedback loops facilitated by continuous deployment and data streams. Focus on experimentation and continuous learning.
Organization	Hierarchical organization with functionally organized departments. HIPPO-based escalation paths to iron out conflicts due to local optimization.	Empowered, cross functional teams responsible for different aspects of value delivery. Cross-team coordination through architecture evolution.
Culture	Atoms-over-bits mindset; tendency for local over global optimization. "I'm responsible for doing my job well; nothing else"	Bits-over-atoms mindset. Deliver on the company mission and take on responsibilities based on what is needed rather than job description.

Figure 24: Comparing traditional and digital organisations (Bosch, 2019)

In a longitudinal multi-company research study with 15 companies, Bosch and Olson (Bosch, Olson 2021) identified four dimensions in which companies in embedded systems domains were evolving from traditional companies towards digital companies: product upgrade dimension, business model dimension, data exploitation dimension, and AI/ML/DL dimension. They also postulated about an evolutionary path through which companies evolve (see figure 25).

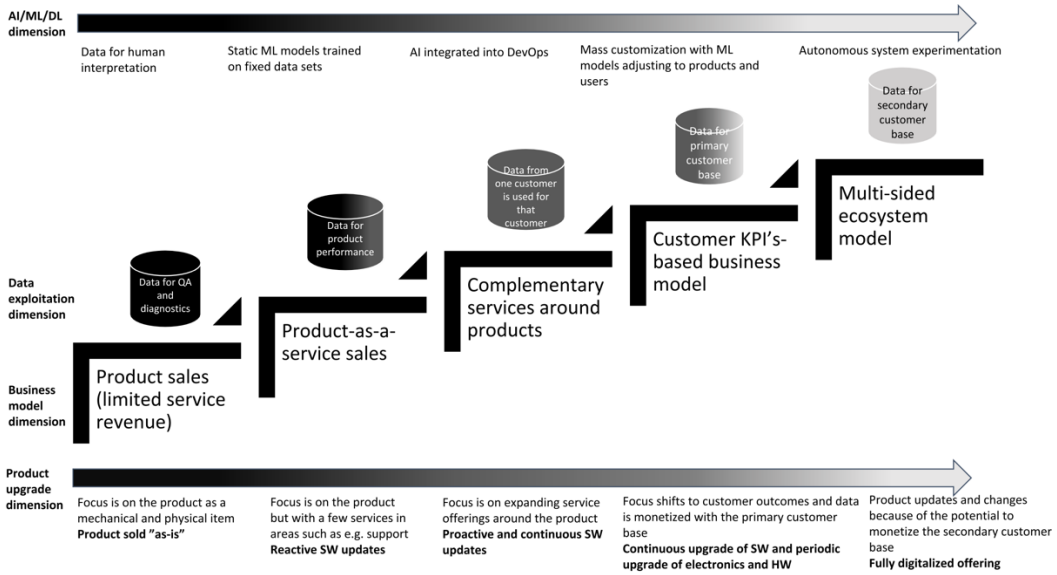


Figure 25: Evolution path from a traditional company to a digital company, based on a case study of 15 companies (Bosch, Olson 2021)

In his book directed towards managers and other leaders, Bosch (2018) provides 5 insights to managers: digitalisation is about business development and transformations, speeding up the heartbeat of R&D is still a challenge, thinking outside the current product portfolio is hard, digitalisation is about data and software - and that accepting that we don't know how things will play out while acting based on our best understanding and adjusting when new information becomes available is a skill that we all need.

A similar theme is expressed by other technology-focused researchers and practitioners, who envision that traditional business and IT division is no longer sufficient in a software-driven world, where the whole sociotechnical system needs to evolve fast. The digital enterprise is an enterprise that is transforming itself to meet the challenges of our post-industrial Digital Age, by embracing an adaptive culture, employing technology at its core, and creating new business models (Highsmith, Luu and Robinson, 2019).

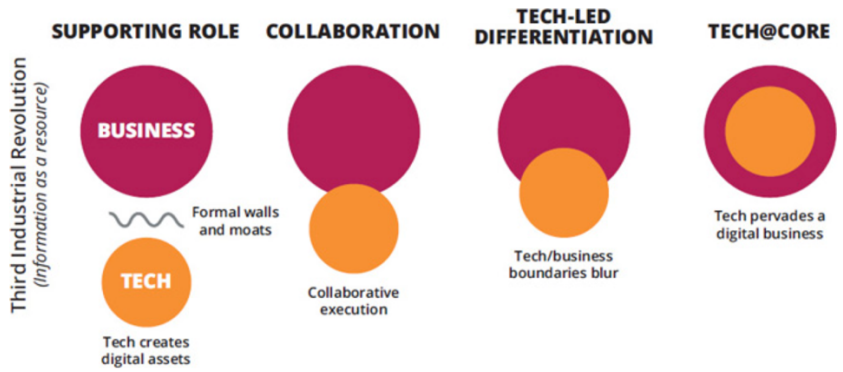


Figure 26: Technology at the core of the business as a strategic differentiator (Highsmith, Luu and Robinson, 2019)

Building the capability to evolve and continuously adapt is critical to transforming an organization. Accelerating the rate of change is overwhelming most organizations' ability to absorb and respond to changes. Can you sustain your ability to adapt over time? Effective digital transformations are not for the timid, but rather for the bold and gritty, hanging out on the edge of chaos. (Highsmith, Luu and Robinson, 2019)

According to Highsmith, Luu and Robinson (2019), success requires that organisations have an operating model that connects the strategic vision to the delivery of value. They suggest that measurements of value shift from traditional return on investment and cost/efficiency metrics towards customer value and speed/adaptability metrics, that organisations accelerate technological edge

over competitors, maintain awareness and take advantage of technological shifts, reduce technical debt to increase speed and adaptability - and get key technical staff involved and constantly improving their capabilities.

Takkunen's (2021) case study is an important contribution to understanding and discussion of digital transformation thinking in Finland, as it brings a very contemporary view from the Nordic markets into the discussion and provides insights into challenges that managers and top management in consumer goods companies see with regard digitalisation and digital transformation.

In her findings, Takkunen (2021) argues that changes are almost impossible to implement without the engagement of strong leadership and the forceful involvement of the CEO. CEOs of transformative companies assumed the leadership role of digital transformation. They provided a vision for the company and constructed a strategy to communicate the vision and to drive the transformation; they also dug into the existing DNA of the organisation and triggered a cultural change process. CEOs also constructed long-term plans with clear agendas and milestones - accepting that change is slow. Additionally, transformative organisations were characterised by attempts to comprehend how digitalization impacts their existing business models in the long term and used external knowledge by listening to experts and hiring new talent (Takkunen, 2021)

Takkunen (2021) identified three different approaches that organisations enacted. Transformative approaches were described by organisations that saw that value creation models are getting disrupted, and organisation needs to restructure their thinking and operations around this new reality. Compartmentalised approaches were cases where digital technologies enable the organisation to augment and improve operations, but there is not yet a transformation into new mindsets and business models. Ambivalent approaches were described as situations where companies were unable to see benefits and opportunities in the change or were locked in thinking about the state of the market dynamics in a way that caused them to see those realities as something that can't be changed.

Takkunen's (2021) findings are in line with other authors have written about transformation, and how it needs to be systematic and holistic improvement of capabilities that lead to value. Westerman and Bonnet argue (2020) that organisations that are digital masters cultivate two capabilities: digital capability, which enables them to use innovative technologies to improve elements of the business, and leadership capability, which enables them to envision and drive organizational change in systematic and profitable ways.

George Western has written and studied extensively digitalisation and, based on research, defined and iterated a practical model of digital capabilities that can be used to explain how successful

companies are leading their digitalisation efforts. Research has been published as a research report with Cap Gemini (Westerman et al., 2011), as a book (Westerman, Bonnet, McAfee 2014) and as an updated version in an article (Westerman, Bonnet 2020).

Westerman's model provides a holistic model for management to think of digital transformation as a concept that starts from a transformative vision at the top and becomes real throughout the organisation through well-governed transformation initiatives that build the required skills and digital building blocks (Westerman et. al 2011). In 2020 model's digital building blocks got updated to put more focus also on employee experience - and give new categories or concepts as examples of digital platform capabilities that organisations have (see figure 27).

The New Elements of Digital Capability

The updated framework places more emphasis on employee experience and business model innovation, as well as on the digital platform, which powers the other elements and, when structured and managed well, enables further innovation.

BUSINESS MODEL		
Digital enhancements		
Information-based service extensions		
Multisided platform businesses		
CUSTOMER EXPERIENCE	**OPERATIONS**	**EMPLOYEE EXPERIENCE**
Experience design	Core process automation	Augmentation
Customer intelligence	Connected and dynamic operations	Future-readying
Emotional engagement	Data-driven decision-making	Flexforcing
DIGITAL PLATFORM		
Core		
Externally facing		
Data		

Figure 27: The new elements of digital capability (Westerman, Bonnet 2020)

Digital transformation requires interplay and changes in multiple different elements in the company, starting from the transformative vision to the business model, organisational structure, ways of working, measurement models and capabilities that support working towards set goals. Digital transformation can be an important driver causing the need to modernise systems and services that provide the needed capabilities to the organisation.

4.2.5 Software delivery capability as a differentiator

A major enabler for digital transformations and delivery of value has been the evolution of the concept of DevOps and the understanding of software delivery performance's impact on organisational performance. Software and technology are key differentiators for organizations to deliver value to customers and stakeholders (Forsgren, Humble and Kim, 2018).

Within practitioner literature, multiple authors emphasise capabilities that enable the organisation to learn fast, evolve with the customers and operate efficiently, and use economic view to drive changes (among others, Scaled Agile Inc., 2021). The same tone is also visible in cloud platform provider guidance, which emphasises organising around value and enabling evolutions to digital platforms that have business capabilities instead of monolithic applications (Thumma, 2020). Platform and tool providers similarly focus on and emphasise the importance of delivery capability via common automated platforms that make software evolution faster and easier (Coté, 2015, 2017, 2019).

Even Gartner analysts (Van Der Zijden, S. and Klinect, T. 2019 and 2022) describe how organisations should take a more continuous business value stream-focused viewpoint to application modernisation and start to build platforms by focusing on friction points by breaking legacy applications with strangler pattern. This recommendation and suggestion align with practices proposed by Thoughtworks consultants, who promote replacing legacy components by using a strangler pattern once proper value streams are identified (Cartwright, Horn and Lewis, 2022).

Organisations in all industries, from finance and banking to retail, telecommunications, and even government, are turning away from delivering new products and services using big projects with long lead times. Instead, they are using small teams that work in short cycles and measure user feedback to build products and services that delight their customers and rapidly deliver value to their organisations. These high performers work incessantly to get better at what they do, letting no obstacles stand in their path, even in the face of high levels of risk and uncertainty about how they may achieve their goals. (Forsgren, Humble and Kim, 2018)

Forsgren, Humble and Kim (2018) have researched high performing organisations and identified practices that separate high performers from others. They postulated that to remain competitive and excel in the market, organizations must accelerate:

- delivery of goods and services to delight their customers;
- engagement with the market to detect and understand customer demand;
- anticipation of compliance and regulatory changes that impact their systems; and
- response to potential risks such as security threats or changes in the economy.

When measuring software delivery performance by four metrics: lead time, deployment frequency, mean time to restore service after service degradation and change fail percentage, researchers (Forsgren, Humble and Kim, 2018) found that compared to low performers, the high performers have:

- 46 times more frequent code deployments
- 440 times faster lead time from a commit to deploy
- 170 times faster mean time to recover from downtime
- 5 times lower change failure rate (1/5 as likely for a change to fail)

In their research Forsgren, Humble and Kim (2018) identified 24 capabilities in 5 categories that drive performance in software delivery performance. The capabilities are classified into five categories: continuous delivery, architecture, product, and process, cultural – and lean management and monitoring. These capabilities provide additional heuristics to assess the modernisation need and opportunity, not just in the software artefact and its usage – but also in the organisation and the ability produce value with software.

4.2.5.1 Capabilities for continuous delivery

Continuous delivery is the engineering discipline of delivering all changes in a standard way safely (Finster et al., 2021). A community-driven manifesto defines minimum activities required for continuous delivery to be: usage of continuous integration, deployment to any environment happens through application pipeline, the pipeline decided the releasability of changes, artifacts created by the pipeline always meet the organization's definition of deployable, artifacts are immutable, all feature work stops when the pipeline has a problem, production-like test environment exists, rollback can be made on-demand, application configuration deploys with artifact and continuous integration is used (Finster et al., 2021). Continuous integration is the activity of very frequently integrating work to the trunk of version control and verifying that the work is, to the best of our knowledge, releasable (Finster et al., 2021).

Forsgren, Humble and Kim (2018) listed following capabilities as key: using version control for all production artifacts, automating deployment process, implementing continuous integration, using trunk based development methods, implementing test automation, having proper test data management, integrating security into design and testing phases of software development – and implementing continuous delivery.

Essentially good continuous delivery capabilities seem to be the new hygienic factors for enabling software development organisations to deliver good value safely and swiftly.

4.2.5.2 Architecture capabilities

For architecture capabilities Forsgren, Humble and Kim (2018) list two capabilities: using loosely coupled architecture and architecting for empowering teams.

The loosely coupled architecture allows teams to work independently, without relying on other teams for support and services, which in turn enables them to work quickly and deliver value to the organization (Forsgren, Humble and Kim, 2018).

Architecting for empowerment focuses on enabling specialist teams to use tools and practices that make them most effective and productive in that context. No one knows better than practitioners what they need to be effective (Forsgren, Humble and Kim, 2018).

This theme is echoed and amplified in practitioner literature and contemporary research. Among others, Woods et. al (2021) define six additional principles that enable organisations to achieve goals and have continuous architecture:

- Architect products; evolve from projects to products. Architecting products is more efficient than just designing point solutions to projects and focuses the team on its customers.
- Focus on quality attributes, not on functional requirements. Quality attribute requirements drive the architecture.
- Delay design decisions until they are absolutely necessary. Design architectures based on facts, not on guesses. There is no point in designing and implementing capabilities that may never be used—it is a waste of time and resources.
- Architect for change—leverage the “power of small.” Big, monolithic, tightly coupled components are hard to change. Instead, leverage small, loosely coupled software elements.
- Architect for build, test, deploy, and operate. Most architecture methodologies focus exclusively on software building activities, but we believe that architects should be concerned about testing, deployment, and operation, too, in order to support continuous delivery.
- Model the organization of your teams after the design of the system you are working on. The way teams are organized drives the architecture and design of the systems they are working on.

These capabilities and principles paint the overall picture that to enable great organisational performance and to enable the business to have flexibility and ability to evolve with the market, organisations need to structure and architect solutions also with this value delivery in mind.

4.2.5.3 Product and process capabilities

Forsgren, Humble and Kim (2018) emphasise four lean product management capabilities: gathering and implementing customer feedback, making flow of work visible through the value stream, working in small batches and fostering and enabling team experimentation. A better flow of value and faster feedback loops in the organisation have an impact on IT performance and enable product teams to innovate quickly and create value.

What is important to understand and realise is that these changes and impacts are not constrained only to new, agile and modern digital organisations in software development industries, games or internet technologies, but rather these practices are transforming even the most notorious bureaucracies and producing hard measurable benefits. Knausenberger and Furtado (2020) describe how the world's largest bureaucracy U.S. DoD (Department of Defence) has changed the way how they are able to produce better business outcomes with technology by turning some parts of the air force into a software company that can win wars. By modernising air force's AOC's (air operation center) in the air fuelling operations planning, an initial 5-person team was able to produce operational improvements that in fuel savings alone produced savings of over 400 thousand dollars per day (Knausenberger and Furtado 2020).

By having these capabilities and well-accredited processes in place, they were able to deploy new software into production even 5 times a day and produce value into use inside the organisation (Knausenberger and Furtado 2020).

4.2.5.4 Lean management and monitoring capabilities

Forsgren, Humble and Kim (2018) also highlight the impact of four lean management practices: having a lightweight change approval process, having constant monitoring of over applications and infrastructure to inform business decisions, visualising work to monitor quality and improving process flow by limiting the work in progress. These practices effectively drive the idea of improving the flow of value through the organisation, and to have a proactive data driven practices to make well informed decisions.

4.2.5.5 Cultural capabilities

Important cultural capabilities as defined by Forsgren, Humble and Kim (2018) are: generative culture, encouragement and support for learning, support and facilitation of learning as well as collaboration among teams, provision of resources and tools to make work meaningful – and embodiment or support for transformative leadership.

Through these capabilities, the leadership can amplify the technical and process work inside the organisations through vision, intellectual stimulation, inspirational communication, supportive leadership, and personal recognition. Organisations that have good information flow, high cooperation, trust, bridging between teams, conscious inquiry and learning is seen as essential investment, will thrive and provide meaningful opportunities for people to succeed in their work.

Having a digital mindset in the organisation and the capability to deliver value fast and effectively enables organisations to make decisions and implement them in the marketplace in new ways and at a new pace.

4.2.6 Business agility

An emerging concept in the practitioner communities and literature, and progressively also in academic management research, is business agility – where previous management practices are challenged with new management innovations to gain the benefits from new emerged opportunities technical innovations make available for organisations.

Steiber (2022) argues that these management innovations are as important to economic progress as technological innovations, and there exists a synergic link between management innovations enabling more technological innovations and vice versa. As an example, and as a case study Steiber uses (2022) the transformation of GE Appliances and adoption on RenDanHeyi principles after Chinese conglomerate Haier acquired GE Appliances from General Electric in 2016 (see figure 28).

Figure 28: Transformation of principles and cultural beliefs (Steiber, 2022)

These emerging new management principles allow companies to be more innovative, agile, and fast-moving – and allow companies to build and strengthen their dynamic capabilities. To be dynamic as a firm, you must have a mindset that the organization and business model will constantly need to change and be updated. For this to happen, the firm needs to be people-centric, so it can

leverage people's creativity. Further, the firm needs to be ambidextrous—that is, be able to explore new opportunities and create new knowledge and value in parallel with exploiting current knowledge and opportunities. One way of doing this is to allow open innovation, leveraging innovation from outside the firm as well as from within. Co-creation with customers, suppliers, and other partners plays an increasingly important role in innovation today. Finally, the firm needs to apply a systemic approach to succeed. The principles need to be applied everywhere in the firm, not only in selected areas such as new product development. (Steiber, 2022)

As these ideas are still emerging and evolving, there is no one set of definitions – but rather a collection of similar expressions of ideas that get combined. As an example Scaled Agile Framework defines business agility accordingly:

> Business Agility is the ability to compete and thrive in the digital age by quickly responding to market changes and emerging opportunities with innovative, digitally-enabled business solutions. Business Agility requires that everyone involved in delivering solutions—business and technology leaders, development, IT operations, legal, marketing, finance, support, compliance, security, and others—use Lean and Agile practices to continually deliver innovative, high-quality products and services faster than the competition. (Scaled Agile Inc., 2021)

Effectively the Scaled Agile Framework (2021) suggests focusing on seven core principles of business agility (see figure 29): lean portfolio management, organisational agility, continuous learning culture, team and technical agility, agile product delivery, enterprise solution delivery and lean-agile leadership that then focuses the organisation with customer centricity.

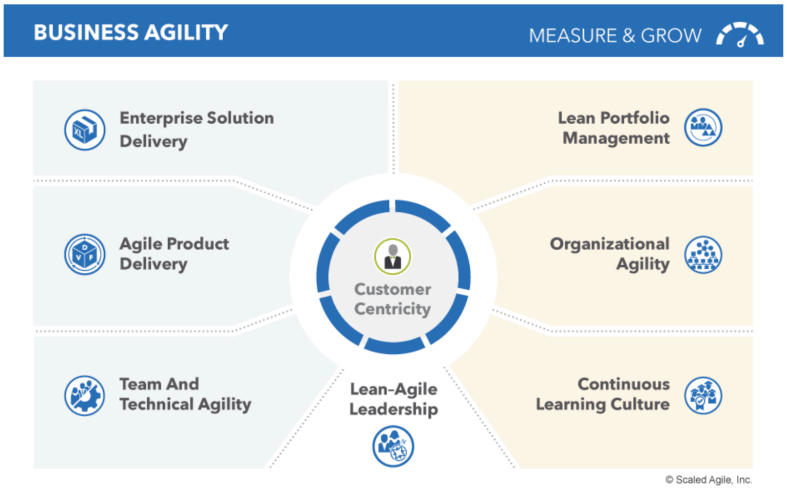


Figure 29: Seven core competencies of business agility as defined in Scaled Agile Framework (Scaled Agile Inc., 2021)

Deloitte consulting's business agility practice leader and a long-time business agility practitioner Jon Smart (2020) describes that the desired outcomes of organisations that he has worked for or worked with could be articulated as "better value sooner safer happier". These words capture the

essential elements of business agility in a very understandable way (see figure 30). Better is about building quality into the product and processes. Sooner is about the flow of value through the organisation. Safer is about having true agility that also fulfils the needs of compliance and resilience. And finally, happier is about having a positive impact and culture inside the company as well as around the organisation.

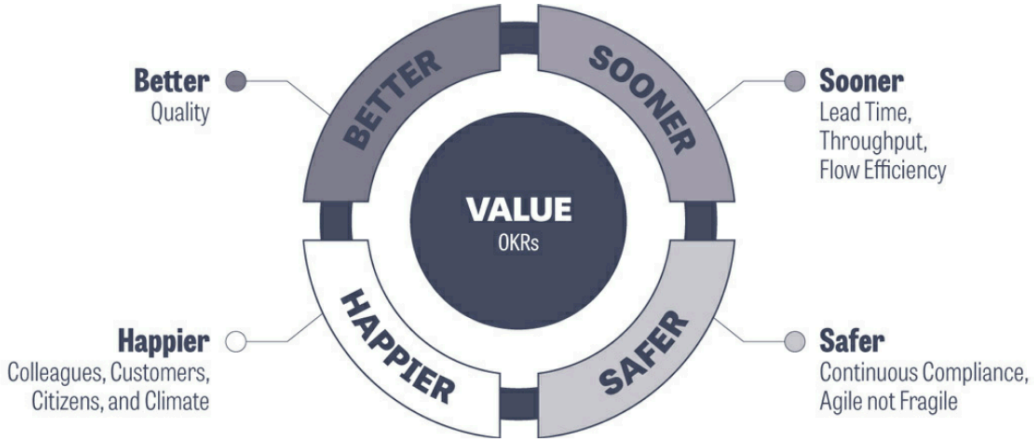


Figure 30: Better value, sooner, safer, happier conceptualization (Smart, 2020)

The common thread in all these emerging conceptualizations and models is that organizations need to look at how their work and management systems and organizational structures support the flow of value to gain full benefits from capabilities that are emerging from new technologies.

4.3 Literary review conclusion

Even though modernization as a term has been most researched and studied from the perspective of modernizing software systems, it is often inherently intertwined with how the organization that is using the technology is evolving or transforming and how the flow of value can be improved or how continuity of it can be guaranteed in the future. This holistic change in thinking is exemplified in digital transformation and business agility literature, which in turn builds on top of emerging practices and ideas of delivering value faster with good software delivery capability.

Modernization, in this study, is defined as “the process of evolving existing software systems by replacing, redeveloping, reusing, or migrating the software components and platforms, when traditional maintenance practices can no longer achieve the desired system properties.” This definition implies that the organization has defined desired system properties and has been able to assess that the system or systems can no longer be made to achieve those properties without more extensive changes. And the business still needs those functionalities or outcomes that the system or systems help to achieve.

As identified by Kankaanpää (2011), there are three core determinants for system renewals: triggers, benefits, and timing. Triggers that cause the consideration and decision to modernize can stem from technology, business, vendor, or otherwise from the external environment. Benefits include economic benefits as well as intangible benefits from the change. And timing includes business interests and business calendar, vendor timetables, and timing of strategic IT updates or project deliveries that affect the organization's opportunity and urgency to take action.

The literature review covered multiple heuristics and models that can be used to assess system status on economic and technical factors. Still, none of the reviewed frameworks or models provides any guidance on how to value or quantify different quality factors. Models can help users assess via multiple viewpoints if a system is becoming a technical liability but usually lack the ways to translate emerging technical quality problems into risks affecting business outcomes or business agility in a quantifiable way.

Reviewed portfolio and service management models guide the organizations to define key performance indicator metrics that enable organizations to assess if services are performing within defined thresholds and providing expected business outcomes. Continuous deviations from these can work as a signal to assess the state of the services properly and, to some extent, to quantify the business reason for changes when expected business outcomes are not achieved. Frameworks and models did not list universal metrics and quantification models, as the measurement is a contextual problem, and businesses often need to derive suitable metrics and indicators for their environment.

Ultimately the modernization assessment and decision are business decisions, and Gartner's (2019) heuristics for modernization decision is apt: If systems are not meeting new requirements, lack the agility or scalability to keep pace with the demands of the business, the total cost of ownership is too high – or if security or support is compromised, then it is time to modernize.

5 Conducting the research

Research work started officially in December 2021 alongside consulting work and continued until May 2022.

During this journey, the perspective on the modernization question shifted and evolved multiple times as synthesis was made of what different researchers and authors had already written about the subject. The work started with a clear focus on the IT system perspective and modernization of single or multiple IT assets. Eventually, it evolved into research into understanding how IT assets and organizational delivery capabilities produce value and how to make value-based decisions about those systems.

Besides the literary review, a core component of the thesis was to research how organisations make modernisation decisions. This section describes the data collection in more detail.

5.1 Data collection: Interviews

During March, April, and May of 2022, 14 interviews were conducted online in Microsoft Teams. Interviews were recorded but not transcribed.

Interviewed persons were collected from the author's professional network and their extended network. Persons were selected both because of their availability to be interviewed and their long experience in different positions in the IT industry. Each interviewed person had at least ten years of experience in the industry, while most interviewed persons had over two decades of experience in various roles.

Interviewed persons primarily represented organizations whose employee counts ranged from a hundred or so employees to over 15 thousand employees. The selection of people to be interviewed was biased towards people who had the technical know-how and technical roles in their organizations.

Interviews were time-boxed to take a maximum of one hour and were structured to be free-form discussions with open questions and the ability to progress from one theme to another based on how the interviewed person was able to describe their experience and memories of past events. Interviewees were promised to be kept anonymous and only use descriptive data about the role and organizations - as specifics of the organizations and business situations are not necessarily meaningful. Any interviewed person was able to describe multiple cases from different industries from their past.

Interviews were meant to support building the model presented in the thesis and understand how different stakeholders in different organizations see modernization decisions being made and if any formal management models and frameworks were successfully applied.

Interviewed people were suggested to prepare for the interview with the invitation listed in appendix 3.

Conducted interviews:
- Interview 1: Lead Architect in a consulting company - 31.3.2022
- Interview 2: Product owner in a media company - 31.3.2022
- Interview 3: ex-product development director in a successful start-up - 31.3.2022
- Interview 4: Private software architecture consultant - 5.4.2022
- Interview 5: Architect in a consulting company, ex IT manager - 4.4.2022
- Interview 6: Principal consultant leading transformation efforts - 4.4.2022
- Interview 7: Architect in a media company - 5.4.2022
- Interview 8: Vice President in a consulting company - 8.4.2022
- Interview 9: Product owner in a media company - 8.4.2022
- Interview 10: Director in a consulting company - 14.4.2022
- Interview 11: Enterprise architect in a large company - 19.4.2022
- Interview 12: Vice President of engineering in a software company - 19.4.2022
- Interview 13: DevOps Lead in a consulting company 4.5.2022
- Interview 14: ex-value stream engineer from a supply chain company in the United States 17.5.2022

The initial plan and hopes were to get more interviews, but it proved to be challenging to find suitable persons from a diverse group of companies to be interviewed and to get a suitable time reserved from their calendars. Therefore, besides interviews, an effort was put to collect more insights with a questionnaire.

5.2 Data collection: questionnaire

To collect more qualitative and quantitative data for the research, a questionnaire was implemented as an online questionnaire in Microsoft Office Forms - and sent through different social networks to potential responders. The questionnaire consisted of 7 demographic category questions, 35 Likert scale questions, and 6 free-form descriptive questions. Questionnaire questions are listed in appendix 4.

The questionnaire was designed to assess how responders felt about the decision-making culture and practices in the organisation, and only then ask more directed questions about what triggers to

consider modernisation, how modernisation needs were measured or quantified – and finally how the modernisation opportunity was analysed and quantified. Questions reflected the core research questions in this thesis and included Likert scale options based on insights gained in the literary review and in the interviews.

The questionnaire was designed and iterated with the help of the modernisation project team inside Siili Solutions and also reviewed with a few interviewed research participants to gain insights and ideas on how they would have responded to the questionnaire and if their responses would have properly reflected what they were able to communicate during the interview session.

The questionnaire was published on the 4th of May, and responses were collected ’till the end of the 11th of May. One-week response time was selected to increase the sense of urgency in responding, especially as the questionnaire was designed to take less than 10 minutes to answer. This estimation was provided by both the tooling in the Forms application as well as by a test drive with test users. The actual completion data from the respondents also confirmed that the estimated time was on the mark.

The form was personally sent to a group of potential responders by email with the request to share the message. Semi-publicly, the form was published in Siili Solutions Slack, in a few customers' Slack networks, and in informal industry forums. Publicly the form was posted on LinkedIn and on Twitter by multiple persons.

Responders were anonymous, and their identity as decision-makers or influencers was not validated.

6 Research results

6.1 Interviews

During March and April of 2022, 14 interviews were conducted online. All the interviewed persons besides one (interview 14) were Finnish and worked in companies that had a presence in Finland.

- Interview 1: Lead Architect in a consulting company - 31.3.2022 - 59 minutes
- Interview 2: Product owner in a media company - 31.3.2022 - 40 minutes
- Interview 3: ex-product development director at a successful start-up - 31.3.2022 - 54 minutes
- Interview 4: Private software architecture consultant - 5.4.2022 - 52 minutes
- Interview 5: Architect in a consulting company, ex IT manager - 4.4.2022 - 49 minutes
- Interview 6: Principal consultant leading transformation efforts - 4.4.2022 - 43 minutes
- Interview 7: Architect in a media company - 5.4.2022 - 54 minutes
- Interview 8: Vice President in a consulting company - 8.4.2022 49 minutes
- Interview 9: Product owner in a media company - 8.4.2022 52 minutes
- Interview 10: Director in a consulting company - 14.4.2022 - 40 minutes
- Interview 11: Enterprise architect in a large company - 19.4.2022 - 45 minutes
- Interview 12: Vice President of engineering in a software company - 19.4.2022 - 29 minutes
- Interview 13: DevOps Lead in a consulting company 4.5.2022 - length 42 minutes
- Interview 14: ex-value stream engineer from supply chain company in the United States - 17.5.2022 – 43 minutes

Key points mentioned in interviews:

1: Discussion revolved around the architect’s experience in helping companies in different industries. In some industries, there is no slack in the organisation. Hence modernisation decisions are reactive and driven by costs or risks. Similarly, for many industries, IT is a cost, not an enabler – and everything revolves around the immediate bottom-line impact.

On the other end of the spectrum, successful modernisations start with a strategic goal and clear hypothesis or proof of how the change will impact the business KPIs. But that also requires that the organization has maturity in IT management to drive business values. Unfortunately, many organizations lack that maturity.

2: Discussion focused on the development of a new capability for the organisation. Capability development had a strategic need from the management as it would align the organization around certain shared metrics. This in-house developed capability has now outgrown from current implementation, and rising costs and lack of business agility have triggered renewal.

Modernization decisions can be challenging if there is no clear linkage to value or there is no common understanding of the value in the organisation. Management-driven modernizations that clearly affect and define how an organisation understands value are more straightforward. Decision-making happens in active dialogue between business and service development.

3: Most of the time discussion was about a data warehouse modernization case where the organization realized that if the business projections about growth become a reality, their existing system and ways of working no longer work. At the same time, changing the data warehouse solution would also enable the development of previously impossible features that the business had multiple times requested. Technology solutions had become a bottleneck. Fixing that would be a larger investment and would not fit into the team's continuous improvement work alongside new development work.

A good business case and estimations about both benefits and costs were required by the management. Benefits were estimated based on how much revenue would be protected and how much new sales would be generated based on new features. Benefit estimations varied greatly as stakeholders predicted how business cases would unfold in the marketplace. Essentially benefit estimations were based on gut feelings, and numbers could be massaged to support whatever business case people wanted to believe in.

Modernization was primarily seen as a success, though all the new business benefits and sales have not yet been realized.

4: The interview covered the consultant's experiences throughout two decades in rewriting systems that had deteriorated into a form that required a complete rewrite for different reasons. In a few cases, the original technology platform was reaching the end of its life, though the system itself still worked well – and the customer would have needed just a few additional features.

The consultant emphasized that systems should be taken care of constantly and lamented that software lifecycle management is missing from many organizations. Consultants' career was filled with examples of rewriting operational systems almost as they were, but with newer technology. Organizations had not done proper lifecycle management of the systems, and changes in the environment that required changes to the system made organizations realize that they needed a complete system renewal.

5: The interviewed consultant had been an ICT manager in his previous career phases and covered his experiences from business and IT management interface. Examples were from the transportation industry, where he transformed the business IT relationship with the application of ICT standard (renamed to Business Technology Standard). He also mentioned Gartner's run, grow,

transform -model as a way to have conversations about how IT investments should be used in companies to deliver positive change.

Overall, he emphasized the impact of good IT governance and the business lead steering model, which in his experience, improved the business-IT relationship. At the same time, he described that companies have challenges when they do not have transparency, clear metrics, and proper feedback loops about value realization in IT management back to business.

6: Discussed two transformation cases where changes in the competitive landscape served as triggers for organizations to renew and improve internal platforms to enable organizations to stay competitive and serve users better. Both transformations were strategic changes led by the top management and linked to clear strategic visionary themes regarding customer understanding.

Cases were different from other interviewed cases, as the transformation and renewal needs were identified in top management. It was identified that existing platforms could no longer support the organizational missions or align with new value streams.

7: Discussed the renewal process of critical capabilities in one of the organization's domains. Triggers for renewal were increased costs and the evolution of the business needs into something that the existing platform does not support. The renewal process included research into market options, proof of concept testing, and vision workshops, where the capability team tried to predict how the market could evolve during the coming years and how that would affect their ability to deliver the service. This future vision was created with the help of Wardley mapping and especially value stream mapping to understand what capabilities and sub-capabilities are needed.

The architect described that the organization has low maturity in quantifying things like value, but they are having continuous alignment discussions with the business to understand better how they support objectives on a tactical level and get fast feedback from the market.

8: Discussion focused primarily on situational awareness application modernization case for an operator of a business ecosystem around a transportation and logistics domain. Modernization was needed as the business environment was evolving, and the existing system was not producing the intended operational benefits. The business needed a solution to enable the operational ecosystem to respond to and coordinate incidents in a challenging multi-stakeholder environment with a common operating window. The business understood that a better solution was needed, but justifying new spending based on hypothetical value seemed challenging – especially as the current system did not provide intended benefits.

Modernization was eventually started as a design-led MVP project that focused on clarifying the concept and outcomes that the organization needed. Eventually, when the system was operational and changed organizational behaviours, it showed cost savings and improved effectiveness with new emergent behaviour from the system's users. The system’s success is now measured with lagging indicators related to the platform's active usage. If relevant actors are actively using the platform, it must be providing value to the ecosystem.

9: The product owner discussed the case of modernizing a user interface and functionality of a back-office functionality of a user-facing service and capability. The business stakeholders who negotiate prioritization and make value judgments were not personally using the system themselves but were expecting value from the usage of the capability in the organization.

The trigger for renewal was identified failure demand from the end users in the form of questions and problems that users expressed having with the system. These problem signals were not in official metrics or discussions about the value that business stakeholders would see. Still, the product owner convinced them that this kind of improvement is important and will impact in greater usage of the capability.

The product owner then iterated that as there was no common understanding of value and impact, this modernization work got blocked multiple times and postponed when business stakeholders got other urgent needs that they wanted to get fulfilled. To his experience, that seemed like a typical scenario, where product owners get very contradicting requirements, and there is a constant pull between the development of shared capabilities and customized, very agile and specific niche solutions. There would be a need for lightweight decision-making and sense-making tools to help to make value visible and to prioritize work.

10: Director described his experiences in observing decision-making in organizations and focused on public sector companies that need to use structured Togaf-based architecture practices and prepare proper life cycle analysis reports before organizations can venture into modernization efforts. Decision-making this way takes a long time and does require many resources – but it also provides alignment and an easily transferrable understanding of the organisational needs.

Typical triggers for modernization discussion and considerations were environmental triggers that change the business of the public sector organization and more technical triggers related to costs, quality, and slowness of development on top of existing platforms or systems. Without these significant triggers, organisations try to manage their operations as long as possible with existing old systems and even accrue a lot of technical debt.

Director noticed that sometimes organizations have a lack of situational awareness of the status of their application portfolio and lack common metrics to make proactive decisions on maintenance or renewal to keep systems fit for purpose and in good technical quality. As a positive development, the director commented that organizations are starting to use value stream thinking as a way to think and measure organizational performance over measuring just the performance of individual applications without the connection to value creation.

11: The enterprise architect reflected on his long experience in large enterprises and discussed this topic within the larger frame of having a well-functioning interaction between the business and IT and maturity to measure and drive organizational benefits with the development of capabilities that are not directly, and self-evidently linked to the bottom-line performance. He identified five primary cases for renewals: application no longer fit for purpose, the total cost of ownership is too high, architectural quality is low even though functionality would still be ok, rationalization of the portfolio, or larger strategic change.

In the discussion, the core focal point was the role of an architect and architecture practices to have a good ongoing relationship with the business to build a runway for the organization to evolve. Different types of processes and tools can be enablers for sense-making, but in the end, the most important thing is to have an ongoing conversation and sense-making about how IT capabilities will help the organization achieve its goals. An organization is a socio-technical entity, and good decision-making is very context-dependent.

12: The interviewed vice president has a long career in software development and decision-making. During the interview, he reflected on how he has observed decision-making and what kind of mental models are needed to learn about the system and problems. The discussion emphasised professional intuition in both recognizing the signals from the business as well as the quality of the software development organization or specific systems.

Instead of focusing on formal frameworks and tools or estimating large and complex changes beforehand, the VP emphasized the need for agility. Agility is the key to making better decisions and understanding their impact in a fast feedback loop with a complex adaptive environment.

13: As the devops lead’s career is focused on building enabling platforms and improving organizations’ capability to deliver valuable software faster, that was also the central perspective in the interview. Some organizations make modernisation decisions based on risk management decisions almost as late as possible instead of having a more proactive and controlled approach to managing the lifecycle. This causes modernization projects or programs to become larger, more complex, and less agile. The interviewee postulated that one reason is that many organizations do not yet

see the impact of software and software delivery capability in their business. Therefore, they do not see delivery value streams and agility as providing value or being competitive advantages. But these days, even banks are software companies that just happen also to have banking licenses.

He identified three core drivers for modernization needs: change in customer demand or within the environment that requires the organization to enable new businesses, the need to accelerate the business cycle inside the organization and decreasing costs and risks. Instead of focusing on systems, organizations need to look at value streams and organize themselves around improving the flow of value. And enhancing the flow of value requires better measurements and proper hypothesis-based development for organizations to actually learn the impact of changes they make. Quality must be built into the product and processes.

Enabling platforms with high levels of automation and self-service enable more mature digital organizations to divide significant transformations into smaller pieces and experiments that produce better value sooner.

14: Discussion focused on two experience reports from a large supply chain company. The first case was about consolidating multiple different regional warehouse management systems into a smaller number of systems to be able to provide common capabilities to all the markets more efficiently. The second case revolved around increasing the organizational delivery cadence from once a quarter to enabling value delivery even daily. Both cases were triggered by the need for business agility and changes in the environment, as competitors like Amazon were causing significant disruption to everyone.

Key insights in the discussion revolved around having the right mental model and measurements for software and software delivery capability. Measuring value is hard, but organizations need to focus on metrics that measure outcomes, not output. In many business environments, organizations would benefit more from a product development mindset than a manufacturing mindset about building and managing software. Enabling platforms make it possible to run low-cost business experiments, learn fast and react to changes in the marketplace.

6.1.1 Interview discussion analysis

Unsurprisingly interviewed persons reflected common themes present in the modern software and product development literature. All the interviewed persons seemed to have similar overall perspectives about managing service and system evolution inside organizations. The following seven themes were repeated in the interviews: collaboration between business and IT, measurements of value and quality, shared understanding of how IT produces business value, value stream thinking, regular maintenance of software systems, business agility and software delivery capability.

The first theme was the good collaboration between business and IT (mentioned in the following interviews 1,2,3,4,5,6,7,9,10,11,12,13,14). This enabled understanding of how the service or capability can serve positive business outcomes and recognize even weak signals if there are business changes or need for changes in capabilities.

Similarly, it was seen as essential to have some measurements of value and quality to support decision-making (mentioned in interviews 1,2, 3, 4, 5, 6, 7,8, 9,10,11,12,13,14). However, interviewed people also recognized that it is hard and that many people trust their gut feelings or instincts. For example, multiple interviewed persons used the example that modernization needs can be identified if the ‘development of new features starts to feel slow.’

If there is no shared understanding of how IT services or capabilities produce business value and how the capability to deliver service and react to changes is important – important capabilities might get seen only as a cost centre and lack the needed funding (mentioned in interviews 1,13,14).

Properly applied value stream thinking can enable organizations to free themselves from the system focus and connect the outcomes that the capabilities produce into a more meaningful context for the organization (mentioned in interviews 6,7,10,11,13,14).

All the interviewed persons signalled their understanding that software systems and capabilities require regular maintenance, or they start to deteriorate. Some interviewees specifically pointed that out, as it had been a source of problems or modernization trigger in some of their cases (mentioned in interviews 1,3,4,5,7,9,11,12,13,14).

Lack of business agility came up as a concept in discussions multiple times, as interviewees explained how changes in the environment, competition, or business needs had shown challenges with existing systems or platforms, limiting the ability of the business to achieve some goals (mentioned in interviews 2,3,6,7,13,14).

Organization’s software delivery capability was an important theme in a few discussions where people operated in environments where organizations saw software as an integral part of their value chains and, therefore, also the organisational capability to deliver software as a competitive advantage (mentioned in interviews 3,4,7,12,13,14).

6.1.2 Based on interviews, how organisations seem to identify and quantify their modernisation efforts

Regarding the actual research question, it is impossible to give insights into a conclusive answer, as interviewed persons represented different organizations and capabilities. But based on these short discussions, few concrete themes and prototypes of behaviour emerged.

First, in identifying modernisation opportunity or need, three distinctive groups were present: 1) cost/value consideration within normal IT governance process, 2) need to re-evaluate the system's future based on an external trigger, and 3) business transformation need.

First group's behaviour was described in the interviews but was not a focal point in discussions. It was implied that costs are well-understood concept and easy to measure. Still, value was considered much harder to quantify, and interviewees considered that value is what the business considers to be valuable. Depending on the size and maturity of the organization organisations can have additional dimensions like technical quality and conformance to the enterprise architecture in their considerations.

The second group was characterized by organisations responding to sudden external events and identifying the need to re-evaluate their previous assumptions and decide how to continue. Examples include situations when organizations recognise inability to respond to business needs, significant pricing changes in platforms, or major security vulnerability that must be patched in the legacy environment.

The third category describes cases where the business recognised the larger need to change. These are characterized by the business management support and clearly defined business driver, even though the outcome would be a highly technical outcome like the capability to have 360-degree view of the customer over separate business units or to improve the organizational value delivery cadence from once a quarter to ability to release features daily.

6.2 Questionnaire results

Even though the questionnaire was shared widely and got thousands of views based on social media data just on LinkedIn and Twitter, there were only 19 responses to the questionnaire. A small number of responses was disappointing but gave the opportunity to look at each answer more closely and reflect on how responses compared to the discussions had in interviews, as well as information presented in the literature.

Initial data analysis was done in Microsoft Forms results interface and Microsoft Excel before loading the data for additional data processing with SciPy and Pandas. IntelliJ IDEA was used as the programming and data science environment, as it allowed fast feedback loop in processing data and checking for correlations. How questions were coded is described in appendix 4, and appendix 5 includes code examples of analyses.

Demographic information from the survey showed that respondents came mostly from large organizations. For analysis, responses are analysed based on the following groups: small companies with less than 10 million euros in revenue, medium-sized companies with up to 50 million euros of revenue, mid-size enterprises with up to a billion euros in revenue, and large enterprises with over billion euros of revenue. The first two categories are based on EU definitions, and the mid-size enterprise definition comes from Gartner. Based on this classification, there were two small companies, two medium size companies, nine midsize and six large companies.

Likert scale responses were coded into numerical values by giving

1 - Strongly disagree
2 – Disagree
3 - Neither agree nor disagree
4 – Agree
5 - Strongly agree

6.2.1 Demographics information

Demographic information shows that based on respondents' answers, the questionnaire mostly reached midsize to large companies.

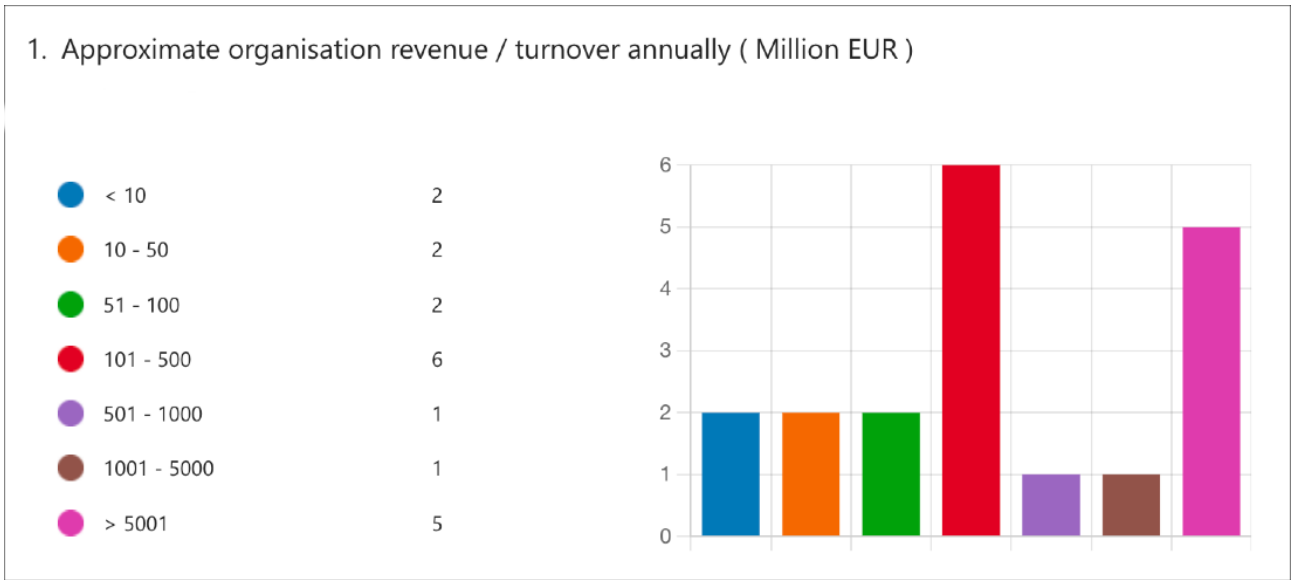


Figure 31: questionnaire result distribution to revenue question

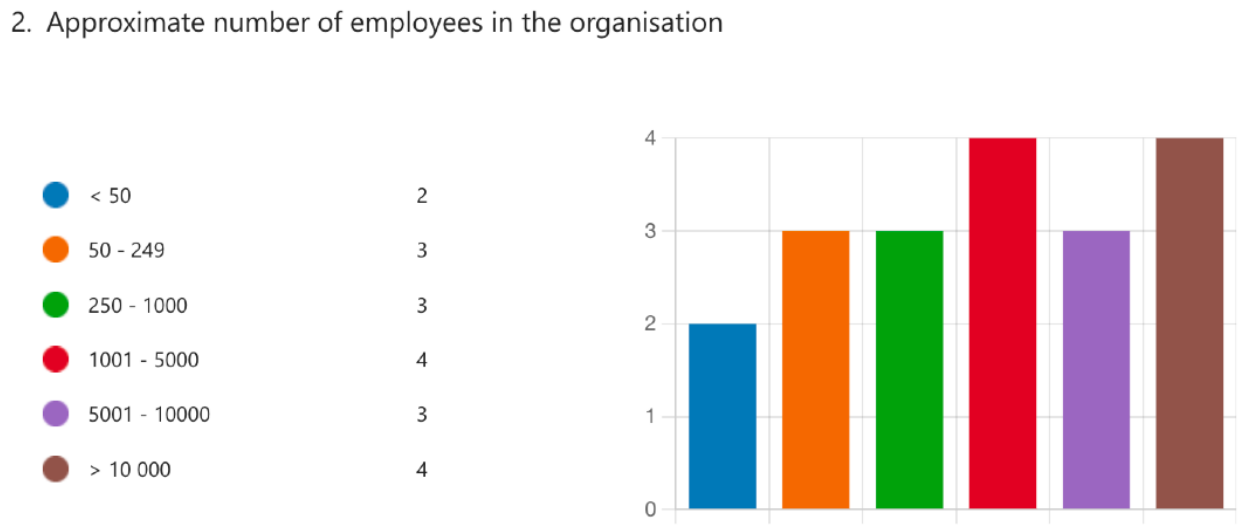


Figure 32: questionnaire result distribution to employee count question

Similarly, it was positive to see that responses mainly were from cases in progress – which gave hope that the responders could remember cases vividly.

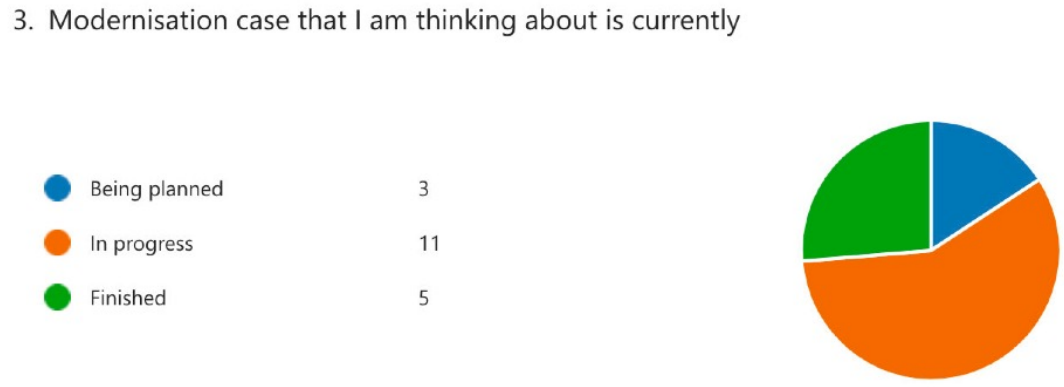


Figure 33: questionnaire result distribution to case status question

Reported modernization cases also covered an extensive range of different scales but mostly focused on larger-scale projects – which was also expected. If the cost of modernization were small, it might not even require special consideration – but instead would be just a decision among other decisions.

4. Approximately how big was / is the considered modernisation effort investment (estimated effort) thought to be in thousands of EUR?

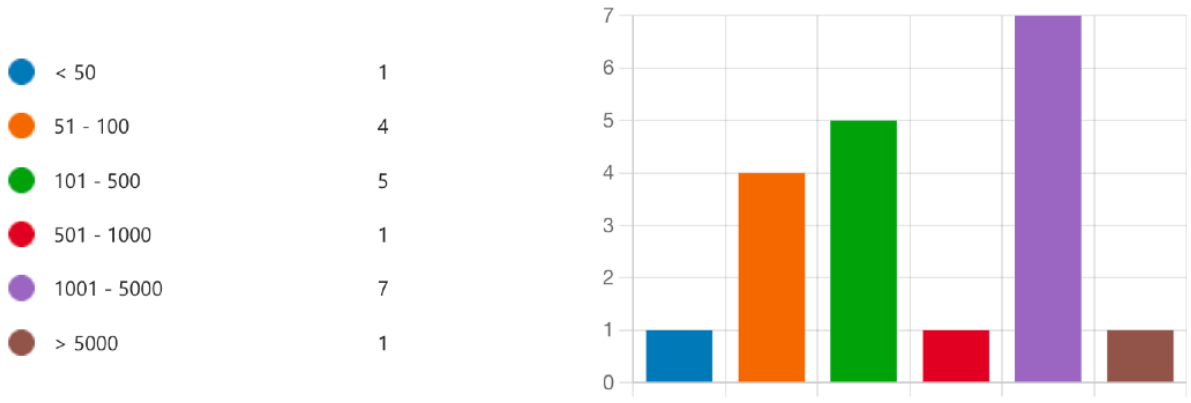


Figure 34: questionnaire result distribution to modernisation case size question

Responders whose modernization effort was finished mostly reported that work was finished with costs as expected. Only a very large modernization effort was reported to cost more than expected.

Of modernization efforts that were still in progress, all the efforts over million euros were expected to either cost more than expected or the responder did not answer the question.

Overall, there was a moderate correlation (correlation of 0.47, weak probability p-value of 0.08) between the size of the modernization and it costing more than expected.

5. If the modernisation effort is underway or done, are the actual costs (based of best available estimation)

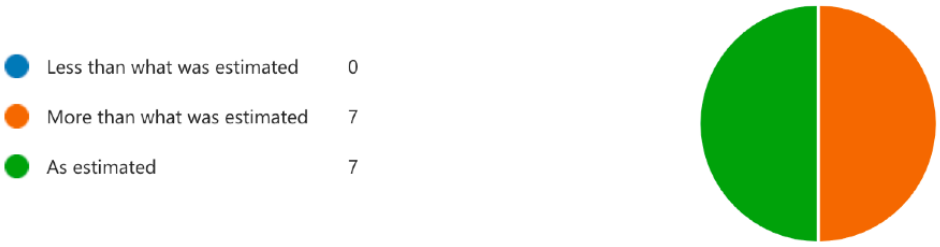


Figure 35: questionnaire result distribution to modernisation cost estimate accuracy question

Responders had a balanced mix of decision makers and influencers.

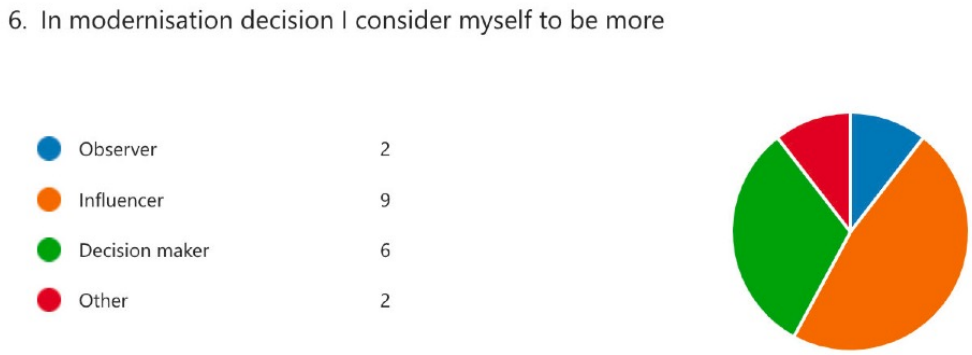


Figure 36: questionnaire result distribution to responder decision role question

Responders were biased more towards technical persons, reflecting the composition of social networks in which the questionnaire was distributed. Also, the nature of the questionnaire was such that it was expected that it would resonate more with people who identify themselves more as technical persons.

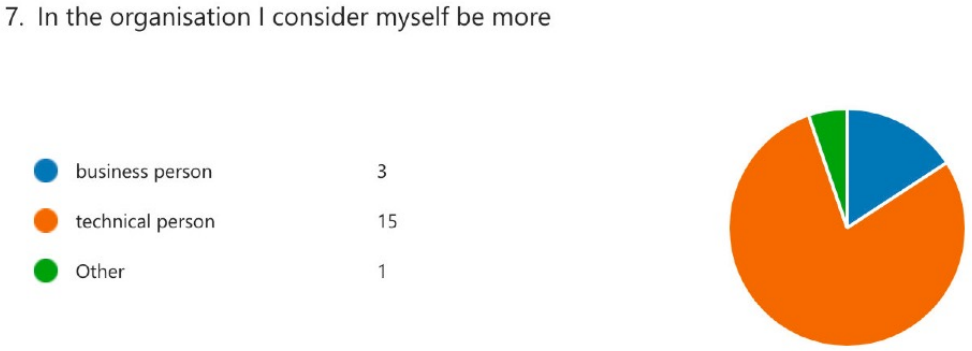


Figure 37: questionnaire result distribution to responder role question

6.2.2 Decision-making environment

Questions relating to the decision-making environment aimed at understanding the context in which decision-makers or influencers do their work and how they perceive the current status in their organization. This contextual information already shows that there were many variances in how people perceived their decision-making environment among responders.

Based on the data, it is also important to notice that decision-making in organizations is human activity, which combines both qualitative and quantitative data and subjective and objective data. Clear bias was towards subjective data.

Interesting questions are those that responders have answered to react strongly, either in agreement or disagreement. And where unexpected differences were noticed between groups.

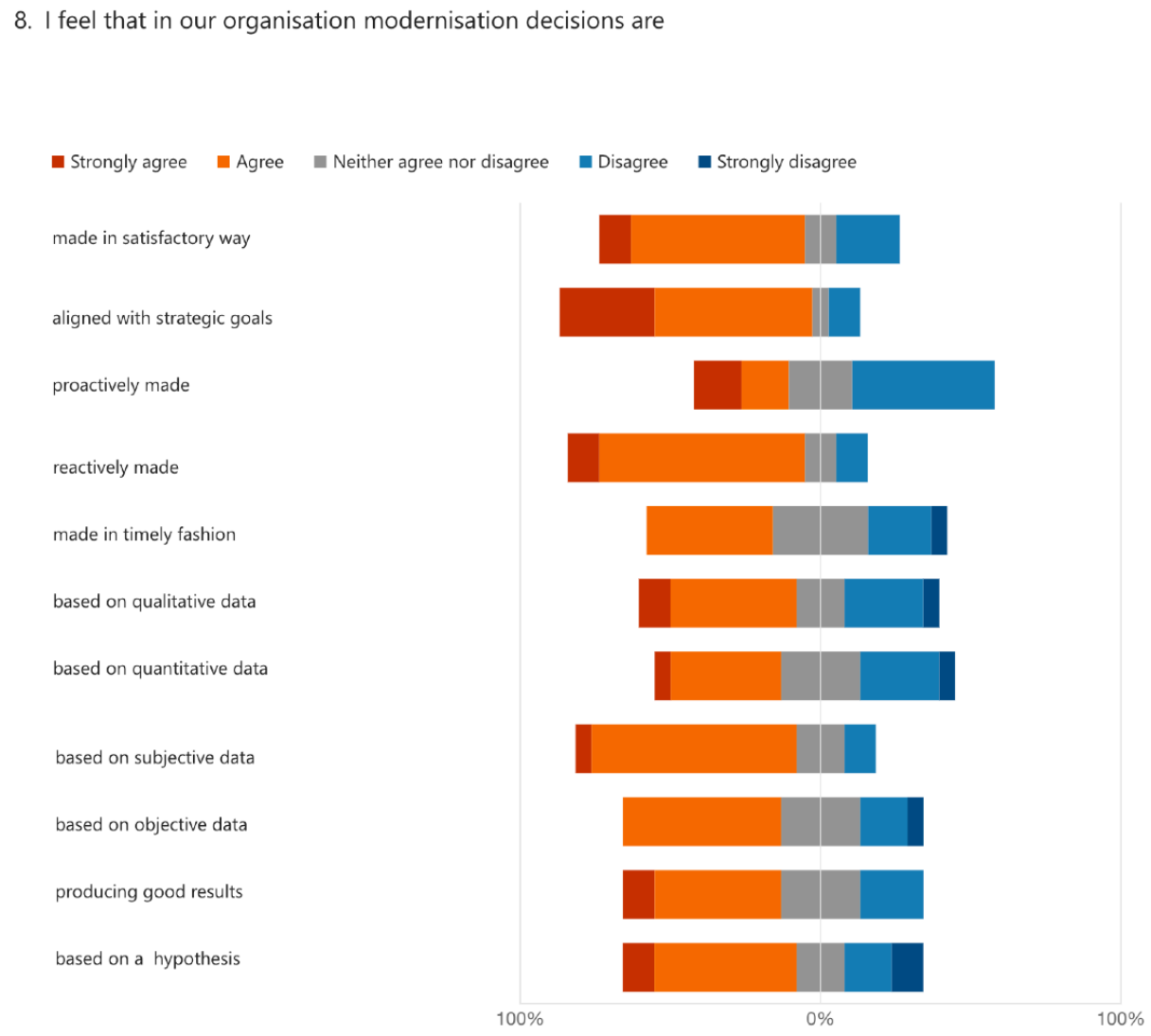


Figure 38: questionnaire result distribution to decision-making question

Responders mostly agreed that decisions are made in a satisfactory way, as 68% of them either agreed or strongly agreed with it. Only responders from large organisations disagreed. The mean value for responses for other groups was 4.0 or 4.5, and for large organizations, it was 2.5.

Strategic alignment was also highly agreeable, as 84% either agreed or strongly agreed (31%). The mean response in all the groups was either 4.5 or 4.0.

Responders indicated that decisions are mostly made reactively, as 79% either agreed or strongly agreed with the statement. Proactive decision-making was agreed upon only by 31%, while 47% disagreed. Three responders had responded they agree/strongly agree on both proactive and reactive questions. Two responded that they were more proactive than reactive, while nine responders had answered that they were clearly more reactive than proactive.

Decision-making timeliness was a dividing issue. Though 42% agreed that decisions were made timely, a large group (31%) did not agree or disagree, and 26% disagreed or strongly disagreed.

On data usage, a bias was towards qualitative data. 52% agreed or strongly agreed with using qualitative data, whereas 42% agreed or strongly agreed with using quantitative data. Of the responders, five respondents agreed or strongly agreed on both questions. 2 respondents agreed more on using qualitative data, and 2 respondents agreed more on using quantitative data.

On data subjectivity, there was a bias toward subjective data. 73% agreed or strongly agreed with using subjective data, while only 52% agreed or strongly agreed with using objective data. Eight responders agreed on both, while three responders agreed more on using subjective data, and 2 responders agreed on using more objective data. Those responding to the use of more subjective data were all from large corporations, and those using more objective data were from medium or midsize organizations.

Responders considered, on average, that modernisations produced good results. 52% of all responders agreed with that statement, while mean values for each group were 3.5, 2.5, 4, and 2.8,

Similarly, respondents considered agreed by 58% that their modernizations are based on hypotheses. This agreement was more substantial in small and medium-sized organizations with mean values of 4.5 and 4.0. Midsize size and large organizations have mean values of 3.2 and 2.8. There was no correlation between agreeing with modernization being hypothesis-driven and producing good results.

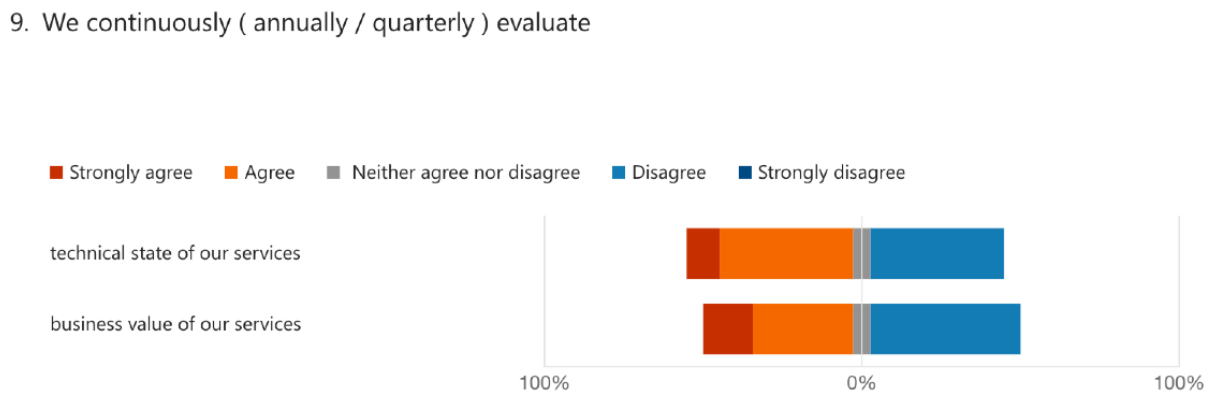


Figure 39: questionnaire result distribution to the continuous evaluation question

Continuous evaluation of the state of services was divisive. While 52% (10% strongly) agreed that they continuously evaluate the technical state of service, 42% disagreed with the statement. On the continuous evaluation of business value, agreement and disagreement both had 47%. There was no correlation between the continuous evaluation of either state and reported agreement between modernizations producing good results or responders agreeing that decisions are made satisfactorily.

Those responders that responded that they both continuously evaluate both technical state and business value of services on average answered that they also got good results from modernizations (mean 4).

6.2.3 Causes to consider modernization

Modernization triggers also partially reflect the modernisation needs identification and measurement, as there usually needs to be some kind of mechanism to form a perception of costs, risks, quality, agility, or value that a system or capability provides.

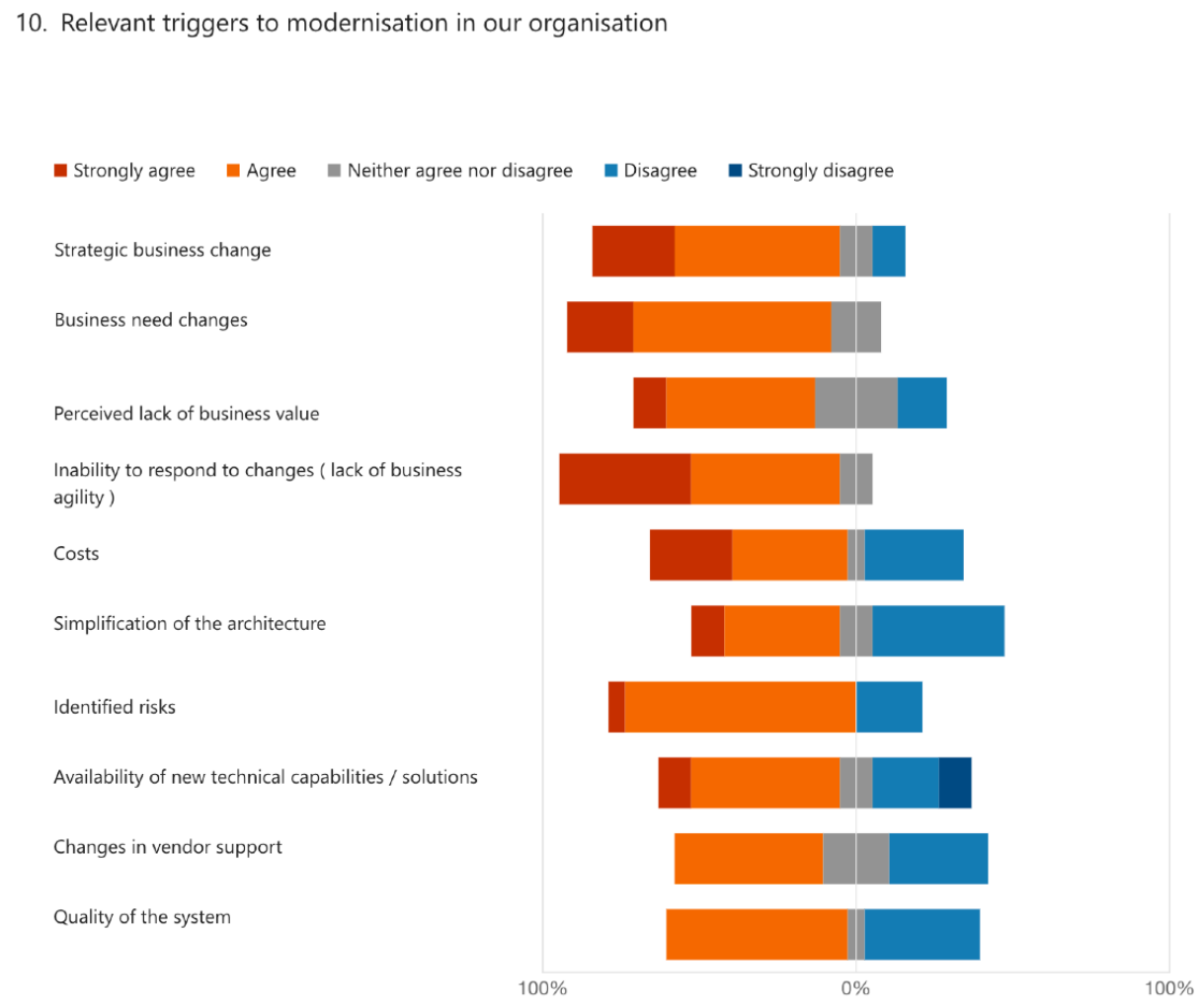


Figure 40: questionnaire result distribution to modernisation trigger question

Some modernisation triggers were clearly agreeable. 78% of responders agreed or strongly agreed that strategic business changes are a relevant trigger, and 26% agreed strongly. This agreement was mainly visible in medium, mid-size and large organizations with mean values being 5, 3.8, and 4 – while smaller organizations did not agree or disagree.

Business need changes were agreed or strongly agreed to be a trigger by 84% of responders, and 21% agreed with it strongly. The mean values for responses in groups were 4.0, 4.0, 4.2, and 3.8.

Perceived lack of business value was agreed to be a trigger by 58% of responders. The agreement was biased to be more present in smaller and medium-sized organisations, as medium values were 4.0, 4.5, 3.1, and 3.6.

Lack of business agility was a highly agreed trigger, with 89% agreeing with it and 42% of those responders agreeing strongly. The mean values in responding groups were 5.0, 4.5, 4.1, and 4.3.

Costs were agreed to be a relevant trigger by 63% of responders, and 26% of responders agreed strongly. At the same time, 31% of responders disagreed with the statement. Mean values in different groups were 2.0, 3.5, 3.7, and 3.8.

Another divisive trigger question was if the simplification of architecture is a relevant trigger. While 47% agreed, 42% disagreed. Mean values were 3.0, 3.5, 3.1 and 3.1.

Identified risks were agreed relevant trigger with 79% agreement. Mean values were 3.5, 3.0, 3.5 and 4.0.

Availability of new technical capabilities / solutions was agreed upon only by 58% of responders. The mean values reported were 3.0, 4.0, 3.2, and 3.1.

Changes in vendor support was agreed to be a relevant trigger by 47%, while 31% disagreed with the statement. Mean values were 2.5, 3.0, 3.1 and 3.5.

The quality of the system was a similarly divisive trigger as 58% agreed with it, and 37% disagreed with it. Mean values in groups were 4.0, 4.0, 3.3, and 2.5.

Free form questions “Are there other important signals that trigger modernization consideration in your organization?” and “Can you give examples of signals and situations that have triggered modernization considerations in your organization?” received 7 and 6 responses, which continued the themes in the Likert-scale questions and made concrete examples about change triggers.

Regulatory changes, increasing risk from legacy technology, growth of the development organization, need to improve development throughput, and need to implement features across systems were mentioned as concrete signals to trigger modernization consideration.

One more extended response also included poignant consideration that problems with product feature in production trigger repair actions and fixes and potentially technical consideration if the platform should be modernized. But based on this responder’s opinion, that decision to modernize does not happen, and more technical debt will be accrued – until the business will fail.

Described situations where considerations were triggered could be described as moments where successful software is no longer fit with the requirements of a changed environment because the change is surprising or because the organization has impaired their ability to respond to changes by letting the architecture to become too coupled/rigid or by collecting too much technical debt.

6.2.4 Need to modernize measurement

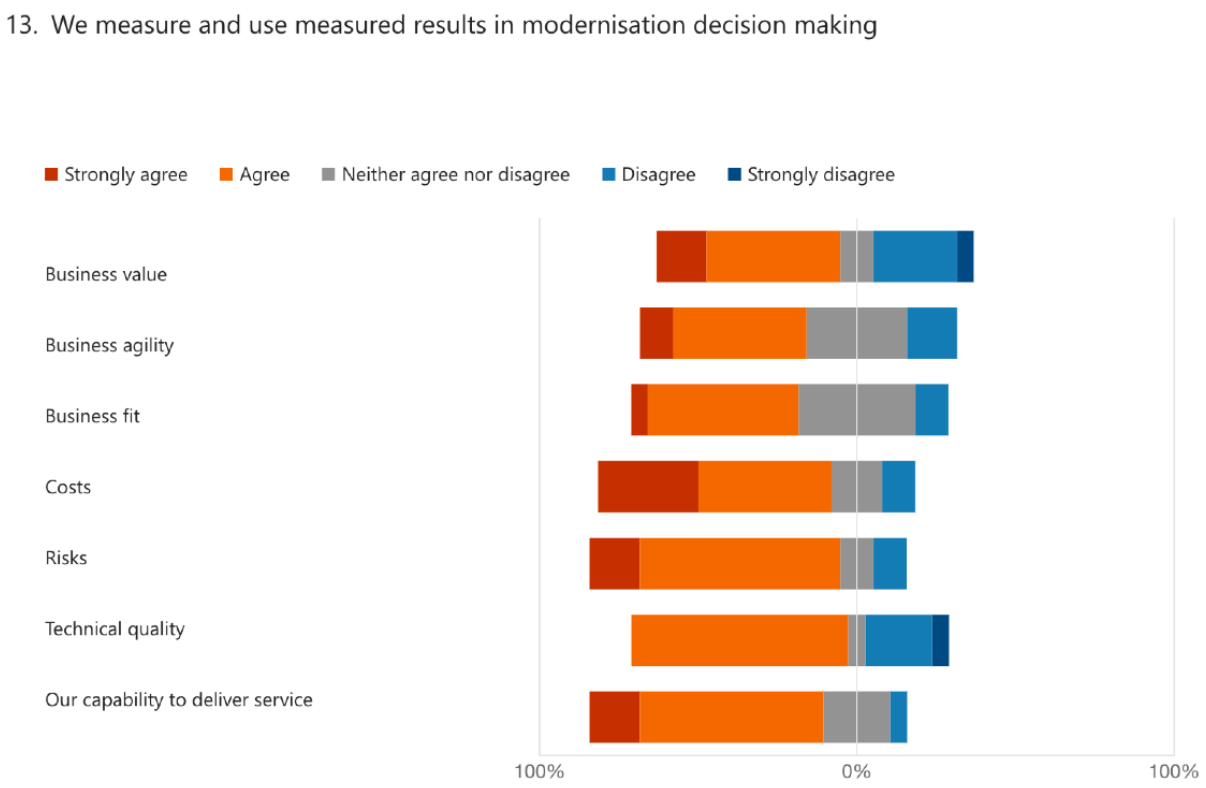


Figure 41: questionnaire result distribution to modernisation needs measurement question

The modernisation decision-making measurement statements also provided interesting insights.

57% of responders agreed or strongly agreed that business value is measured in decision-making. Mean values in responder groups were: 1.5, 3.5, 3.6, and 3.5.

Business agility measurement was agreed upon by 52% of responders. Mean values are 3.0, 4.0, 3.7, and 3.

Business fit measurement was also agreed by 52% of responders. Mean values are 3.0, 4.0, 3.4, and 3.5.

Costs as a measuring element in decision-making were agreed or strongly agreed upon by 74% of responders and strongly agreed upon by 31% of responders. Mean values were 2.5, 3.5, 4.3, and 4.0.

Similarly, risks were agreed to be a measured element in decision-making by 79% of responders. Mean values are 3.0, 4.0, 4.1, and 3.6.

Technical quality was agreed to be a measured element by 68% of responders. Mean values being: 2.5, 2.5, 3.7 and 3.3.

An organization's capability to deliver service was agreed to be measured by 73%. Mean values were 4.5, 4.0, 3.8, and 3.5.

The freeform question for examples about measurement received eight responses. Responses included general business metrics like revenue growth, productivity growth, sales, customer complaints, total costs for usage, cost-benefit assessments, risk assessments, and delivery speed of new features.

Freeform questions for additional quantifications and considerations received five responses. Responses included the following consideration to the availability of development talent with used technology, how aligned the system is with selected architecture and technology decisions in the organization, the opportunity to automate previously manual work steps, and customer feedback.

6.2.5 Modernization opportunity quantification

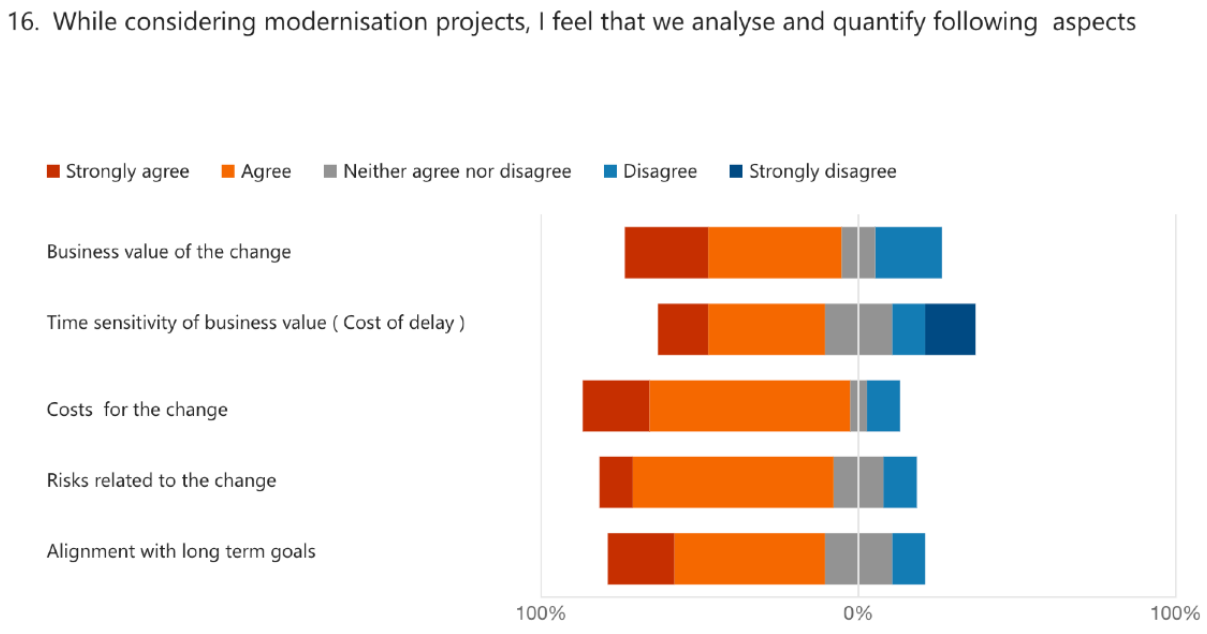


Figure 42: questionnaire result distribution to modernisation opportunity quantification question

In considering modernization projects, responders agreed or strongly agreed with 68% that they analyse the business value of the change. 26% agreed with that strongly. Response groups' mean values were: 2.5, 5, 3.8, and 3.5.

Time sensitivity as an analysis factor was divisive. 62% agreed or strongly agreed. 21% neither agreed nor disagreed. Mean values were 3.0, 4.0, 3.3 and 3.0.

Costs for the change were agreed or strongly agreed by 84% of responders. The mean values in groups were 2.5, 5, 3.8, and 4.1.

Risk related to the change was agreed or strongly agreed to be analysed by 73% of responders. The mean values in groups were 3.0, 3.0, 3.8, and 4.0.

Alignment with long-term goals was agreed or strongly agreed to be analysed by 68% of responders. The mean values in groups were 4.0, 3.5, 4.1, and 3.

The freeform question about examples of quantification of value or benefits of modernization gained five responses: lower total costs for operations, increased effectiveness, saved effort, and ability to improve the speed of delivering business capabilities.

The freeform question about the quantification of costs received six individual comments. All the responses emphasized that standard business cases are based on work and investment estimates.

The freeform question about risk quantification got six responses, but the responses were essentially the same: assessing risk probability and impact on a risk map.

The freeform question about other things typically quantified and considered got one response that listed four things: criticality of the system, what business function the system is for, how many other systems are dependent on the modernized system, and how many other organizational dependencies there are.

6.3 Analysis of interview and questionnaire results

As the sample size is relatively small from a very large population, making too far-reaching conclusions from these results is not sensible. But it is possible to get some insights from even this data.

Based on the interview discussions and questionnaire responses, it is safe to say that modernization needs identification and considerations are reactive activity. During interviews, interviewed persons expressed that their organization is aware of assets they have in use, and their status is monitored. Still, as there was no unified measurement for the status and associated risk of the

deteriorating asset, action is not necessarily taken until a sufficiently important external signal forces the organization to act finally.

Interviewed persons and responders to the questionnaire mostly did not express that they would be worried about the situation or that they would consider the state of matters as problematic for the business, except for one questionnaire responder who expressed frustration that the lack of action from the business to fix technical problems on the organization's platform will cause the business to collapse eventually.

And this could be the crux of the whole problem. Some decision-makers in the organization are intuitively making probabilistic predictions about the future without necessarily quantifying and communicating their heuristics and decision-making in the organization. Hence ageing and problematic systems are kept an eye on, but the thresholds and signals to act and how much to act are extremely fuzzy.

This professional intuition can be seen as a huge asset in the organizations, but at the same time, it could be considered a liability – as, without a common measurement and understanding, the organization is not necessarily aware of the risk position it is taking.

Top external signals expressed in interviews and in the questionnaire were, in addition to cost-cutting trigger ***inability to react to changes***, ***identified risks***, ***strategic changes***, and ***business need changes***.

In quantifying the need to modernize risks, the capability to deliver service and costs were identified as key components that organizations evaluate. But there were no clear definitions or examples of how people in organizations quantify and evaluate these fuzzier components like risks and capability to deliver service. So even though customer complaints, incidents, or downtime would be tracked, it is still most likely interpreted intuitively to eventually make expert judgments whether the time to act is now. Additionally, key considerations in making the actual modernization project decision were described to be **costs**, **risks**, business **value,** and **alignment** with long-term goals. Within interviews or in the questionnaire responses, it was not elaborated how value or alignment with long-term goals is quantified or measured.

7 The proposed model to quantify modernization needs and opportunity

Based on the literature review and interviews in this research, I postulate that fundamentally work system modernization decision-making is a messy problem domain where actors are trying to make long-term decisions in complex adaptive systems with imperfect information.

Accepting this axiom allows us to focus on hypothesizing a model that can work as a sense-making tool and help actors make better decisions even in situations where organizational maturity to make data-driven decisions and the capability to consistently follow them through successfully is low.

This model was developed iteratively with the project team at Siili Solutions, reflecting insights and ideas gained during the thesis project and in customer projects. Model contents and descriptions were evaluated by consultants who lead or participate in modernisation efforts to gain feedback on how it made sense to them and how they could see it being used as a tool in real-life scenarios.

The model is not intended to be complete or perfect, but rather a good enough starting point and practical enough to improve decision making in organisations that do not already have a better alternative decision making framework available.

The model is presented in detail in the following sections.

7.1 Identify the primary business driver

The first component of the model is the business driver of the modernization consideration. Identifying the correct business driver is crucial to focus on the right metrics and options in the effort. Depending on the organizational size and different contexts, it might not be self-evident to all participants in the decision-making if the business driver is more about costs, enabling growth, or achieving some larger transformations in the business.

In this thesis, I postulate that it helps, and it is important that the business driver is clarified, shared and metrics are selected based on the selected business driver. As a conceptual model, I propose to use Gartner's "Run, grow, transform"-model and to select contextually applicable business metrics to understand how value could be quantified in these different categorial cases.

The focal point in this framework and thinking is to be able to categorize how services under consideration provide value to the business - and to focus on the right arguments.

1. ***Run the business*:** Providing consistent quality services and improving price-to-performance ratios while reducing cost and risk.

Value statements: Justify the investment in terms of price/performance.

2. **Grow the business:** Improving top-line revenue with existing business models through improvement and innovation of products and services, the processes that deliver them, and the IT services that enable them.

Value statements: From measurable operational improvements and a plausible set of value chain connections instead of directly forecasting financial benefit. Stakeholders must see how the business value is generated to understand the opportunity properly.

3. **Transform the business:** Radical innovation of products and services, the processes that deliver them, the business models that drive them, and the new markets and customers they serve.

Value statements: At the market level, describe what makes the market new or different and the new rules that will separate winners from losers. At the enterprise level, describe what the bet is: what is at risk for the client and what can be gained.

Adapted from Bell, Betz, Schmidt (2012) and Hunter et al. (2008)

Unfortunately, run, grow, transform -model naming does not convey the business driver. Hence, I propose the following reframing to be used in this thesis to verbalize the primary business driver: ***cost and risk*** focus, ***acceleration*** focus, and ***transformation*** focus.

Business driver identification, clarification, and communication can then help further analysis and decision-making, as everyone participating in the process understands the business context and can focus on the solution space relevant to the company.

This model does not yet guide how to find proper metrics to be used in these different primary focus scenarios. It is up to the user to figure out contextually applicable metrics and measurements that can clarify communication and decision-making.

7.2 Identify capabilities needed

Depending on the organization's maturity and the availability of the architecture practice, the organization might have an architecture vision and documents that help in this. The goal is to understand how IT systems and services provide capabilities to the business and how those capabilities in use produce business value.

Capabilities describe what the business does, not how it is done. Understanding the needed capabilities allows one to reflect or identify if there is a capability gap in the organization.

As an example, a modified capability example from the real world.

Capability needed: the ability to personalize customer service and offers in all the available service channels based on the 360-degree view of the customer.

Current state: three main business units with separate CRM systems and multiple separate service channels, integrated customer data warehouse without record linking or ability to use the data in operational services.

Without an understanding of what capabilities the business needs and why the collaboration and decision-making between the business and IT can be cumbersome and unproductive. People might end up talking about just individual trees when we should look at the forest.

These identified missing capabilities or improvements of capabilities can be used in section 7.4.1 when the value of the potential change is evaluated. The development of common missing capabilities can be seen to have strategic enablement value besides the measurable tactical value.

7.3 Assess current state

Data can be easily and readily available depending on the organizational maturity of IT governance and service management capabilities. If data is not available, a rough estimation could be used. It is important to note that the assessment does not need to be precise. Precision and accuracy need to be at the suitable granularity for decision-making purposes.

I propose an assessment in three steps:

1. overview of the portfolio state
2. costs and risks
3. improvement opportunities

Each step requires additional work and might not be needed for all the services/applications. So, depending on the context, step 1 could be sufficient on the portfolio level for some applications, and then analysis could continue in additional steps with selected key applications.

7.3.1 Assess the current portfolio

The goal of light portfolio level assessment in the model is to make sure that there is a consensus about the situation before investing in further analysis – and prioritizing those services or components that have the most significant potential to impact the organization.

Stakeholders are suggested to be interviewed about three distinctive dimensions: business importance of the system or service, quality of the current system or service – and third, the currently understood change pressure that exists both from the business and IT side.

Business importance	If the system or service would stop being available, what would the impact to the business be? How could operations be continued and at what costs? What alternatives exist to continue the business processes without the system?
Quality assessment	What is the confidence that service levels are achieved? Based on understanding of how business is changing, what is the confidence that system can be modified to fulfil next change requests or new emerging requirements? What are the risks related to the service?
Change pressure	Based on current understanding about the near future, how the system's importance and technical assessment is going to evolve? Is some other system used for same functionality? Are new business units taking system into use? Are components requiring updates, or coming close to the end of life?

Table 2: Example discussion points to be used in the assessment

Business importance means what is the impact of the system on the business, considering all the other alternatives that the business has available or are easily acquirable to serve or help in serving the function that the system provides. What would be the impact if the system were no longer available to the business? How quickly and at what costs would the business be able to continue operations, and what would the impact be on the capability of the business to deliver value to customers?

This is a distinctively different question than regularly asked value questions, where the focal point is more on the current situation and processes as they have evolved throughout the years. The business can see the service as critical or highly valuable to them. Still, the actual impact of losing that implementation of that service would not be such critical, as there are alternatives and ways for the business to cope with potential problems.

For example, a hotel operator's businesspeople could argue that an electronic check-in & check-out system, which also prints outdoor keys to the hotel, is a critical and high-value system. But the loss of that system would not necessarily bring down the company. Nordic Choice hotels chain was

a victim of a ransomware attack and data theft that crippled their system in December 2021 for two days, but the operations continued with backup plans (Stupp 2022). On the other hand, in 2020, a psychotherapy service provider Vastaamo in Finland, was a victim of data theft from their patient database (Ralston, 2021). The public chaos resulting from the publication of the theft and release of patient data drove the company to bankruptcy (Ralston, 2021).

By having this distinction between highly valuable and actually critically important systems and services, the organization can focus on working on and improving systems and services that could put the business at risk.

Assessment of service quality should consider the organizational service delivery capability perspective, including maintainability, data security, and support risks that are inherently present in ageing or esoteric technologies. A technical solution can be solid and work superbly as it is now. Still, if there is no longer know-how or support available when the technology fails – it should not be ranked high as a technology that the organization can fix and get support on. Perception of technical quality is ever evolving, as the technology landscape and threats related to information technology are in constant flux. A system developed and engineered for another era can quickly become dangerous in a changed, more connected environment.

Assessment of change pressures tries to capture how business and service development and delivery already see the potential for that service to evolve in the future. Is the business aiming to increase the importance and usage of a system, and will that change the system's impact on the business? Are there trend reports suggesting that the system's technology, platform, or know-how gradually worsens, becomes scarce, or even ends?

This assessment is not intended to be scientific and accurate in all the potential dimensions but rather to get the understanding and perception what the potential business impact of a loss of a service or system is and what is the current confidence that the required service and functionality can be delivered in the near future. Results could then be quantified, ranked, and visualized, as presented in figure 43.

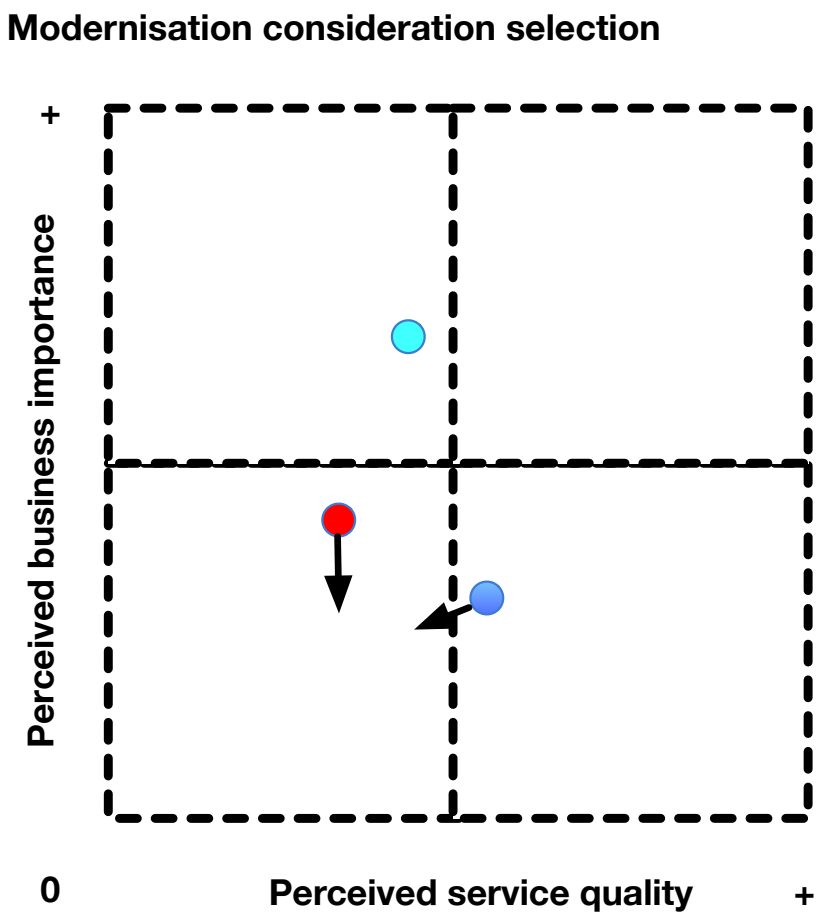


Figure 43: Modernisation consideration matrix with position showing assessment of the current state and arrow showing where and how much change pressure has been identified

With the help of created perception and visualization, a conversation can be had about where to focus on more in-depth analysis: systems with high impact and low or decreasing perceived quality.

The outcome from this phase is a business-focused shared understanding of the portfolio situation and an agreed focus on further analysis targets if needed. This means that it is also highly possible that, based on this analysis, an organization can agree that they are on top of the situation. There is no need to assess and quantify the situation more.

7.3.2 Assess systems for costs and risks, and link them to value stream steps

The second step in the assessment is to gather an overview of the costs that the current service or systems accrue. Overall, cost understanding is the foundation for assessing the impact of changes on the work system at hand. Risk identification is important to understand how much value is at risk in the current environment. Any change or changes will look expensive without a proper understanding of the costs, cost structure, and status quo risks.

Costs are usually readily available per service or system, but the analysis is needed to connect these costs to organizational value streams that produce value. A system or a service by itself does not produce value, but the service can provide organizational value when people in the organization use the system to achieve some goals.

System	Annual costs	Cost drivers
Salesforce CRM + service	1500k Euros	Number of users (500)
Product website	900k Euros	Support and development
Data warehouse	1500k Euros	Data capacity, Support
Product Infrastructure	6500k Euros	Used capacity
Product development infrastructure	3500k Euros	Number of developers and used capacity

Table 3: Example assessment of costs with system focus for a small company

Linking systems to value streams can be harder in organisations that do not have existing culture and mentality to think and communicate processes clearly. But the goal once again is clarity, not precision.

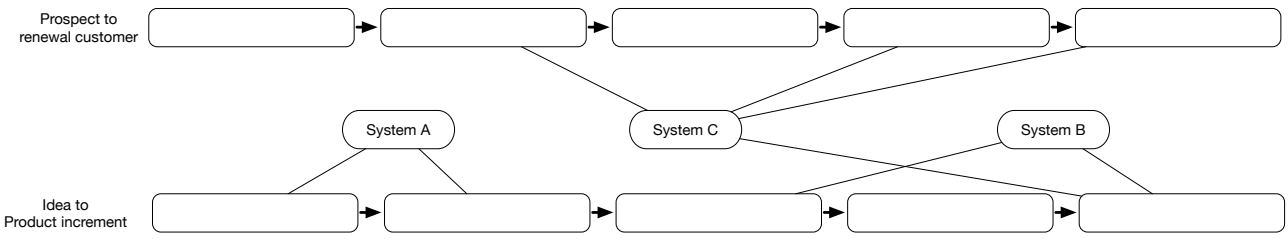


Figure 44: Linking systems to value streams

After systems are linked to the value streams, it is easier to estimate, evaluate, and understand the risks associated with each system linked to the organisation's value chains. Each system has inherent risks in itself through the information assets it controls or has access to. Still, additionally, systems have risks through the impacts they cause to the value stream if there is a problem, even with just the availability of a system. For example, what is the impact of one-hour downtime on the e-commerce site billing system during normal operations?

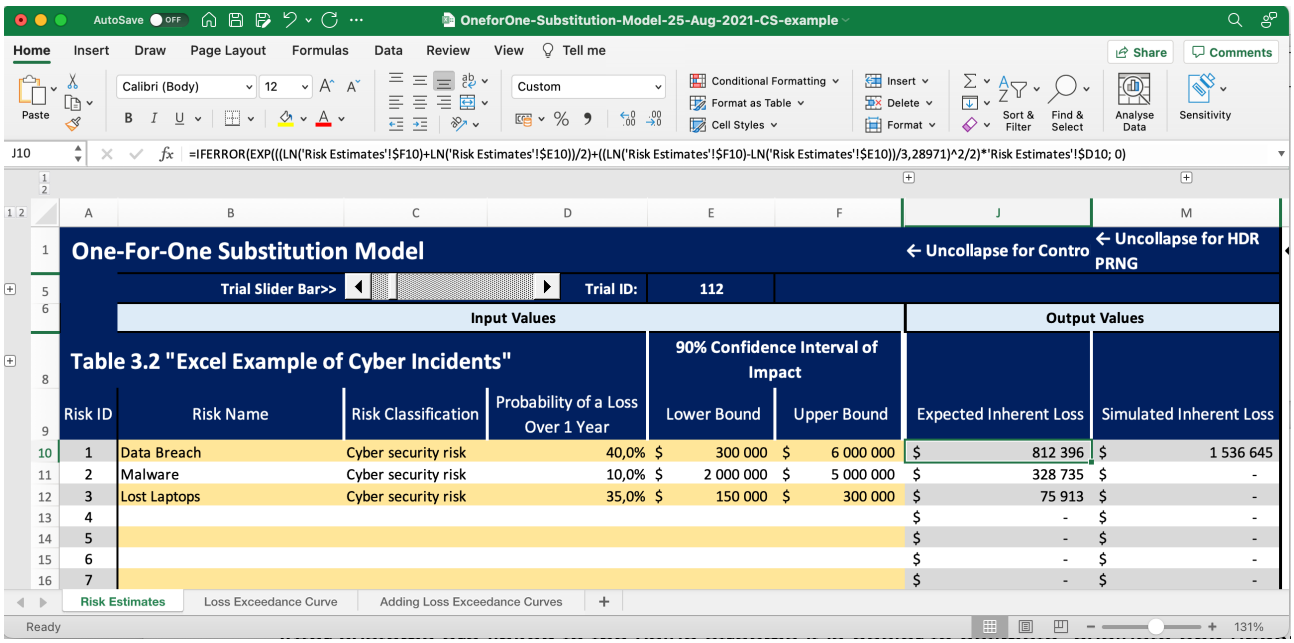
In this model, I propose that decision-makers try to quantify all the operational, technical, or service-level challenges as risk probabilities and impacts. There is no doubt that trying to assess what is the probability and impact of tightly coupled architecture to cause a business problem, for example, an inability to respond to business change requests in a timely fashion, is hard. Or what is the impact of increasing service incidents that users are experiencing with the service. Or what is the impact of bad user experience on a feature in an internal system that is used sporadically but needs to be done correctly, or it causes cumbersome and costly problems that take time to fix.

The core idea in this is that expressing all the challenges, quality problems, and accrued technical or architectural debt as risks with probabilities and impact makes it possible to assess if the risk position is acceptable or if an effort should be invested to improve the situation. Without such common assessment, every decision maker needs to do their interpretations and assessments individually and most likely just trust their intuition and be prone to all the available biases.

It will also be challenging for technical development teams and leaders to start to express technical debt as risks with measurable business impact. Still, I postulate that it is one of those missing pieces that will enable better collaboration and decision-making. What do we mean when we complain code quality of the system or the lack of agility in the architecture? How do we turn these assessments and characteristics of the work system into business risks and have a rational dialogue about how a quality attribute impacts the business?

There are different methods for assessing and rating risks. Among others, the OWASP association promotes a certain type of risk assessment method (Williams, 2020) that analyses and categorizes risks based on assessed likelihood and impact. Such categorization has its benefits and downsides, especially if risk assessment needs to be compared to actual investments that could lower or remove the probabilities of some of those incidents. Hubbard (2016) argues, based on research done by psychologists and decision-making scientists, that such scales and matrixes are problematic, introduce vagueness of communication, and should be abandoned in all forms of risk analysis.

Hubbard et al. (2016) propose the usage of quantitative methods to assess risks inside a system. In the simplest form, Hubbard proposes a simple probabilistic estimation model. In it, calibrated specialists estimate the probabilities of certain incidents happening over a specific timeframe and related range of the impact with a 90% confidence interval. A rough estimate can be calculated based on these estimations by taking a mean from a suitable probability distribution. In the examples given by Hubbard (2016), the lognormal distribution is used.



One-For-One Substitution Model

Trial Slider Bar>> Trial ID: 112

Input Values | Output Values

Table 3.2 "Excel Example of Cyber Incidents"

Risk ID	Risk Name	Risk Classification	Probability of a Loss Over 1 Year	90% Confidence Interval of Impact: Lower Bound	90% Confidence Interval of Impact: Upper Bound	Expected Inherent Loss	Simulated Inherent Loss
1	Data Breach	Cyber security risk	40,0%	$ 300 000	$ 6 000 000	$ 812 396	$ 1 536 645
2	Malware	Cyber security risk	10,0%	$ 2 000 000	$ 5 000 000	$ 328 735	$ -
3	Lost Laptops	Cyber security risk	35,0%	$ 150 000	$ 300 000	$ 75 913	$ -
4						$ -	$ -
5						$ -	$ -
6						$ -	$ -
7						$ -	$ -

Figure 45: screenshot from loss estimation worksheet by Hubbard et al. (2016)

Identifying potential risks and their probability and impact with finer granularity than rough categories requires more work. It also provides more value as specialists are able to express the impact that can result from incidents – and base that on available internal operational and shared industry data.

The outcome of the assessment is to understand costs and risk profile per system and how systems link to relevant value streams when possible.

7.3.3 Assess value streams for improvement opportunities

The third component in the model is to assess lightly where value stream acceleration opportunities could be. The emphasis in this is *lightly* and *could* be. Full value stream analysis can be a large project, but even a light analysis and benchmarking to other industry examples can give insights for acceleration opportunities.

Depending on the context, these considerations can be very high-level business process assessments from order to cash value stream or value streams inside one domain like in software development, the value stream from new business feature request to having that feature in use in production by the business users.

Depending on the context and business driver, the focal point for analysis can be very different. Acceleration for the sake of acceleration is not the goal, but to identify places where acceleration can produce a relevant business impact. Industry benchmarks and case studies can be used as

reference points to understand how market leaders or other actors in other industries can provide value faster in their comparable operations.

Besides value stream analysis, other available business performance metrics and benchmarks could be used to identify improvement opportunities. Gartner's business value model provides a framework to analyse business performance metrics and identify potential performance gaps that could be analysed in more detail to find improvement opportunities (Proctor, Smith 2017).

The outcome of this phase is not yet to have a clear solution in mind but to identify if the organization is getting left behind compared to relevant industry baselines or if there are identified improvements or solutions that could produce better outcomes.

7.3.4 Assessment scorecard

The more detailed analysis is reduced into an analysis scorecard for the systems selected for closer assessment from the portfolio. An assessment scorecard collects relevant data into a single table. It allows decision-makers to focus on assessing if current state costs and risks are acceptable – or if the effort should be directed toward assessing and preparing improvement options.

	Current annual costs	Expected inherent loss	Improvement opportunities identified?
Internally hosted continuous integration system	40k Euros	85k Euros	Integrated cloud options available with lower costs and guaranteed SLA and elasticity.
Custom inhouse developed ERP	70k Euros	200k Euros	Some functionality could be migrated to packaged software. Custom development needed too.

Table 4: Example of assessment of system costs, risks, and improvement opportunities in a small company

At the heart of the assessment is the notion that keeping a business operational always accrues costs and risks, and the key decisions in keeping the business operational is to be able to make

well-informed decisions regarding acceptance of both, especially with the perspective of availability of options. If the business lacks a proper understanding of its risk position, the outcome can be unintentionally too high-risk position, which opens the business up to major risks and disruptions.

In this thesis, I postulate that this is also why organisations end up in situations where complicated and risky modernization efforts are needed. Work systems development and maintenance are neglected because there is a lack of vocabulary and quantification of the business impact of legacy.

7.4 Quantify modernisation opportunity

At the core of decision-making is the value quantification model, which should help decision-makers make better decisions. The model consists of the following elements: current costs, current risk profile, future value opportunity, costs related to the change, and risks related to the change. These elements should be evaluated with contextually relevant timeframes for the organization and the system.

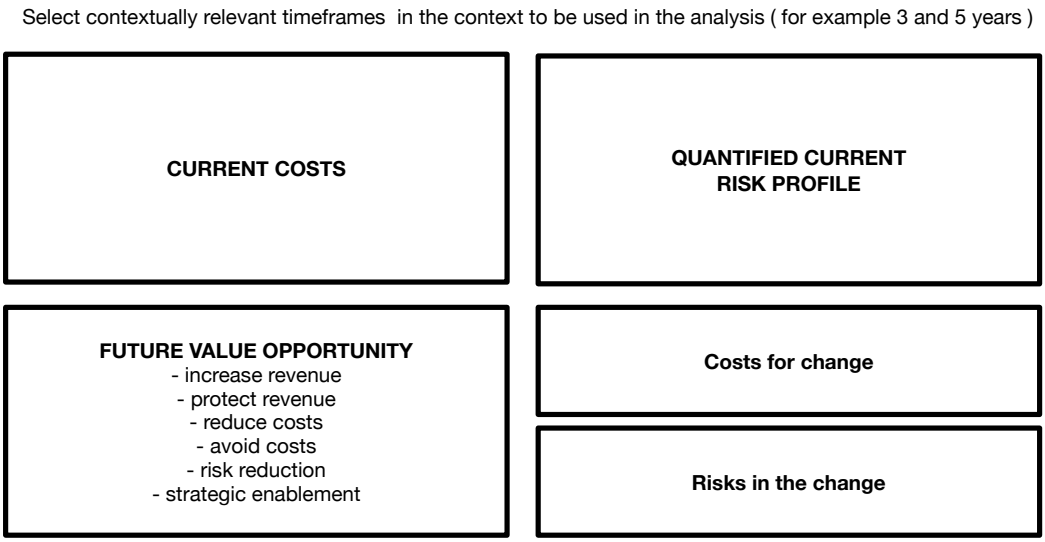


Figure 46: Suggested quantification model

In some situations, current costs and risks are not relevant in the decision-making. If the organisation is forced to make changes because of external events like a hard end-of-life announcement or organisational restructurings of business units into separate companies. In those situations, organisations might just focus on quantifying and evaluating between available options if continuing as-things-were is no longer an option.

New components of the model are defined in more detail below.

7.4.1 Identify and evaluate value opportunity components

A well-identified challenge in IT business cases is how value and benefits are defined, quantified, and linked to the organization's strategic goals. This section of the model aims to guide the decision-maker through different value types and think about how to quantify them.

For practical purposes, as a foundation, this thesis uses the value framework from Arnold and Yüce (2013). And even though two categories I am adding to the model (risk reduction and strategic enablement) could be categorized under existing categories, I choose to add them as their own value buckets to give focus to rigorous quantification of those.

Increase revenue	Improvements that increase sales to new or existing customers. Creating delight or disruption on the market to increase market share and size.
Protect revenue	Improvements and incremental innovation to sustain current market share and revenue. Investment value needed to keep up with the competition.
Reduce costs	Improvements that reduce costs that the organisation is currently incurring, but can be reduced through efficiency, improved margin or other contributions.
Avoid costs	Improvements to sustain current costs base. Costs that are not currently incurring, but may do in the future.
Reduce risks	Quantified reduction of risks that have been identified and assessed previously. Risk reduction implies that there is a quantified risk catalogue available.
Strategic enablement	Value bets that drive larger strategic goals, but where economic benefits are not necessarily immediately clear or measurable in a short timeframe. Does this change link to business capabilities that were identified in section 7.2?

Table 5: Proposed value categories

This model does not replace the usage or need for additional quantitative methods and models that organizations might use in making business cases but rather provides a simple framework for clarifying the discussion and conceptualization of the value. This is also in line with how original model

authors define its major impact in enabling the conversations around value rather than exact values estimated.

7.4.2 Identify cost components with the change

After the concept of the value of the change has been clarified, the next component to clarify is the costs that the change will create. There are well-defined models to estimate costs in different-size projects. Hence this thesis does not go into detail about how to make that estimation.

The relevant notion that this thesis adds to the discussion is the estimation of the change of the costs as time goes on, as it can affect the urgency of making the decision sooner than later – or the other way around. This consideration should be directed both to internal resources and external resources.

As an example, an organisation that is considering modernizing existing mainframe solutions that are developed in-house could project that both internal and external costs are bound to rise as the market availability of knowhow is shrinking and those who are working with the systems in-house are becoming eligible for pensions and might not be available in the near future.

During the thesis interviews, one such case was described in detail as a company had to pay exorbitant consulting fees to a retired contractor, who was the only person with the specific know-how of how a certain critical component worked.

7.4.3 Identify risks with the change

The third component to assess is the risks related to the change. Risk management is another well-researched area. Hence this thesis will not try to cover that body of knowledge – but just guides the practitioner to understand different areas that could impact the realization of intended benefits. Risks can be related, among others, to the project itself, how the business does not adopt the solution for some reason, or how the market changes around the organization while the modernization effort is underway.

Modernization risks and risk management is discussed, among others, in Bergey et al. (1997) model for disciplined evolution of legacy systems. Similarly, Bergey et al. (1999) re-engineering project failure analysis provides good insights into how efforts have previously failed.

Challenges with even well-intentioned IT system development efforts are well documented and available in the literature. For example, Betz (2018) describes the Swedish National police PUTS technology rationalization case from existing open-source software to work on top of a commercial

software platform with the unsuccessful rollout and unhappy users for costs of over one billion euros.

7.5 Usage of the proposed models as a sense-making tool

The created model can be used at different levels in the organization, either at the portfolio level while trying to make sense of what to modernize – or at the project level while evaluating alternative options or paths to take. The model's four phases (identification of the primary business driver, capabilities that the organization needs, assessment of the portfolio state, and quantification of the change) can be used sequentially or individually based on the need, context, and availability of existing insight.

Identifying organisational business drivers and capabilities the organization needs aims to help the decision maker or influencer align assessment with the larger organizational context and goals. Even larger transformations can be achieved by making small incremental improvements if those improvements are properly aligned with the larger vision.

The core idea in the assessment of current assets is to focus analysis on two components: costs and risks. Costs include all the costs related to operating the service efficiently, and risks include all the relevant risks that could have a business impact with some probability. Transforming operational, technical, or other quality problems to quantifiable risks and impacts forces the organization to understand that lack of maintenance or quality is a business risk that must be accepted or controlled.

To assess modernization opportunity or alternatives to the current state, this thesis proposes quantifying modernization improvement value in six distinctive categories: how it increases revenue, how it protects existing revenue, how it reduces costs currently accrued, how it avoids future costs not yet accrued, how it decreases previously quantified risk profile and how the change enables achieving some larger strategic goals in the organization. The goal of this categorization is to help decision-makers and influencers to think and verbalize better how the change will have an impact, instead of just trying to lump all the different elements of value into a single estimation.

In the end, this sense-making model does not make the decision on behalf of the decision maker but can help uncover and structure inquiry and data into a format that makes it easier to make well-informed decisions.

The proposed model is included in a visual single-page format in Appendix 7.

8 Conclusions and analysis

8.1 Answers to research questions

This research started with four research questions.

Q1) Based on literature: how modernization need can be identified

Q2) Based on literature: how modernization need can be quantified

Q3) How are organizations in the marketplace currently identifying and quantifying their modernization efforts

Q4) Based on literature and market research findings, how should modernization need be quantified to help decision making

8.1.1 Based on literature: how modernization need can be identified

The literature review covered multiple heuristics and models to assess the fitness of a system subjectively. But ultimately, fitness evaluation and modernization need decision are business decisions. If systems are not meeting requirements, lack the agility or scalability to keep pace with the demands of the business, the total cost of ownership is too high – or if security or support is compromised, then it is time to modernize.

8.1.2 Based on literature: how modernization need can be quantified

Reviewed portfolio and service management models guide the organizations to define measurable key performance indicators and metrics that enable organizations to assess if services are performing within defined thresholds and providing expected business outcomes. Continuous deviations from these can work as a signal to assess the state of the services properly and, to some extent, to quantify the business reason for changes when expected business outcomes are not achieved.

Frameworks and models did not list universal metrics and quantification models, as the measurement is a contextual problem, and businesses often need to derive suitable metrics and indicators for their environment.

8.1.3 How are organizations in the marketplace currently identifying and quantifying their modernization efforts

Based on responses given in interviews and the questionnaire, organisations identify the need to modernize mostly reactively when external signal forces organizations to evaluate situations and options more closely. Top external signals expressed in interviews and in the questionnaire were, in addition to cost-cutting trigger the inability to react to changes, identified risks, strategic changes, and business need changes. Additionally, key considerations in making the actual modernization project decision were described to be costs, risks, business value, and alignment with long-term goals.

8.1.4 Based on literature and market research findings, how should modernization need be quantified to help decision making

To answer this question, I have proposed in section 7 a model for how to identify modernization opportunities and quantify the need and opportunity. The model consists of four distinctive phases: identification of the primary business driver, capabilities that the organization needs, assessment of the portfolio state, and quantification of the change.

The core idea of the portfolio assessment is to focus analysis on two components: costs and risks. Costs include all the costs related to operating the service efficiently, and risks include all the relevant risks that could have a business impact with some probability. Transforming operational, technical, or other quality problems to risks forces the organization to understand that lack of maintenance or quality is a business risk that must be accepted or controlled.

To assess modernization opportunity or alternatives to the current state, this thesis proposes quantifying modernization improvement value in six distinctive categories: how it increases revenue, how it protects existing revenue, how it reduces costs currently accrued, how it avoids future costs not yet accrued, how it decreases previously quantified risk profile and how the change enables achieving some larger strategic goals in the organization.

8.2 Validity of results

The literary review is based on a very small sample of books and articles from each of the reviewed domains. And even though care was made to try to include and evaluate articles that review the larger body of knowledge, this work only scratches the surface of the work done in multiple different fields. However, from the practical point of view of applying thinking and practices in the field, this study should provide a sufficient glimpse into the research for practitioners.

This thesis proposes a sense-making framework to support thinking and decision-making inside organizations, but the application of the framework has not yet been tested in any organization. The framework itself consists of a combination of models presented in previous works and tested in the marketplace. Hence there is a possibility that usage of the presented model could help some organizations to make better decisions - but that is to be tested in additional research efforts and in practice.

Perspectives gained in interviews are interpretations about decision-making in their respective organizations as seen by interviewed persons. Those perspectives might contradict other people in the same organizations in different positions.

The design of the questionnaire might not have been rigorous enough to counter biases the author has or solicit freeform responses that would correctly capture the perceptions of responders. Additionally, as there were so few responses to the questionnaire and because the questionnaire was not sent to a closed targeted group of validated responders, the validity of responses as representative of anything larger can be questioned.

8.3 Contribution to the research

This thesis has taken a contemporary - though limited - view into the state of modernization decision-making by focusing on the question of quantification of the modernization need.

Literary review done on multiple fields of research is valuable in connecting the dots between different perspectives of the same puzzle and in resurfacing some older research that has been done previously - but has not been applied since.

Created sense-making and quantification model is a novel addition to the existing body of knowledge and can immediately be used in practice. Its value can be evaluated in future case studies and developed by defining supportive checklists and examples of how practitioners evaluate and quantify elements in their contexts.

9 Discussion and further research

9.1 The challenge of making sense of multidisciplinary phenomena

This research started with a very concrete problem that I, as a researcher, had witnessed in numerous cases in real-world organizations, usually filled with intelligent, talented, and devoted people trying to do the best they can in their work. Making modernization decisions has been challenging, and I have witnessed and seen multiple failures related to software modernization efforts. And personally contributed to some of those wrong decisions.

The intended goal of my research was to try to take a holistic view of the phenomena from a few different identified perspectives, try to understand how the picture looks from different perspectives, and create a sufficiently stable bridge to bring at least some of these perspectives closer to each other. And to enable better sense-making and better decisions inside organizations.

Each new paper I reviewed about related questions and topics opened further interesting questions and avenues to continue forward and to try to understand how people make decisions about changing sociotechnical systems. At the same time, it was exhilarating to read old research papers where authors had made very poignant statements about the state of the world decades ago, as it was frustrating to realize that we are still grappling with the same questions. The wording is just a bit different.

The scoping of my work shows grandiosity and hubris, as I had the audacity to think that by scratching the surface of each field of study could gain insights that hundreds of PhDs, practitioners, and leaders had missed entirely. A multidisciplinary research team and a research program would be needed to provide proper insights into the question. Especially as traditional boundaries of the field of study become meaningless when digital capabilities are more and more at the core of new organizational value creation for even many very traditional industrial organizations.

This is also the crux of the whole topic. We need new concepts and models to understand how organizations work and create value and how to measure, manage and make sense of it all. I postulate that this requires new multidisciplinary research programs that work in tight collaboration between academia and industries, just like current research programs at Chalmers Software Center in Sweden or Jyväskylä University's Value Creation for Cyber-Physical Systems and Services-program.

Even though I recognize that within this master thesis project I could not make a significant dent in the general knowledge and understanding of the topic, I am sure of the value of this meek contribution to the discussion – as there was nothing as such available.

And at the same time, I recognize that this is just the beginning of my quest to understand how to make better decisions and how our evolving understanding of how to build and manage systems also changes how we can make decisions.

9.2 Measuring IT: cost, value, and risk

The fundamental perspective I tried to take in this work is how to quantify things and how to make better data-driven decisions. In the end, everything could be reduced to three components: cost, value, and risk.

Based on literary research and interviews, there are challenges in understanding or measuring value or risk. We understand and agree that IT provides value to the business but are less sure about quantifying how much and how IT delivers value. And even more importantly, do the expected value benefits ever get realized as measurable value?

Risk is even harder to measure and quantify on an organisational level, as many chief security officers or cybersecurity company salespeople could attest. As organizations are more and more connected and have ever-growing attack surfaces, we are most likely less aware of the risks we have and less able to quantify our inherent risk positions. Risks are not limited to cyber security risks, as technology risks, know-how risks and business agility risks are also real risks that organizations face as time goes by.

Combined with the challenge of not having a shared understanding of value creation and the risks associated with it, organizations can unintentionally drift into positions where simple fixes and changes are no longer available, and organizations need to try more costly and risky transformations.

There is more work to be done in improving the conceptualisation and measurement of the value of IT in organizations and how that understanding of value gets connected to decision-making about software systems that will be part of the whole work system.

Similarly, more research is needed to create better models to understand and quantify a holistic picture of different risks organisations have with their IT systems. Within the industry, we have multiple other concepts that are essentially risks to the business, but we do not talk about or handle them as such. For example, known technical debt and lack of agility in feature development could be considered business risks, but they are discussed and managed as separate concepts.

9.3 IT decision making

A dimension that was almost entirely neglected in this thesis research is how decisions get made inside the organizations. What are the processes in which decisions are made, who the decision makers are, and what impact do different processes and decision-making models have on the eventual outcomes?

There is already an extensive body of literature about IT decision-making, but as our ideas and models on how to produce value with software, how to build and maintain software services, and how to organize to produce software evolve – I hypothesize that there would also be a need to research the impact of these changes.

Practitioners are evolving practices and testing new things in the marketplace, but research and academic validation naturally lags behind – and sometimes get confined inside specific domains. Agile, lean, and, more recently, the devops community is leading new efforts to study software development organizations and organisational delivery performance with new lenses. Similarly, in many practices, decision-making ability and power are given to those who have the best view of the problem. As an example, emergent practices and architectural models like moving from data warehouses to data mesh enable many decisions to be made closer to the data usage in a way that was not possible before.

Enterprise architecture researchers have studied this topic for a long time, and I postulate that some of the practices and ideas seen as good practices are getting challenged as organisations get renewed, and new technical capabilities change the ways of work. At the same time, it can also mean, that practices and procedures that have been created to provide co-ordination on sufficient high levels of the organisation are still valid and good foundation also for future value creation.

Nevertheless, this is a worthwhile field for further research as organisations and value creation systems change.

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Appendices

Appendix 1. Literature review search terms

Software development search terms

Research into software development perspective of modernisation started with a known base set of books that the author was aware of before the work started. This set was then extended with additional searches to library and article databases. Directed searches were then made to see what major technology providers and industry analysts have to say about the subject.

Start set of materials were:
- Modernizing Legacy Systems: Software Technologies (Seacord et al., 2003)
- Continuous Architecture in Practice: Software Architecture in the Age of Agility and DevOps (Woods et al., 2021)
- Kill It with Fire: Managing Aging Computer Systems (Bellotti, 2021)
- Accelerate: The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations (Forsgren, Humble and Kim, 2018)
- Sooner Safer Happier: Antipatterns and Patterns for Business Agility (Smart, 2020)
- Scaled Agile Framework 5.1 (Scaled Agile Inc., 2021)

This set of books reflects the author's experience as an architect focused on business agility.

Following databases were used to search for additional materials:
1) Google Scholar
2) Semantic scholar
3) Haaga Helia Finna search database

Following search terms were used as the start set:
"software modernisation decision"
"application modernisation"
"application modernisation" AND "decision making"
Modernization
"legacy modernization"

Important article search results was 'Legacy system evolution - A Comparative Study of Modernisation and Replacement Initiation Factors'-paper (Kankaanpää et al., 2007). Paper was published in Tekes funded research project ELTIS (Extending the Lifetime of Information Systems) by team of researchers working at University of Jyväskylä. This paper then became crucial starting point to forward and backwards search, and finding related research by searching with co-authors in the

research program. Additionally I contacted co-author of the paper, professor Jussi Koskinen, and received additional papers published in the program - but unavailable or harder to reach via online services.

For industry analysts and service vendors I focused the search to cover major consulting vendors (IBM, Accenture, Cap Gemini, PWC, Deloitte), cloud software vendors (Microsoft, AWS, Google, VMWare) and from independent analysts focused on what Gartner and Forrester have published openly without subscription to their services.

Following publications were included for further study with the heuristics that they provided insights on decision making beyond just application architecture opportunities. Other consulting briefs and cloud provider reports were excluded from further analysis as they provided mostly very similar insights and considerations as already selected materials.

Analyst perspectives from Gartner:
- 7 Options To Modernize Legacy Systems (Gartner, 2019)
- Application Modernization Should Be Business-Centric, Continuous and Multiplatform (Van Der Zijden and Klinect, 2019)
- Use Continuous Modernization to Build Digital Platforms From Legacy Applications (Van Der Zijden and Klinect, 2022)

Forrester report:
- The Six Most Meaningful Metrics To Prove And Improve App Dev’s Business Value (Gerush and West, 2011)

AWS publication:
- AWS Prescriptive Guidance - Strategy for modernizing applications in the AWS Cloud (Thumma, 2020)

VMWare publications:

- Monolithic Transformation: Using DevOps, Agile, and Cloud Platforms to Execute a Digital Transformation Strategy (Coté, 2019)
- Changing Mindsets: The Missing Ingredient to Digital Transformation (Coté, 2021)
- The Cloud Native journey. (Coté, 2015)
- Crafting Your Cloud-Native Strategy (Coté, 2017)

Digital transformation search terms

Research into the the concept of digital transformation started with four books, of which two are based on research done at MIT, third is based on research and practice done at Chalmers

University Software center - and the fourth is based on consulting practices and ideas developed at global technology consulting company Thoughtworks.

Start set was:
- Leading Digital: Turning Technology into Business Transformation (Westerman, Bonnet and McAfee, 2014)
- Speed, Data, and Ecosystems: Excelling in a Software-Driven World (Bosch, 2016)
- EDGE: Value-Driven Digital Transformation (Highsmith, Luu and Robinson, 2019)

Limited papers to since 2021 to focus on contemporary research and insights that could contradict or augment information presented in selected publications.

Additionally searches were made to article databases with search terms:
- digital transformation
- digitalisation / digitalization
- digitalisation / digitalization dissertation

From the search results focus was put to select meta studies and dissertations to further evaluation - to get a more holistic view on what the current and future research on this theme will be, and how the emerging understanding should reflect on this study.

Enterprise architecture search terms

Research towards enterprise architecture started with two books that link business strategy perspective to enterprise architecture and a longitudinal study about application of enterprise architecture as alignment mechanism at Credit Suisse over a decade.

Start set of the research was:
- Enterprise Architecture as Strategy: Creating a Foundation for Business Execution (Ross, Weill and Robertson, 2006)
- Managed Evolution: A Strategy for Very Large Information Systems (Murer and Bonati, 2014)

Additional papers were searched from databases with following search terms:
- “enterprise architecture” dissertation
- “enterprise architecture” modernisation
- "enterprise architecture" transformation

Then used related searches as suggested by Google Scholar:
- benefits of enterprise architecture "organizational transformation"

Search was focused to papers to since 2021, but as I researched referenced materials - I included into review few papers and dissertations that were published earlier.

IT Governance search terms

Research towards IT-Governance started with a list of popular books that should define sufficiently core concepts needed in this thesis. Selected materials included business books describing the practices of IT governance and portfolio management for business value, as well as four different holistic models to run and govern operations.

Start set of the research was:
- IT Governance (Weill and Ross, 2004)
- The Business Value of IT: Managing Risks, Optimizing Performance and Measuring Results (Harris, Herron and Iwanicki, 2008)
- IT Portfolio Management: Unlocking the Business Value of Technology. 1st edition (Maizlish, 2005)
- Real Business of IT: How CIOs Create and Communicate Value (Hunter and Westerman, 2009)
- The Art of Business Value (Schwartz and Kim, 2016)
- Run Grow Transform: Integrating Business and Lean (Bell, Betz and Schmidt, 2012)
- IT Capability Maturity Framework (Kennealy et al., 2017)
- Business technology standard (Business Technology Forum*, 2021*)
- Managing Digital: Concepts and Practices (Betz, 2018)
- Gartner report: The 9 Rules for Demonstrating the Business Value of IT (Naegle, R. Ganly, C., 2020)

Additional articles were searched with following terms:
- "it-governance" modernisation
- "it-governance" transformation
- business value of it
- modernisation business value
- transformation business value

Focus in the search was on contemporary articles published after 2021 and otherwise influentially referenced papers also earlier.

IT Service management search terms

Last domain for literary research was IT-service management, and the search started with some materials that were already partially covered with earlier sections, but now evaluated more from the perspective of service management than from the perspective of service development or governance.

- Business technology standard (Business Technology Forum, 2021)
- IT Capability Maturity Framework (Kennealy et al., 2017)
- Scaled Agile Framework 5.1 (Scaled Agile Inc., 2021)
- ITIL 4 foundations (AXELOS, 2019)

Additional articles were searched with following terms:
- “it-service”
- “it-service” modernisation
- "it-service” transformation

Appendix 2: Reviewed papers in the literary review

Software development literature papers

Title	Contribution to the study
LEGACY SYSTEM EVOLUTION - A Comparative Study of Modernisation and Replacement Initiation Factors (Kankaanpää, I., Tiihonen, P., Ahonen, J., Koskinen, J., Tilus, T., & Sivula, H., 2007)	Case study on modernisation initiating factors. Provides clear categories and listings for expressed triggers for renewal.
Defining the Process for Making Software System Modernization Decisions (Ahonen et al., 2006)	Case study and creation of process for making modernisation decisions based on data: business value, obsolescence and cost efficiency of the system.
'A preliminary review of legacy information systems evaluation models (Bakar and Razali, 2013)	Provides concrete review of different characteristics emphasised in two system evaluation methods (Hierarchical model and Renaissance model) and compares those to characteristics defined in ISO standards for product quality and data quality.
Legacy Systems: Coping with Success (Bennett, 1995)	Connects the problem to the roots as same problems existed already in 1990s, when systems developed earlier started to age. Legacy systems are the result of management inaction.
Decision model for legacy systems (Bennett, Ramage and Munro, 1999)	Describes SABA model to use organisational scenarios from top down to evaluate options and impact before evaluating technical scenarios for system change. Includes also trabsformative element: how IT restructures a set of tasks or processes.
Managing legacy system costs: A case study of a meta-assessment model to identify solutions in a large	Reasonably new case study, which proposes a new metamodel to identify and classify systems as legacy based on existing work by De Lucia et al., Alkazemi et al. and Ransom et al.

financial services company (Crotty and Horrocks, 2017)	
A decisional framework for legacy system management (De Lucia, Fasolino and Pompelle, 2001)	Presents assesment model with business and technical value attributes, and proposes portfolio analysis to be used to decide what to do with specific applications / systems.
Timing the information system upgrade (Kankaanpää and Pekkola, 2010)	Case study on system upgrade timings in Finnish organisations. Business reasons are the main motives for defining IS version change or upgrade timing. They are strongly related to risk management, expected business benefits, and avoiding hindrance to business.
IS Evolution Benefit Assessment – Challenges with Economic Investment Criteria (Kankaanpää et al., 2007)	Research paper studies eight financial investment criteria and their advantages and disadvantages with respect to IS evolution benefit assessment are studied. Presents ISEBA model to support selection of IS evolution options.
IT artefact renewal : triggers, timing and benefits (Kankaanpää, 2011)	Important PhD work on IT artefact renewal. Provides linkages to existing body of knowledge and defines new concepts to be used in information system lifecycle management.
How do professionals perceive legacy systems and software modernization? (Khadka et al., 2014)	Research into perceived benefits of legacy systems, as well as drivers for modernisation and identified challenges / risks related to it.
Does software modernization deliver what it aimed for? A post modernization analysis of five software modernization case studies (Khadka et al., 2015)	Collection of five casestudies on modernisation projects and their effects. Literary review on typically expected and communicated expected benefits. Two concrete insights: Industry can utilize software modernization not only to reduce maintenance cost and to phase out obsolete technology but also for other (business) opportunities. Apart from possible technical improvements, software modernization can be used to improve organizational aspects such as bringing transparency and flexibility.

Revisiting legacy software system modernization (Kahdka, 2016)	PhD dissertation by experienced legacy system modernisation researcher. Defines also serviceFi methodology, which resembles other new modernisation strategies with strangler pattern.
Software Modernization Decision Criteria: An Empirical Study (Koskinen et al., 2005)	Case study based on interviews of experts in 8 organisations in Finland, rating 49 decision criterias into top 20 criterias considered in modernisationd ecisions.
SMART: The Service-Oriented Migration and Reuse Technique.(Lewis, G.A., Morris, E.J., O'Brien, L., Smith, D., & Wrage, L., 2005)	Presents service-oriented migration and reuse technique (SMART) for organisations to analyze legacy systems and organisational needs for migrations. Developed for the needs on DoD.
Evaluation of software modernization estimation methods using NIMSAD meta framework (Koskinen et al. . 2004)	Report charts and compares some of the most promising methods and approaches available for 1) estimating the profitability of software modernizations and for 2) supporting the actual modernizations. Profitability is affected by benefits, risks, and costs. There exists multiple approaches for evaluating these issues, including strategy selection of legacy system evolution and modernizations. Report provides a comparison of 12 well-known approaches.
A method for assessing legacy systems for evolution (Ransom, Sommerville and Warren, 1998)	Presents a systematic method called Renaissance for system evolution and re-engineering. The principal product of following the method is a system which has been transformed from a legacy state to an evolutionary system. Evolutionary systems accommodate change by incorporating evolution as a core activity of the software life cycle, and not as an extension to it.
Renaissance: a method to support software system evolution (Warren and Ransom, 2002)	More detailed description of the Renaissance method and evolution strategies.

Digital transformation literature papers reviewed:

Title	**Contribution to the study**
Understanding Organizational Orientations Towards Digitalization: A Sensemaking Approach (Takkunen, 2021)	Relevant PhD thesis from Finland, providing insight into digitalization definions and how leaders in Finland perceive terms. Connects again multipole themes together: Information systems, marketing, strategic management.
Digital Transformation: A roadmap for billion-dollar organizations (Westerman et al. 2011)	Research publication that eventually turned into the Leading Digital book's model. Provides important insight how the management perception to the model was collected and what the details were.
The New Elements of Digital Transformation (Westerman, Bonnet 2020)	Updated model to the 2017 book Leading digital. Changes the model to be a bit more detailed on customer experience and on digital platforms.
Digital transformation: A multidisciplinary reflection and research agenda (Verhoef et al., 2021)	Meta research into the domain of digital transformation. Identifies three stages of digital transformation: digitization, digitalization, and digital transformation. And identifies growth strategies for digital firms as well as the assets and capabilities required in order to successfully transform digitally.
Digitalization and business models: Where are we going? A science map of the field (Caputo et al., 2021)	Important review of the field and identification of core authors and research themes linked to the topic.
Developing a unified definition of digital transformation (Gong and Ribiere, 2021)	Paper unfies 134 different definitions into single unified digital transformation definition.
Digital Transformation - A Holistic Perspective for Business Leaders (Bosch, 2018)	Book reflects what is the relationship of R&D, business strategy and organisational structure in software driven world.

Digital for real: A multicase study on the digital transformation of companies in the embedded systems domain (Bosch, Olsson, 2021)	Current longitunal case study about digital transformation from companies in embedded systems domain in Scandinavia. Applying and reflecting theories presented in Bosch's research.
Towards a Digital Business Operating System (Bosch, 2019)	Conference paper about same ideas that Bosch has presented in books. How continuous integration and deployment are enablers for R&D innovation system. Provides concept: digital business operating system.
Understanding digital transformation: A review and a research agenda (Vial, 2019)	Another research into definitions of digital transformation, linking authors and research topics together.

Enterprise architecture papers reviewed

Title	**Contribution to the study**
Improving IT Decisions with Enterprise Architecture (van den Berg, 2019)	Comprehensive PhD dissertation that studies how EA practice could help the quality and value of IT decisions.
The Benefits of Enterprise Architecture in Organizational Transformation (Niemi and Pekkola, 2019)	Contemporary research paper reviewing how EA programs produce value in prganisations based on synthesis from literature.
Dual Capability EAM for Agility in Business Capability Building : A Systems Theoretical View (Poutanen, J., & Pulkkinen, M. 2021)	System of systems view to enterprise architecture development. case study in two companies.

IT Governance papers reviewed

Title	**Contribution to the study**

Information technology (IT) governance and IT capability to realize firm performance: enabling role of agility and innovative capability (Ilmudeen 2021)	Study linking good it governance to better performance in business agility and creating dynamic it capabilities
Exploring the relationship between IT Governance and Strategic Alignmen (Hiekkanen, 2016)	Dissertation studying IT governance impact on IT strategic alignment
Avoiding the Alignment Trap in IT (Shpilberg et al. 2007)	Article about dangers of misalignment of It and business needs
The business value of IT: New perspectives on IT value creation (Bayer, 2021)	Dissertattion that conceptualizes how IT produces value and how to manage it.
A Literature-Based Derivation of a Meta-Framework for IT Business Value(Seufert et al. 2021)	Detailed value framework based on literary research describing how IT can produce value in different business units.
Impact of IT governance process capability on business performance: Theory and empirical evidence (Joshi et al 2021)	Literary review on the impact of IT governance.

Appendix 3: Interview invitation

Interviews were conducted as freeform discussions over Microsoft Teams platform. Discussions were recorded and recordings were then used to identify key points and insights after the actual interview.

Interviewees were instructed to prepare to the discussion with message in Finnish.

Here is the same content translated to English:

To prepare for the interview please think a context where you have been participated as a decision maker or influencer in modernising a system or a capability. My interests are towards the decision making processes and what factors are considered in the decision making.

System / Capability can be one program or a collection of different programs / services, which form a relevant capability.

Modernisation can be a major refactoring of the system or replacement of the system with another.

Themes I will ask questions about are:
- What were the triggers for the modernisation consideration?
- What benefits / value was considered to be achieved with the modernisation?
- What costs were considered to be related to the modernisation decision?
- What risks were identified and considered related to the change?
- What things were quantified and how in the decision making?
- Are there any feedback mechanisms to evaluate what were the eventual outcomes of made decisions to enable improvement of decision making in the future?

Original instructions in Finnish:

Haastatteluun kannattaa valmistautua miettimällä jotain kontekstia jossa olet ollut mukana päättämässä tai vaikuttamassa jonkin järjestelmän / kyvykkyyden modernisointipäätöksiin. Ki-innostuksen kohteenani on päätöksentekomekanismi ja kuinka siihen liittyviä asioita käsitellään.

Järjestelmä / kyvykkyys voi olla yksi ohjelma tai kokoelma erilaisia ohjelmia / palveluita, jotka muodostavat kokonaisuuden.

Modernisaatio voi olla joko esimerkiksi järjestelmän refaktorointi uusiksi tai korvaaminen kokonaan toisella järjestelmällä.

Teemoja joista tulen kyselemään ovat:

- Mikä nosti/nostaa modernisaatiotarpeen esiin tarkasteluun?
- Mitä arvoa/hyötyjä muutoksella haluttiin/halutaan saada aikaiseksi?
- Mitä kustannuksia muutoksen tekemiseen liittyy/liittyi?
- Mitä riskejä muutokseen liittyen tunnistetaan/tunnistettiin?
- Mitä asioita päätöksenteossa kvantifioidaan ja miten?
- Onko käytössä feedbackmekanismeja, joiden avulla tehtäviä/tehtyjä päätöksien onnistumista tarkastellaan tulevaisuuden opeiksi?

Appendix 4: Questionnaire results data coding

Questionnaire responses were exported from Microsoft Forms as Excel sheet. Data was then encoded in following way.

Likert scale responses were transformed from textual responses to integers in Excel.

1 - Strongly disagree
2 – Disagree
3 - Neither agree nor disagree
4 – Agree
5 - Strongly agree

Question columns were renamed to code question into the numerical code of that question. For example, 10th topic's 'Relevant triggers to modernisation in our organisation' first likert scale question 'Strategic business change' was coded to be 10_1.

In the table below all the questions are listed and their data column listed. Questions 1 to 7 were category questions, and results were transformed to numeric rank values. Questions 11,12,14,15,17,18,19 and 20 were freeform questions. All the other questions were likert-scale questions.

Question	Column
Approximate organisation revenue / turnover annually (Million EUR)	1
Approximate number of employees in the organisation	2
Modernisation case that I am thinking about is currently	3
Approximately how big was / is the considered modernisation effort investment (estimated effort) thought to be in thousands of EUR?	4
.If the modernisation effort is underway or done, are the actual costs (based of best available estimation	5
In modernisation decision I consider myself to be more	6
In the organisation I consider myself be more	7
I feel that in our organisation modernisation decisions are	

made in satisfactory way	8_1
aligned with strategic goals	8_2
proactively made	8_3
reactively made	8_4
made in timely fashion	8_5
based on qualitative data	8_6
based on quantitative data	8_7
based on subjective data	8_8
based on objective data	8_9
producing good results	8_10
based on a hypothesis	8_11
We continuously (annually / quarterly) evaluate	
technical state of our services	9_1
business value of our services	9_2
Relevant triggers to modernisation in our organisation	
Strategic business change	10_1
Business need changes	10_2
Perceived lack of business value	10_3
Inability to respond to changes (lack of business agility)	10_4
Costs	10_5
Simplification of the architecture	10_6
Identified risks	10_7

Availability of new technical capabilities / solutions	10_8
Changes in vendor support	10_9
Quality of the system	10_10
Are there other important signals that trigger modernisation consideration in your organisation?	11
Can you give examples of signals and situations that have triggered modernisation considerations in your organisation?	12
We measure and use measured results in modernisation decision making	
Business value	13_1
Business agility	13_2
Business fit	13_3
Costs	13_4
Risks	13_5
Technical quality	13_6
Our capability to deliver service	13_7
Can you give example how these things are measured (what data is used)?	14
What other things are typically quantified and considered in your organisation while identifying the need to modernise?	15
While considering modernisation projects, I feel that we analyse and quantify following aspects	
Business value of the change	16_1
Time sensitivity of business value (Cost of delay)	16_2
Costs for the change	16_3
Risks related to the change	16_4

Alignment with long term goals	16_5
How is expected value / benefits of modernisation effort typically quantified in your organisation?	17
How are expected costs typically quantified in your organisation?	18
How are expected risks typically quantified in your organisation?	19
What other things are typically quantified and considered when considering making the modernisation decision in your organisation?	20

Results Excel sheet with this encoding was saved as a csv file and imported into Python code for analysis.

Appendix 5: Python code used in the analysis

```
from scipy import stats
import pandas as pd

path = "/Users/heimo.laukkanen/kysely/final.csv"
raw_df = pd.read_csv(path, sep=";", skip_blank_lines=True).dropna(how='all')

def transformSizesToRanks(data):
    transformer = {"< 50": 1,
                   "51 - 100": 2,
                   "101 - 500": 3,
                   "501 - 1000": 4,
                   "1001 - 5000": 5,
                   "> 5000": 6}
    return transformer[data]

def transformCostEstimationToRanks(data):
    transformer = {"Less than what was estimated": 1,
                   "As estimated": 2,
                   "More than what was estimated": 3}
    if type(data) == str:
        return transformer[data]
    else:
        data

raw_df["4_RANK"] = raw_df["4"].transform(transformSizesToRanks)
raw_df["5_RANK"] = raw_df["5"].transform(transformCostEstimationToRanks)

small_companies = raw_df.loc[raw_df["1"].isin(["< 10"])]
medium_companies = raw_df.loc[raw_df["1"].isin(["10 - 50"])]
mid_companies = raw_df.loc[raw_df["1"].isin(["51 - 100","101 - 500","501 - 1000"])]
large_companies = raw_df.loc[raw_df["1"].isin(["> 5001", "1001 - 5000"])]
large_modernisation = raw_df.loc[raw_df["4_RANK"].isin([5,6])]
```

```
producing_good = raw_df.loc[raw_df["8_10"].isin([5,4])]
cost_answered = raw_df.loc[raw_df["5_RANK"].notna()]
cost_answered_large = large_modernisation.loc[large_modernisation["5_RANK"].notna()]

measure_tech_or_business = raw_df.loc[raw_df["9_1"].isin([4,5]) | raw_df["9_2"].isin([4,5])]
measure_tech_and_business = raw_df.loc[raw_df["9_1"].isin([4,5]) & raw_df["9_2"].isin([4,5])]

# Correlation between modernisation size and that costs are more than expected
stats.spearmanr(cost_answered["4_RANK"],cost_answered["5_RANK"])

# How organisation size and perception of usage of qualitative and quantitative data differs
print(raw_df[["1","8_6", "8_7"]])

# How organisation size and perception of usage of subjective and objective data differs
print(raw_df[["1","8_8", "8_9"]])

# Good results and hypothesis?
print(raw_df[["1","8_10", "8_11"]])
print(producing_good[["1","8_10", "8_11"]])

# Organisation size, Continuous evaluation of technical state, business value, good results?
print(raw_df[["1","9_1", "9_2", "8_10"]])
print(producing_good[["1","9_1", "9_2", "8_10"]]) # Only those who get good results

# Organisations that state proactive AND reactive decision making
raw_df.loc[raw_df["8_3"].isin([4,5]) & raw_df["8_4"].isin([4,5])][["1","8_3","8_4"]]

# Organisations that more proactive
raw_df.loc[raw_df["8_3"].isin([4,5]) & raw_df["8_4"].isin([1,2])][["1","8_3","8_4"]]

# Organisations more reactive
raw_df.loc[raw_df["8_3"].isin([1,2]) & raw_df["8_4"].isin([4,5])][["1","8_3","8_4"]]

# Both qualitative and quantitive data
raw_df.loc[raw_df["8_6"].isin([4,5]) & raw_df["8_7"].isin([4,5])][["1","8_6","8_7"]]

# More qualitative
raw_df.loc[raw_df["8_6"].isin([4,5]) & raw_df["8_7"].isin([1,2])][["1","8_6","8_7"]]

# More quantitative
raw_df.loc[raw_df["8_6"].isin([1,2]) & raw_df["8_7"].isin([4,5])][["1","8_6","8_7"]]
```

```
# Both subjective and objective data
raw_df.loc[raw_df["8_8"].isin([4,5]) & raw_df["8_9"].isin([4,5])][["1","8_8","8_9"]]

# More subjective
raw_df.loc[raw_df["8_8"].isin([4,5]) & raw_df["8_9"].isin([1,2])][["1","8_8","8_9"]]

# More objective
raw_df.loc[raw_df["8_8"].isin([1,2]) & raw_df["8_9"].isin([4,5])][["1","8_8","8_9"]]

# Hypothesis driven
raw_df.loc[raw_df["8_11"].isin([4,5])][["1","8_10","8_11"]]

# Monitoring either tech or business
raw_df.loc[raw_df["9_1"].isin([4,5]) | raw_df["9_2"].isin([4,5])][["1","8_10","9_1","9_2"]]

# Correlation between good results or satisfaction how decisions get made
stats.spearmanr(raw_df["9_1"], raw_df["8_10"].to_list())
stats.spearmanr(raw_df["9_2"], raw_df["8_10"].to_list())
stats.spearmanr(raw_df["9_2"], raw_df["8_1"].to_list())
stats.spearmanr(raw_df["9_1"], raw_df["8_1"].to_list())

# Monitoring  tech AND business
raw_df.loc[raw_df["9_1"].isin([4,5]) & raw_df["9_2"].isin([4,5])][["1","8_10","9_1","9_2"]]

# Disagree with costs being a trigger
raw_df.loc[raw_df["10_5"].isin([1,2])][["1", "10_5"]]

# Disagree with availability of new solutions being a trigger
raw_df.loc[raw_df["10_8"].isin([1,2])][["1", "10_8"]]


def checkCorrelationBetweenOrgDecisionMakingFactors(data):
    satisfactory = data['8_1'].tolist()
    aligned = data['8_2'].tolist()
    proactively_made = data['8_3'].tolist()
    reactively_made = data['8_4'].tolist()
    timely_made = data['8_5'].tolist()
    qualitative = data['8_6'].tolist()
    quantitative = data['8_7'].tolist()
```

```
    subjective = data['8_8'].tolist()
    objective = data['8_9'].tolist()
    good_results = data['8_10'].tolist()
    hypothesis = data['8_11'].tolist()

    print(stats.spearmanr(satisfactory, good_results))
    print(stats.spearmanr(aligned, good_results))
    print(stats.spearmanr(proactively_made, good_results))
    print(stats.spearmanr(reactively_made, good_results))
    print(stats.spearmanr(timely_made, good_results))
    print(stats.spearmanr(qualitative, good_results))
    print(stats.spearmanr(quantitative, good_results))
    print(stats.spearmanr(subjective, good_results))
    print(stats.spearmanr(objective, good_results))
    print(stats.spearmanr(hypothesis, good_results))

def differenceInQuestion(question,small,medium,large,big,all):
    s = small[question]
    m = medium[question]
    l = large[question]
    b = big[question]
    a = all[question]

    data = {"mean": [], "deviation": [], "max": [], "min": []}
    for y in [s,m,l,b,a]:
        x = y.describe()
        data["mean"].append(x["mean"])
        data["deviation"].append(x["std"])
        data["max"].append(x["max"])
        data["min"].append(x["min"])
    return data

def printQuestionoutput(question,small,medium,large,big,all):
   data = differenceInQuestion(question,small,medium,large,big,all)
    print("Question: " + question)
    print("mean: " + str(data["mean"]))
    print("max: " + str(data["max"]))
```

```
    print("min: " +str(data["min"]))
    print("deviation: " + str(data["deviation"]))
```

printQuestionoutput("8_1",small_companies, medium_companies, mid_companies, large_companies, raw_df)

Same call was repeated for all questions.

Appendix 6: Questionnaire results analysis raw data

This section lists the analysis of raw numeric results. For each Likert scale answer, mean, max, minimum, and standard deviation are given to small companies, medium companies, mid-market companies, large companies, and the whole dataset.

I feel that in our organisation modernisation decisions are

Question: 8_1 made in satisfactory way
mean: [4.0, 4.5, 4.0, 2.5, 3.5789473684210527]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [4.0, 4.0, 3.0, 2.0, 2.0]
deviation: [0.0, 0.7071067811865476, 0.5, 0.8366600265340756, 0.9612370197756297]

Question: 8_2 aligned with strategic goals
mean: [4.5, 4.5, 4.111111111111111, 3.6666666666666665, 4.052631578947368]
max: [5.0, 5.0, 5.0, 5.0, 5.0]
min: [4.0, 4.0, 2.0, 2.0, 2.0]
deviation: [0.7071067811865476, 0.7071067811865476, 0.9279607271383371, 1.0327955589886446, 0.9112679939102143]

Question: 8_3 proactively made
mean: [3.0, 3.5, 3.2222222222222223, 2.5, 3.0]
max: [4.0, 5.0, 5.0, 3.0, 5.0]
min: [2.0, 2.0, 2.0, 2.0, 2.0]
deviation: [1.4142135623730951, 2.1213203435596424, 1.3017082793177757, 0.5477225575051661, 1.1547005383792515]

Question: 8_4 reactively made
mean: [3.0, 4.5, 3.6666666666666665, 4.0, 3.789473684210526]
max: [4.0, 5.0, 4.0, 5.0, 5.0]
min: [2.0, 4.0, 2.0, 3.0, 2.0]
deviation: [1.4142135623730951, 0.7071067811865476, 0.7071067811865475, 0.6324555320336759, 0.7873265148181359]

Question: 8_5 made in timely fashion
mean: [4.0, 2.0, 3.111111111111111, 3.1666666666666665, 3.1052631578947367]
max: [4.0, 3.0, 4.0, 4.0, 4.0]
min: [4.0, 1.0, 2.0, 2.0, 1.0]

deviation: [0.0, 1.4142135623730951, 0.927960727138337, 0.752772652709081, 0.936585811581694]

Question: 8_6 based on qualitative data
mean: [2.5, 4.5, 3.5555555555555554, 2.6666666666666665, 3.263157894736842]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [1.0, 4.0, 2.0, 2.0, 1.0]
deviation: [2.1213203435596424, 0.7071067811865476, 0.8819171036881968, 1.0327955589886446, 1.1470786693528088]

Question: 8_7 based on quantitative data
mean: [1.5, 4.0, 3.6666666666666665, 2.5, 3.1052631578947367]
max: [2.0, 4.0, 5.0, 4.0, 5.0]
min: [1.0, 4.0, 3.0, 2.0, 1.0]
deviation: [0.7071067811865476, 0.0, 0.7071067811865476, 0.8366600265340756, 1.0485300208760657]

Question: 8_8 based on subjective data
mean: [4.0, 2.5, 3.5555555555555554, 4.166666666666667, 3.6842105263157894]
max: [4.0, 3.0, 4.0, 5.0, 5.0]
min: [4.0, 2.0, 2.0, 4.0, 2.0]
deviation: [0.0, 0.7071067811865476, 0.7264831572567788, 0.408248290463863, 0.7492686492653552]

Question: 8_9 based on objective data
mean: [3.5, 2.5, 3.6666666666666665, 2.8333333333333335, 3.263157894736842]
max: [4.0, 4.0, 4.0, 4.0, 4.0]
min: [3.0, 1.0, 3.0, 2.0, 1.0]
deviation: [0.7071067811865476, 2.1213203435596424, 0.5, 0.983192080250175, 0.9334586382051249]

Question: 8_10 producing good results
mean: [3.5, 2.5, 4.0, 2.8333333333333335, 3.4210526315789473]
max: [4.0, 3.0, 5.0, 4.0, 5.0]
min: [3.0, 2.0, 2.0, 2.0, 2.0]
deviation: [0.7071067811865476, 0.7071067811865476, 0.8660254037844386, 0.752772652709081, 0.9612370197756298]

Question: 8_11 based on a hypothesis
mean: [4.5, 4.0, 3.2222222222222223, 2.8333333333333335, 3.3157894736842106]
max: [5.0, 4.0, 4.0, 5.0, 5.0]
min: [4.0, 4.0, 1.0, 1.0, 1.0]
deviation: [0.7071067811865476, 0.0, 1.092906420717, 1.4719601443879746, 1.2042808632793343]

We continuously (annually / quarterly) evaluate

Question: 9_1 technical state of our services
mean: [2.0, 3.5, 3.3333333333333335, 3.3333333333333335, 3.210526315789474]
max: [2.0, 5.0, 5.0, 4.0, 5.0]
min: [2.0, 2.0, 2.0, 2.0, 2.0]
deviation: [0.0, 2.1213203435596424, 1.118033988749895, 1.0327955589886444, 1.134261745631201]

Question: 9_2 business value of our services
mean: [2.0, 3.0, 3.5555555555555554, 3.0, 3.1578947368421053]
max: [2.0, 4.0, 5.0, 4.0, 5.0]
min: [2.0, 2.0, 2.0, 2.0, 2.0]
deviation: [0.0, 1.4142135623730951, 1.3333333333333333, 1.0954451150103321, 1.2139539573337679]

Relevant triggers to modernisation in our organization

Question: 10_1 Strategic business change
mean: [3.0, 5.0, 3.888888888888889, 4.0, 3.9473684210526314]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [2.0, 5.0, 2.0, 4.0, 2.0]
deviation: [1.4142135623730951, 0.0, 1.0540925533894598, 0.0, 0.9112679939102143]

Question: 10_2 Business need changes
mean: [4.0, 4.0, 4.222222222222222, 3.8333333333333335, 4.052631578947368]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [4.0, 3.0, 3.0, 3.0, 3.0]
deviation: [0.0, 1.4142135623730951, 0.6666666666666666, 0.408248290463863, 0.6212607441973955]

Question: 10_3 Perceived lack of business value
mean: [4.0, 4.5, 3.111111111111111, 3.6666666666666665, 3.526315789473684]
max: [4.0, 5.0, 4.0, 5.0, 5.0]
min: [4.0, 4.0, 2.0, 2.0, 2.0]
deviation: [0.0, 0.7071067811865476, 0.7817359599705717, 1.0327955589886446, 0.9048278567177283]

Question: 10_4 Inability to respond to changes (lack of business agility)
mean: [5.0, 4.5, 4.111111111111111, 4.333333333333333, 4.315789473684211]
max: [5.0, 5.0, 5.0, 5.0, 5.0]
min: [5.0, 4.0, 3.0, 3.0, 3.0]
deviation: [0.0, 0.7071067811865476, 0.6009252125773316, 0.816496580927726, 0.6710382982072027]

Question: 10_5 Costs
mean: [2.0, 3.5, 3.7777777777777777, 3.8333333333333335, 3.5789473684210527]
max: [2.0, 4.0, 5.0, 5.0, 5.0]
min: [2.0, 3.0, 2.0, 2.0, 2.0]
deviation: [0.0, 0.7071067811865476, 1.3944333775567928, 0.983192080250175, 1.2163602113447687]

Question: 10_6 Simplification of the architecture
mean: [3.0, 3.5, 3.111111111111111, 3.1666666666666665, 3.1578947368421053]
max: [4.0, 5.0, 4.0, 5.0, 5.0]
min: [2.0, 2.0, 2.0, 2.0, 2.0]
deviation: [1.4142135623730951, 2.1213203435596424, 0.927960727138337, 1.3291601358251257, 1.11868761873192]

Question: 10_7 Identified risks
mean: [3.5, 3.0, 3.5555555555555554, 4.0, 3.6315789473684212]
max: [5.0, 4.0, 4.0, 4.0, 5.0]
min: [2.0, 2.0, 2.0, 4.0, 2.0]
deviation: [2.1213203435596424, 1.4142135623730951, 0.8819171036881968, 0.0, 0.8950807732508138]

Question: 10_8 Availability of new technical capabilities / solutions
mean: [3.0, 4.0, 3.2222222222222223, 3.1666666666666665, 3.263157894736842]
max: [4.0, 4.0, 5.0, 4.0, 5.0]

min: [2.0, 4.0, 1.0, 1.0, 1.0]
deviation: [1.4142135623730951, 0.0, 1.3944333775567925, 1.3291601358251257, 1.2401659953032227]

Question: 10_9 Changes in vendor support
mean: [2.5, 3.0, 3.111111111111111, 3.5, 3.1578947368421053]
max: [3.0, 4.0, 4.0, 4.0, 4.0]
min: [2.0, 2.0, 2.0, 2.0, 2.0]
deviation: [0.7071067811865476, 1.4142135623730951, 0.927960727138337, 0.8366600265340756, 0.8983415518941831]

Question: 10_10 Quality of the system
mean: [4.0, 4.0, 3.3333333333333335, 2.5, 3.210526315789474]
max: [4.0, 4.0, 4.0, 4.0, 4.0]
min: [4.0, 4.0, 2.0, 2.0, 2.0]
deviation: [0.0, 0.0, 1.0, 0.8366600265340756, 0.976328005472037]

Question: 13_1 Business value
mean: [1.5, 3.5, 3.6666666666666665, 3.5, 3.3684210526315788]
max: [2.0, 4.0, 5.0, 4.0, 5.0]
min: [1.0, 3.0, 2.0, 2.0, 1.0]
deviation: [0.7071067811865476, 0.7071067811865476, 1.3228756555322954, 0.8366600265340756, 1.2115429242540032]

Question: 13_2 Business agility
mean: [3.0, 4.0, 3.7777777777777777, 3.0, 3.473684210526316]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [2.0, 3.0, 3.0, 2.0, 2.0]
deviation: [1.4142135623730951, 1.4142135623730951, 0.6666666666666666, 0.8944271909999159, 0.9048278567177283]

Question: 13_3 Business fit
mean: [3.0, 4.0, 3.4444444444444446, 3.5, 3.473684210526316]
max: [4.0, 5.0, 4.0, 4.0, 5.0]
min: [2.0, 3.0, 3.0, 2.0, 2.0]
deviation: [1.4142135623730951, 1.4142135623730951, 0.5270462766947298, 0.8366600265340756, 0.7723284457212329]

Question: 13_4 Costs
mean: [2.5, 3.5, 4.333333333333333, 4.0, 3.9473684210526314]
max: [3.0, 5.0, 5.0, 5.0, 5.0]
min: [2.0, 2.0, 3.0, 3.0, 2.0]
deviation: [0.7071067811865476, 2.1213203435596424, 0.7071067811865476, 0.6324555320336759, 0.9703197760719182]

Question: 13_5 Risks
mean: [3.0, 4.0, 4.111111111111111, 3.6666666666666665, 3.8421052631578947]
max: [4.0, 4.0, 5.0, 4.0, 5.0]
min: [2.0, 4.0, 3.0, 2.0, 2.0]
deviation: [1.4142135623730951, 0.0, 0.7817359599705715, 0.816496580927726, 0.8342100651206134]

Question: 13_6 Technical quality
mean: [2.5, 2.5, 3.7777777777777777, 3.3333333333333335, 3.3684210526315788]
max: [4.0, 3.0, 4.0, 4.0, 4.0]
min: [1.0, 2.0, 2.0, 2.0, 1.0]
deviation: [2.1213203435596424, 0.7071067811865476, 0.6666666666666667, 1.0327955589886444, 1.01162829777814]

Question: 13_7 Our capability to deliver service
mean: [4.5, 4.0, 3.888888888888889, 3.5, 3.8421052631578947]
max: [5.0, 4.0, 5.0, 4.0, 5.0]
min: [4.0, 4.0, 2.0, 3.0, 2.0]
deviation: [0.7071067811865476, 0.0, 0.927960727138337, 0.5477225575051661, 0.7647191129018726]

Question: 16_1 Business value of the change
mean: [2.5, 5.0, 3.888888888888889, 3.5, 3.736842105263158]
max: [3.0, 5.0, 5.0, 4.0, 5.0]
min: [2.0, 5.0, 2.0, 2.0, 2.0]
deviation: [0.7071067811865476, 0.0, 1.1666666666666667, 0.8366600265340756, 1.0975784083941789]

Question: 16_2 Time sensitivity of business value (Cost of delay)
mean: [3.0, 4.0, 3.3333333333333335, 3.0, 3.263157894736842]
max: [5.0, 4.0, 5.0, 5.0, 5.0]

min: [1.0, 4.0, 1.0, 1.0, 1.0]
deviation: [2.8284271247461903, 0.0, 1.2247448713915892, 1.4142135623730951, 1.3267380744248862]

Question: 16_3 Costs for the change
mean: [2.5, 5.0, 3.888888888888889, 4.166666666666667, 3.9473684210526314]
max: [3.0, 5.0, 5.0, 5.0, 5.0]
min: [2.0, 5.0, 2.0, 4.0, 2.0]
deviation: [0.7071067811865476, 0.0, 0.7817359599705717, 0.408248290463863, 0.8481145238787242]

Question: 16_4 Risks related to the change
mean: [3.0, 3.0, 3.888888888888889, 4.0, 3.736842105263158]
max: [4.0, 4.0, 5.0, 5.0, 5.0]
min: [2.0, 2.0, 3.0, 3.0, 2.0]
deviation: [1.4142135623730951, 1.4142135623730951, 0.6009252125773316, 0.6324555320336759, 0.8056815791722831]

Question: 16_5 Alignment with long term goals
mean: [4.0, 3.5, 4.111111111111111, 3.3333333333333335, 3.789473684210526]
max: [4.0, 5.0, 5.0, 4.0, 5.0]
min: [4.0, 2.0, 3.0, 2.0, 2.0]
deviation: [0.0, 2.1213203435596424, 0.7817359599705715, 0.816496580927726, 0.9176629354822471]

Appendix 7: The sense-making model one pager

Primary business driver

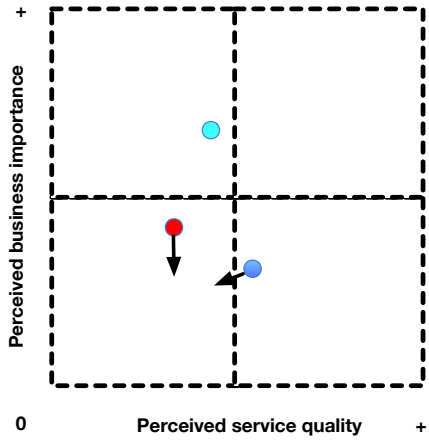
Identify alignment with the strategic initiatives or business drivers that either limit or enable different considerations.

Cost focus.
Growth focus.
Transformation focus.

Identify capabilities business needs

Identify capabilities that the business needs and if there is a gap between capabilities needed and capabilities in use.

Modernisation consideration selection



What is the assessed business value and importance, and technical quality of each system. Arrow shows how identified market forces or other expectations project the system / service to develop towards to next.

Assessment can be used to quickly evaluate on portfolio level which systems or services should have the focus for more in-depth consideration.

System	Costs	Expected loss	Improvements?

Value based opportunity quantification model

Select contextually relevant timeframes in the context to be used in the analysis (for example 3 and 5 years)

CURRENT COSTS	**QUANTIFIED CURRENT RISK PROFILE**
FUTURE VALUE OPPORTUNITY - increase revenue - protect revenue - reduce costs - avoid costs - risk reduction - strategic enablement	**Costs for change** **Risks in the change**