cumlaude.ai
Analytics & Data Services

Strategic Workforce Planning Model in Business Intelligence

Timo Petersen
28 August 2022
MSc. Business Administration
First supervisor: Matthias de Visser
Second supervisor: Agata Leszkiewicz

UNIVERSITY OF TWENTE.

Abstract

In recent years, more employees are changing profession. This causes new challenges for organizations to manage their workforce. The acquisition of essential knowledge is crucial for organizations and threatened if the competition has a better analysis of the market, better management of job preferences or is more resilient to the dynamics of supply and demand. Strategic workforce planning implies governing that "the right people with the right competencies are in the jobs at the right time" (Willis et al., 2018, p. 3). The difficulty of workforce management should be captured in strategic workforce planning research, along with the creation and application of models to advise strategies for workforce management.

Cumlaude.ai is a data start-up, specialized in realizing Business Intelligence and Artificial Intelligence solutions. They developed a mathematical model that provides parameters for workforce transitions through the organization which could predict future workforce occupation. This model builds on the Markov chain theory and offers a theoretical framework for strategic workforce planning. The research field of the Markov model lacks publications on the possibilities and the application of Markov in business intelligence, its integration into mainstream analytics tools, or how it could enable strategic workforce planning.

The goal of the research is to assess how the integration of Markov chains in Business Intelligence can enable strategic workforce planning. It is important to understand what strategic workforce planning consists of, how Markov chains can integrate into a mathematical model and how the mathematical model can be used for analysis, strategic decision making and strategic workforce planning. According to the Creative Technology Design Process that consists of an Ideation, Specification, Realization and Evaluation phase, a Business Intelligence solution with an integration of a mathematical model based on Markov theory was developed in the Microsoft Power BI application. This solution visualizes the current workforce occupation, personnel change, predicted future workforce occupation and the onboarding targets to reach the desired workforce occupation.

The evaluation through semi-structured interviews with potential users shows that the solution enables innovation, automation, standardization, customization, and development in relation to strategic workforce planning. The model contributes to innovation by accelerating digitalization and modernisation. The model contributes to automation by automatising data processing, limiting manual work and increasing efficiency by using a structured dataflow, reliable solution and unlocking capacity. It contributes to standardization by using centralized definitions, methodologies, and data processing. The model contributes to customization by offering room for changes in parameters, variables, definitions, formulas, and goals while offering organization-specific insights.

The research contributes to the academic discussion by making a first attempt at integrating Markov into business intelligence, a mainstream analytics tool, exploring its contribution to workforce analytics and realizing a strategic workforce planning model that enables analysis, strategic decision making and strategic workforce planning while incorporating different needs and applications in an effective approach.

The interviewees endorse that the model alone cannot replace the entire process of strategic workforce planning. There are many aspects that are often nuanced or require more in-depth research in addition to quantitative analysis. The interviewees indicate that the model can contribute to the further development of strategic workforce planning and enable organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented.

Table of Contents

List of Figures

List of Tables

1 Introduction

In recent years, more employees are changing profession. The Central Bureau for Statistics (2021) reports this based on the latest figures on changing professions, shown in Figure 1. This causes new challenges for organizations to manage their workforce. Given the value of talent and people, it is time to move beyond gut instinct and tribal wisdom when it comes to employment. If the organization is not leveraging workforce data and analytics to inform its hiring decisions, it may make too late, inefficient, wrong or, in the worst case, no decisions at all. This can pose a risk to the decisiveness needed to distinguish from competitors (Deloitte, 2021). The acquisition of essential knowledge is crucial for organizations and threatened if the competition has a better analysis of the market, better management of job preferences or is more resilient to the dynamics of supply and demand. The loss of essential knowledge can have a long-term and negative impact on an organization. An aging workforce, retiring specialists, recruiting, and retaining staff challenges, and the need to continuously enhance operational efficiency worsen workforce management efforts and keep the loss of essential knowledge a major issue for Human Resource departments (Lacey, 2012).

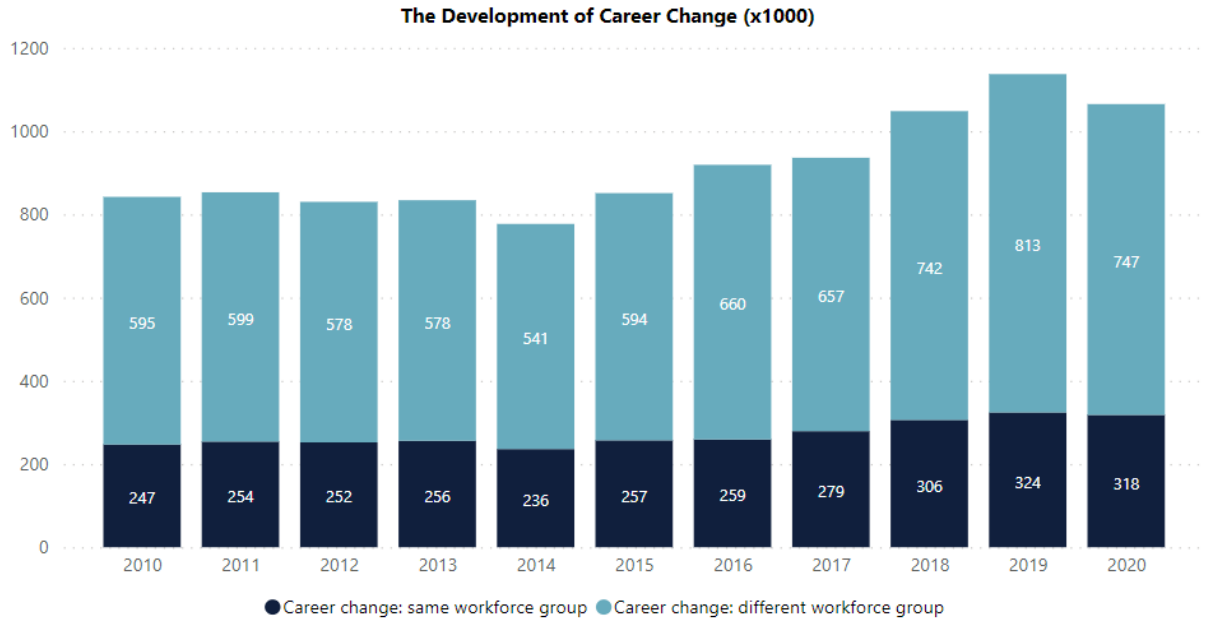


Figure 1: The development of career change in the Netherlands

Strategic Workforce Planning

Organizations have recognized the growing importance of Strategic Workforce Planning throughout the years. The advancement of technology, as well as the automation and digitization of professions, necessitates a new skill set than before. The supply of talent with those specialized talents and abilities is insufficient to meet the demand. To achieve their strategic goals, organizations must improve their capability to acquire, educate, and maintain talent. As a result, organizations must coordinate the workforce to guarantee that the necessary talents and capabilities are available at the appropriate time and location (Deloitte, 2017).

Strategic workforce planning is becoming increasingly important in organizations. The need for businesses to be more adaptable and agile is growing, requiring greater flexibility and adaptability in the workforce occupation. Strategic workforce planning allows organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented. Workforce analytics is predicting future workforce and talent-related behaviour and events using statistical models that include internal and external data. These models can assist companies in any industry in concentrating limited resources on crucial talent decisions (Deloitte, 2017).

Organizations could get away with underestimating the importance of planning as part of their workforce strategy before the constant evolution of the digital era. Not only are there too few organizations that engage in scenario planning, but those that do use ineffective methodologies. Planning is done in disparate systems, reflects ad hoc demands, and uses workforce data that is delayed. It also has a limited focus on internal staff alone, ignoring external workforce, material capacity, and client exchanges (Deloitte, 2017).

It falls well short of the predictive planning required to develop a long-term employable workforce to serve business objectives. This planning gap could explain why 61% of CEOs think they are unprepared to modify the skill and job mix of their personnel to shift to a digital firm.

Workforce planning is now catching up to the corporate environment and becoming as dynamic as it is. Today, prescriptive analytics solutions are available to assist businesses go beyond describing "what is happening now" or "what might happen in the future" to controlling "what should happen." Strategic workforce planning based on scenarios does more than forecast the future of work based on previous trends. It is a digital playground where the company may assess, learn, and tune workforce choices across dimensions and futures to fulfil the company's goal (Accenture, 2016).

Only strategic workforce planning verifies that the company has the capability and capacity to execute out the company's business strategy. Companies risk losing their competitiveness if they do not have the right personnel at the proper time, place, and cost. Because in the digital age, people, not technologies, are the differentiators. Despite this, 55% of executives claim their company only undertakes scenario planning once a year (Accenture, 2016).

In a survey of 10,447 business and HR leaders, McIver et al. (2018) found that 71% consider utilizing data analytics to manage workforce occupation as crucial for operating. Just 8% indicate that their organization has applicable data, just 9% consider that their organization has sufficient knowledge of what capabilities are effective, and just 15% indicate that their organization has implemented management reports on human resources and capabilities. Organizations have difficulties to yield improvement and transition from exciting analysis to organizational effects while the popularity of data analytics and organizational data increases.

With the developments in Data Analytics, Machine Learning and Artificial Intelligence, new analysis methods are possible. With the use of the latest technologies, organizations want to shift to data-driven management. These organizations have been using administrative systems to collect data for years but are often unable to make the transition to standardize, automate and optimize their data processing, visualization, or analysis to support their decisions. Let alone implementing innovative technology to, for example, detect pattern anomalies, identify emerging trends, predict

the development of performance indicators, or prescribe policy adjustments to increase performance.

Cumlaude.ai

Cumlaude.ai is a data start-up, specialized in realizing Business Intelligence and Artificial Intelligence solutions. This includes the development, implementation and support of automated dashboards and management reports that contain action-oriented insights, the processing and analysis of data flows, the education and training of experienced and prospective data engineers and analysts and strategic advice in the field of digital innovation. Cumlaude.ai works throughout the Netherlands for leading organizations in the public and private sector.

In their daily work they see the effects of the changing labour market, technological developments and the need for better and more complete information and analysis to make important decisions. To emphasize it, they engage in educating and retraining employees who lack the technological skills to adapt to the new demands from organization and society, to contribute to a more valuable society and to derive satisfaction from their work.

They developed a mathematical model that provides parameters for workforce transitions through the organization which could be used to predict future workforce occupation. This model builds on the Markov chain theory and offers a theoretical framework for strategic workforce planning. One of the most significant stochastic processes is the Markov chain. Markov chains are stochastic, and the description of their current state encompasses all the information that could have an impact on how they develop in the future. "The Markov property is satisfied when the current state of the process is enough to predict the future state of the process and the prediction should be as good as making prediction by knowing their history" (Biswal et al., 2021, p. 385). Examples of Markov applications are the PageRank algorithm used by Google, stock market predictions, next word predictions and election polls (Verma, 2021).

The model can be applied to organizational datasets through an R script, a programming language for statistical computing and graphics. These insights are interesting for organizations that want to gain insight into the inflow, movement or outflow of personnel and enable workforce predictions.

Currently, the model is based on a fixed structure of the data, requiring manual operations to prepare the data, present the results, and offers a standalone solution. Competencies in R-scripting are needed to run the model, it must be reiterated once the dataset is updated, requires fixed variables, and must be reconstructed for each dataset.

The usability can be increased and benefit organizations as it improves accessibility, agility, adaptability, scalability and allows integration into other Business Intelligence reports or tools and enables strategic decision making. It has the potential to become the go-to solution for organizations seeking standardized, automated, repeatable, repetitive, and customizable solutions for the entire organization.

Research goal

If the organization is not leveraging workforce data and analytics to inform its hiring decisions, it can pose a risk to the decisiveness needed to distinguish from competitors. Strategic Workforce Planning enables organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented. With the developments in Data Analytics, Machine Learning and Artificial Intelligence, new analysis methods are possible. The interviewees indicate that the model can contribute to the further development of strategic workforce planning and enable organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented.

The developed mathematical model that offers a theoretical framework could be used to predict future workforce occupation but lacks an accessible, dynamic, adjustable, and scalable method for calculation and analysis which can be integrated in other Business Intelligence reports or tools and enable strategic decision making.

There is a gap in the research field of the Markov model and its possibilities and applications. There are no publications on the application of Markov in business intelligence, its integration into mainstream analytics tools, or how it could enable strategic workforce planning. In addition, there are few practical examples of Markov's application to workforce development, let alone in an integrated or optimized way.

The goal of the project is to research how the integration of Markov chains in Business Intelligence can enable strategic workforce planning. To reach this goal, it is important to understand what strategic workforce planning consists of, how the mathematical model can be integrated in a calculation method and how the mathematical model can be used for analysis, strategic decision making and strategic workforce planning.

The previous section introduced the main challenges for strategic workforce planning models:

- The organization could be falling behind the curve and lose its competitive advantage if workforce data and analytics is not leveraged to inform its hiring decisions.
- Organizations must coordinate the workforce to guarantee that the necessary talents and capabilities are available at the appropriate time and location Strategic workforce planning today is static, inconsistent, and spreadsheet intensive.
- 55% of executives claim their company only undertakes scenario planning once a year.
- Organizations that do engage in workforce planning use ineffective methodologies
- Planning is done in disparate systems, reflects ad hoc demands, and uses workforce data that is delayed.
- It also has a limited focus on internal staff alone, ignoring external workforce, material capacity, and client exchanges.
- 61% of CEOs think they are unprepared to modify the skill and job mix of their personnel to shift to a digital firm.
- Executives claim their company only undertakes scenario planning once a year.
- Only 8% report of executives claim that their organization has usable data.

Based on these challenges, the following provisional requirements for the new strategic workforce planning model can be identified:

- Allows for dynamic strategic workforce planning (non- static, cope with data updates and irregular analysis).
- Allow users to interactively modify underlying assumptions
- Can be integrated in Business Intelligence tools
- Based on historical organizational data
- Operational with basic and complex datasets
- Predict future workforce
- Prescribe actions to reach the preferred workforce occupations

After introducing the situation and complications the following research questions are identified:

Main research question:

1. **How can the integration of Markov chains in Business Intelligence enable Strategic Workforce Planning?**

Sub research questions:

2. **What is strategic workforce planning?**
3. **How can Markov be integrated in a new strategic workforce planning model?**
4. **How can the model be integrated in a Business Intelligence solution for strategic workforce planning?**

Research strategy

In order to answer these research questions, it is important to first review the existing literature in the field of strategic workforce planning, Business Intelligence, prediction models and mathematical or statistical theories about Markov chains. In addition, the lessons from the literature are applied to specify user requirements, design a new strategic workforce planning model, and integrate this model in a Business Intelligence solution. Finally, the solution will be analysed through semi-structured interviews with potential users of Strategic Workforce Planning models.

2 Theoretical framework

In this chapter, the related literature on strategic workforce planning, business intelligence and Markov chains will be reviewed. Next to that, the literature in relation to the research will be discussed.

2.1 Semi-structured literature review

The rate of knowledge production in the field of business research is increasing dramatically, yet it is still distributed and interdisciplinary. This makes it challenging to follow the latest academic progress and evaluate evidence in a certain field. Wherefore literature reviews have become more important (Snyder, 2019).

A literature review can combine the findings and points of view from various empirical studies to address research subjects. As a research approach, an effective and well-conducted review establishes a strong basis for increasing expertise and facilitating theory development. It can also assist in providing an overview of areas where the research is multidisciplinary and divergent. A literature review is also a good method to integrate results to provide evidence and identify fields where more research is required, which is an important part of developing conceptual models and constructing theoretical frameworks (Snyder, 2019).

Conventional methods of explaining and presenting the literature, on the other hand, frequently lack completeness and are not conducted in a systematic way. As a result, there's a good likelihood that writers' research is based on flawed assumptions.

A semi-structured literature review is effective for detecting topics, theoretical assessments, or general questions within a particular field of study and that have been developed over time (Snyder, 2019). Furthermore, Snyder (2019) suggests that a clear methodology including search terms, databases, and selection rules is required in the design of a semi-structured literature review.

2.2 Semi-structured literature review in relation to the research project

The goal of this chapter is to review the related literature on strategic workforce planning, business intelligence and Markov chains. This review will enable understanding of the underlying context, theory, frameworks, and models. Because the research involves multiple topics from multiple researchers and various fields, a semi-structured literature review approach is used. A semi-structured literature review is effective for detecting topics, theoretical assessments, or general questions within a particular field of study and that have been developed over time.

2.3 Strategic Workforce Planning

The first semi-systematic literature review focuses on strategic workforce planning. The aim of this review is to answer the first sub research question: What is strategic workforce planning?

The search terms that were used in this literature review, are:

Strategic workforce planning (Topic) OR Workforce occupation (Topic) AND Business intelligence (Topic) AND Model (Topic) AND 2015-2022 (Year Published). These search terms have been utilized through search in the Web of Science database. A flowchart of the semi-systematic

literature review for the theoretical analysis is presented in Appendix A. The articles are included in the review based on the content of the abstract and in the form of impact and findings.

2.3.1 What is Strategic Workforce Planning?

Strategic workforce planning is "a plan that should be driven by the need to determine the right sized work force having the right competencies to meet current and future business objectives and goals of an organization" (Patra & Tripathi, 2017, p. 3). According to Patra and Tripathi (2017) strategic workforce planning is a fundamental process in human resources. It is a significant chance to contribute to the direction of the organization. Hard workforce planning is the term used when the planning is only dependent on data to estimate future supply and demand based on historical trends. Soft workforce planning can be defined as a key people management process that is shaped by organizational strategy and ensures that the workforce is matched appropriately to accomplish organizational goals based on the strategy of the organization. It defines the combination of necessary experience, knowledge, and abilities, as well as the sequential actions to get the appropriate quantity of individuals in the appropriate locations at the appropriate times.

Strategic workforce planning implies governing that "the right people with the right competencies are in the jobs at the right time" (Willis et al., 2018, p. 3). According to Willis et al. (2018), there are three different strategic workforce planning approaches: judgmental, mathematical and a combination of both. They found that mathematical models are centred in research while the application of outcomes is neglected. In addition, the research of mathematical models are, most of the time, generalisations of complicated workforce circumstances. On the other hand, research built on case studies offered judgments of the complicated workforce circumstances short of statistical support. According to Willis et al. (2018), little of the mathematical models were utilized on strategic levels. They were utilized on operational and tactical level. They identified this as an opportunity and assessed that the difficulty of workforce management should be captured in strategic workforce planning research, along with the creation and application of models to advise strategies for workforce management.

'Horizon scanning' was identified as a potential framework for strategic workforce planning. This is an analysis method that advises strategic management on possible chances and risks without the prerequisite to have effect on the present operations (Willis et al., 2018). This method does not only have to inform about potential challenges but can also be an approach to deal with them. Scenarios offer a broader view of the potential challenges than horizon scanning. Scenarios consist of descriptions about potential challenges and enable to discover how the different challenges could develop and assess the effect on the organizational strategy.

The Robust Workforce Planning Framework, shown in Figure 2, consists of four stages:

1. Horizon scanning: identify possible chances and risks without the prerequisite to have effect on the present operations.
2. Scenario generation: analyse how the different challenges could develop and assess impact on the organizational strategy.
3. Workforce modelling: model the workforce with the different scenarios and potential challenges in mind.

4. Policy analysis: compose strategies to prepare the organization for the different scenarios and potential challenges.

This framework does not try to generate an accurate forecast but recognizes the uncertainty and difficulty of the different components that have impact on the workforce occupation. The framework begins by asking stakeholders to consider the main worry or query regarding a workforce. The next stage is to think about what the future of the workforce might look like. The framework can be used to create a set of believable and extremely difficult situations by analysing the main problems and uncertainties. Each probable future is represented by a scenario. To understand how workforce occupation or capabilities vary over time, demand and supply for each scenario are then simulated (Willis et al., 2018).

These scenarios can be used to evaluate potential policies to see which is the most successful. To be resilient against uncertainty, decisions made about labour requirements must function effectively across a variety of scenarios. The strategic workforce planning framework can be used to assess the size of the workforce in unpredictable environments at the organizational and governmental levels (Willis et al., 2018).

Application of this framework is dependent on significant limits which restrict the executive options, such as governmental instructions, financial or time restraints or the demands of clients. Numerous considerations, such as personal preference, the modeler's standard practice, and/or institutional pressures, frequently play a role in the choice of tools and approaches in practice. Therefore, selection is not governed by a predetermined design; instead, it may be the outcome of organizational changes and/or learning processes. Instruments and processes could be switched out, which makes the application in practice unstable. To externalize learning, additional research on solutions with a practical focus is required (Willis et al., 2018).

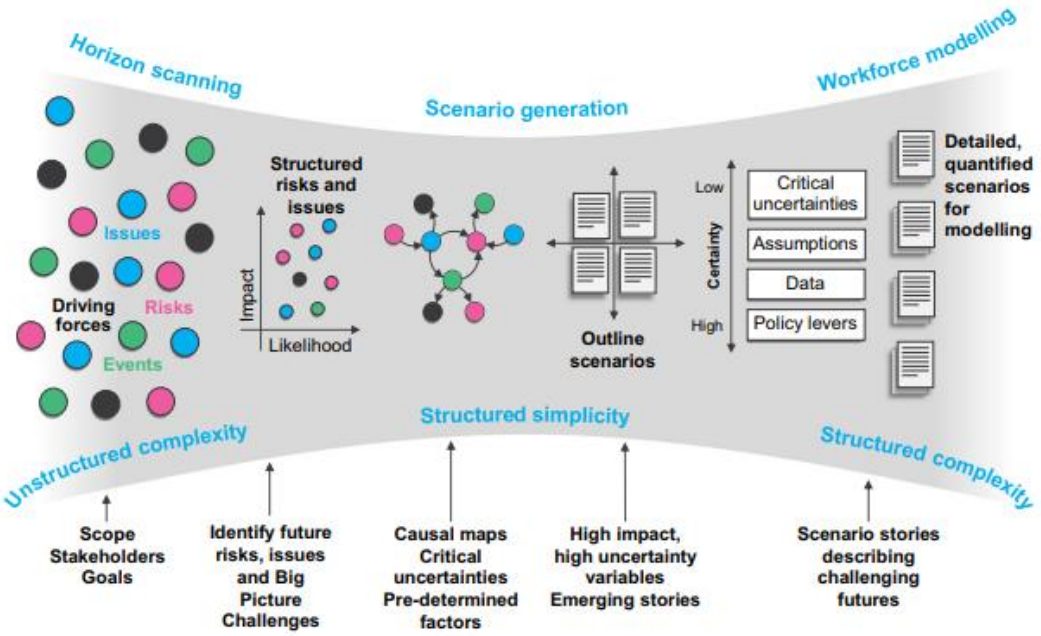


Figure 2: The Robust Workforce Planning Framework

According to Patra and Tripathi (2017), the overall benefits of workforce planning consist of:

- Helps eliminate traumatic stress brought on by surprises
- HR has enough time to find qualified candidates for essential positions, allowing for the best and most efficient use of resources
- Smoothing of business phases through improving adaptability of talent supplies and pipelines
- Building correct budgeting for training, development, and career promotion requires realistic estimates
- A company has a system in place to spot issues before they become serious
- Demand volatility and demand uncertainty can be effectively controlled
- HR has enough time to train the skills of employees
- By planning minimal paid agent labour hours, workforce initiative in the service sector is essential to minimizing costs and maximizing service levels
- It has been discovered to support successful financial outcomes
- Investments in human resource operations have a demonstrable impact on organizational success

Llort et al. (2018) researched strategic workforce planning at consulting organizations. For this kind of organization, the main resources are professionals thus capacity depends on workforce occupation. Consequently, strategic workforce planning is a strategic human resource planning problem. These organizations offer clients complicated, personalised solutions thanks to their trained and skilled employees.

The human resource decision-making process in consultancies consists of three steps:

1. Hiring employees
2. Promoting employees. The personnel flow is limited because not all employees get promoted.
3. Firing employees. Possible when there is a lower demand for projects in a specific category, industry, business line or the employees do not achieve their objectives.

Other activities that influence the workforce occupation are departures, health problems, parenthood, availability, or turnover.

Strategic workforce planning is usually applied on a period from 18 months to 10 years, varying on field and external influences. There is growing interest in the creation of mathematical tools to support strategic workforce planning at consultancies. According to Llort et al. (2018), consulting organizations must execute strategic workforce planning through a large scope to guarantee the right occupation.

2.3.2 The challenges of Strategic Workforce Planning

Previous section introduced the strategic workforce planning frameworks and processes. Willis et al. identified the challenges that workforce planning research should consider how the results are implemented, prevent the mathematical models to be 'simplifications of complex workforce situations,' entail mathematical support in descriptive explanations of complex workforce models,

and aim to achieve application on strategic levels. Llort et al. (2018) identified the growing interest in the creation of mathematical tools to support strategic workforce planning and other activities, next to hiring, promoting, and firing, that influence the workforce occupation are departures, health problems, parenthood, availability, or turnover.

The introduction identified the challenges that the organization could lose its competitive advantage if workforce data and analytics is not embedded, organizations must coordinate their workforce to guarantee that they have access to the relevant talents, strategic workforce planning today is static, inconsistent, spreadsheet intensive, ineffective, done in disparate systems, reflects ad hoc demands, uses workforce data that is delayed, has a limited focus on internal staff alone, executed irregular and requires usable data.

Sinclair (2021) states that what is applicable for an organization depends on the ease of implementation and adaptability to the current situation. Most organizations do not require a complex approach. Sinclair states that the majority of workforce planning fails and describe issues from which organizations could learn. First, strategic workforce planning should not be viewed as predictions of the future but as establishing the perspective for organizational issues and enabling strategic decision making. Secondly, human resource employees lack the capabilities to understand the business issues that are needed to produce workforce plans and use them in their traditional role. Thirdly, the strategic workforce planning is frequently applied in the wrong way.

According to Sinclair, effective workforce planning requires being adaptable, sustaining, and considerate of the various demands of units. The integration of workforce planning with organizational instructions in a cooperative way is needed so that they both respond to and inform one another, rather than standing alone.

2.3.3 Strategic Workforce Planning in relation to the research project

Strategic workforce planning implies governing that "the right people with the right competencies are in the jobs at the right time" (Willis et al., 2018, p. 3). There are three different types of strategic workforce planning approaches: judgmental, mathematical and a combination of both.

The difficulty of workforce management should be captured in strategic workforce planning research, along with the creation and application of models to advise strategies for workforce management.

Llort et al. (2018) described that strategic workforce planning is a strategic human resource planning problem and the human resource decision-making process in consultancies consists of hiring, promoting, or firing consultants. Other activities that influence the workforce occupation are departures, health problems, parenthood, availability, or turnover.

The Robust Workforce Planning Framework is an analysis method that advises strategic management on possible chances and risks without the prerequisite to have effect on the present operations (Willis et al., 2018).

This framework does not try to generate an accurate forecast but recognizes the uncertainty and difficulty of the different components that have impact on the workforce occupation.

The Robust Workforce Planning Framework consists of four stages:

1. Horizon scanning: identify possible chances and risks without the prerequisite to have effect on the present operations.
2. Scenario generation: analyse how the different challenges could develop and assess impact on the organizational strategy.
3. Workforce modelling: model the workforce with the different scenarios and potential challenges in mind.
4. Policy analysis: compose strategies to prepare the organization for the different scenarios and potential challenges.

The semi-structured literature review for strategic workforce planning showed that mathematical models are, most of the time, 'simplifications of complex workforce situations.' Since this research focuses on the integration of Markov chains in Business Intelligence it is a challenge for this research is to take all stages of workforce planning into account while analysing how the integration can enable strategic workforce planning.

The challenges of strategic workforce planning indicate the knowledge gap in realizing a strategic workforce planning model that enables analysis, strategic decision making and strategic workforce planning while incorporating different needs and applications in an effective approach.

2.4 Business Intelligence

In 1996, the Data Warehouse Toolkit was launched. Kimball introduced the business intelligence field to dimensional modelling. Dimension modelling has developed to be the acknowledged method for data processing in data warehouse and business intelligence (DW / BI) systems (Kimball & Ross, 2013). The Data Warehouse Toolkit contains methods, procedures, and examples for dimensional modelling.

2.4.1 The Data Warehouse Toolkit

Any organization's information is one of its most valuable resources, both for operations and decision-making. Simply said, the DW/BI system is where the data is extracted and collected, while the operational systems are where you enter the information. The organization's machinery is operated by its users. Orders are taken, new clients are added, operational actions are tracked, and complaints are logged. Systems used for operations are designed to move transactions along rapidly. Often, one transaction record at a time is managed by these systems. They execute the business operations of the corporation by consistently performing the same operational responsibilities. Given this emphasis on execution, operational systems often update data to reflect the most recent condition rather than maintaining history.

On the other hand, users of DW/BI systems observe how the organization functions to assess performance. They analyse the number of new customers, reasons for complaint, and compare numbers to previous periods. They are concerned with the efficiency of operational procedures. DW/BI users hardly ever manage one transaction at a time, even though they require comprehensive data to answer their continuously evolving questions.

Because the answers to users' requests frequently require the search and compression of tens of thousands or even hundreds of thousands of transactions, these systems are designed for high-performance searches (Kimball & Ross, 2013). Users of a DW/BI system frequently insist on reserving historical data to appropriately assess the development of organization.

According to Kimball, there are different requirements for a DW/BI system:

- It should facilitate simple access
- It should be up to date
- It should be flexible
- It should enable convenient data collection
- It should be a protected environment
- It should be reliable and truthful
- It should be accepted by the users

The development of DW/BI system requires technological embeddedness while it requires, on the other hand, embeddedness in the organizational environment.

Kimball identifies three responsibilities for a DW/BI engineer:

- Identify with the organizational users.
- Provide useful, applicable, straightforward analysis to the organization.
- Support the DW/BI system

2.4.2 The ETL system

The extract, transformation, and load (ETL) process consist of everything between the operational source systems and the BI visualization tooling (Kimball & Ross, 2013). Extraction means to read, comprehend, and copy the source data into the process for further modification. There are many transformations that can be performed on the data once it has been extracted using an ETL system, including cleaning the data (removing empty rows, removing duplicates, or transforming datatypes), splitting data, and merging data. With these functions of cleansing and conforming, the ETL system changes and improves the data, adding value to it. Additionally, these activities can be designed to generate diagnostic information, which will result in the reengineering of business processes to enhance the data quality in the source systems over time.

The actual organizing and transferring the data towards the dimensional model for the visualization area is the last step of the ETL procedure. These subsystems are crucial since the delivery of dimension and fact tables are the main tasks of the ETL system. Many of these defined subsystems concentrate on processing dimension tables, performing operations like adding unique identifiers, descriptions, new columns, and the right formats for the dimensional model. Fact tables often require more time to load, but they are typically simple to prepare for the visualization environment. Once the fact and dimension tables are validated, deployed, and related to each other, the organizational users have access to the latest information.

2.4.3. Dimensional Modelling Myths

Even though dimensional modelling is widely accepted, certain misconceptions about it still exist. These untrue claims are a deterrent, especially if you wish to unite your staff around a set of best practices. Kimball and Ross (2013) identified five myths about dimensional modelling:

1. It is only suitable for aggregated information
2. It is not suitable for organizations but only for smaller units
3. It is not scalable
4. It is only suitable for predictions and not for descriptive analytics
5. It is not possible to relate to other data models

In the introduction, multiple provisional requirements for the new strategic workforce planning model were identified. That included the integration in Business Intelligence tools, foundation on historical organizational data, operation with basic and complex datasets and the prediction of future workforce occupation. Kimball found that dimensional models can be integrated, are not only for predictable usage, are scalable and can be integrated.

2.4.3. Kimball DW/BI Lifecycle Overview

The Kimball Lifecycle method was developed by the creators of The Data Warehouse Lifecycle Toolkit using years of expertise (Kimball & Ross, 2013). When it was first presented in 1998, it was called the Business Dimensional Lifecycle, which reinforced the principles for the success of a data warehouse: pay attention to the requirements of the business, give users access to dimensionally structured data, and take on manageable and iterative projects. The Lifecycle Overview, shown in Figure 3, shows the task structure, dependence, and compatibility. This overview enables BI developers to structure their approach.

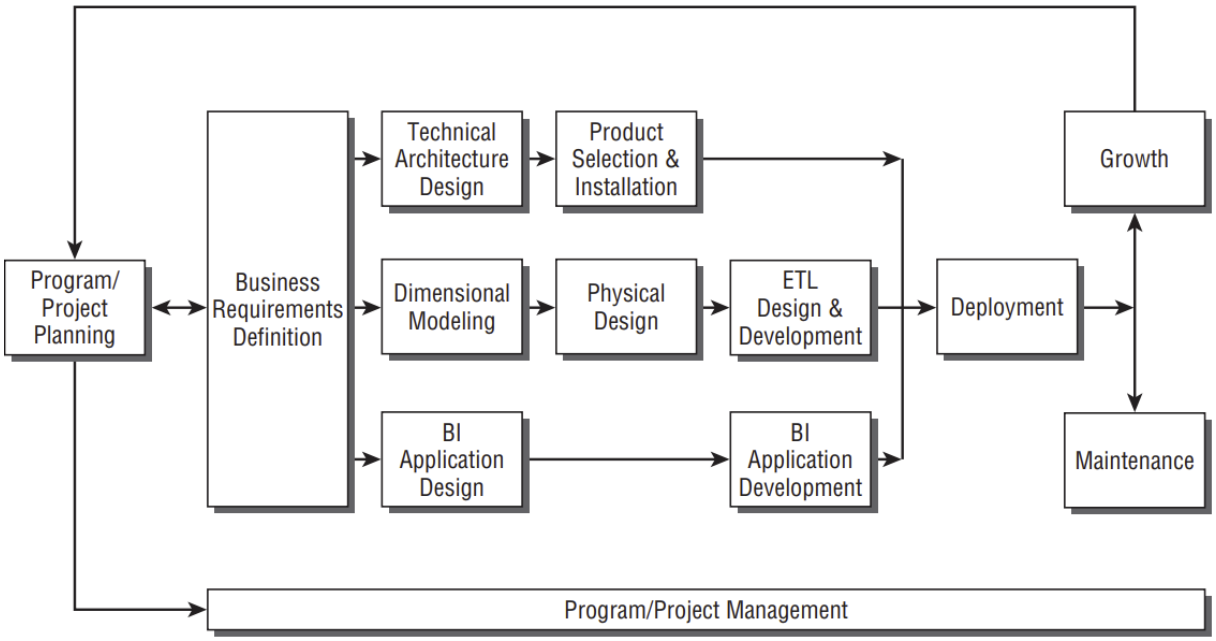


Figure 3: Kimball DW/BI Lifecycle Overview

2.4.4. BI in Perspective

Van Beek and van der Steen (2018) authored a book about Business Intelligence, Big Data, Artificial Intelligence, Data Science and Machine Learning models for organizations and developers. This book provides a good overview of the Business Intelligence process, shown in Figure 4. According to van Beek, the BI process consists of six iterative steps:

1. Data collection
2. Data storage
3. Data visualization
4. Data analysis
5. Data interpretation
6. Action

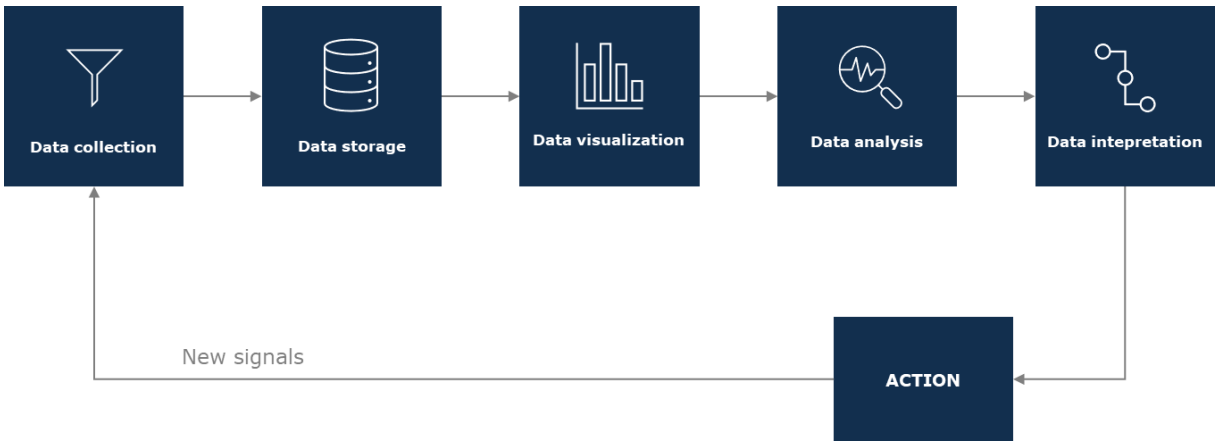


Figure 4: The BI process

2.4.5 Business Intelligence in relation to the research project

In the strategic workforce planning section, it was found that the Robust Workforce Planning Framework consists of four stages:

1. Horizon scanning: identify possible chances and risks without the prerequisite to have effect on the present operations.
2. Scenario generation: analyse how the different challenges could develop and assess impact on the organizational strategy.
3. Workforce modelling: model the workforce with the different scenarios and potential challenges in mind.
4. Policy analysis: compose strategies to prepare the organization for the different scenarios and potential challenges.

Kimball and Ross (2013) introduced ETL system, dimensional modelling, dimensional modelling myths and the Lifecycle Overview. They described those BI systems should be up-to-date, flexible, a protected environment, reliable, truthful, accepted by the users, enable convenient data collection, and facilitate simple access. Next to that, they showed that dimensional models can be integrated, are not only for predictable usage, are scalable and can be integrated.

Van Beek introduced the Business Intelligence process, which consists of data collection, storage, visualization, analysis, interpretation, and action.

The dimensional modelling technique is suitable for data collection, storage, visualization and can contribute to the analysis, interpretation, and monitoring of actions. If the lessons of the Data Warehouse Toolkit and BI process are applied to the development of the strategic workforce planning model, Business Intelligence could contribute to the scenario generation, workforce modelling and policy analysis of the Robust Workforce Planning Framework.

2.5 Markov chains

Markov is a probability model that is applied to processes that change at random (Wikipedia, 2021). The variable's next state is determined only by its present state and the transitional probabilities that determine how the next state is going to develop. The Markov property is "satisfied when current state of the process is enough to predict the future state of the process and the prediction should be as good as making prediction by knowing their history" (Biswal et al., 2021, p. 385). In general, this assumption makes it possible to use the model for computation and reasoning that would otherwise be impossible. Therefore, a model that possesses the Markov property is desired if predictions about a process are required (Wikipedia, 2021).

Markov analysis has two main advantages: simplicity and observational forecasting precision. Simple Markov models are frequently more accurate forecasters than more complex models. Markov analysis can't usually be the accurate model of the underlying situation, which makes it unhelpful for describing events (Kenton, 2021).

In relation to the research, the model would not be suitable to explain underlying events that cause, for example, a decrease in occupation. Markov Chains are exceptionally applicable to represent a discrete-time, discrete-space stochastic process in a variety of domains (Kenton, 2021). Exploring this model is appealing in relation to strategic workforce planning, considering the immense utility of this concept in various domains and its pivotal importance to a substantial number of algorithms in data science.

There are four different types of Markov techniques, for which the application differs on observability and consistency of the process, shown in Table 1 (Wikipedia, 2021).

	System state is fully observable	**System state is partially observable**
System is autonomous	Markov chain	Hidden Markov model
System is controlled	Markov decision process	Partially observable Markov decision process

Table 1: Markov models

The strategic workforce planning system is an autonomous and fully observable system since the states can be observed in the data collection and observations do not adjust the system.

The Markov chain is the most basic Markov model. It uses a random variable that evolves over time to model the state of a system. The Markov property in this situation implies that the next

state is determined only by its present state and the transitional probabilities that determine how the next state is going to develop.

2.5.1. Markov and Business Intelligence

Markov models are used in predictive models but is not often used in Business Intelligence. At least, that is concluded based on the low search results in the semi-structured literature review. A search entry of Markov (Topic) AND Business Intelligence (Topic) AND 2015-2022 (Year Published) in the Web of Science database, one of the largest academic research databases, results in only one search result.

Markov chains and regression analysis are the most important methods for predicting systems (Uchwat & Macleod, 2012). Regression analysis is the simplest to apply and enables multifactor analysis. The method tries to calculate the numbers at which the variables meet the current observations. Regression gets better as more data is included in the model. A disadvantage is that it needs multiple years of data to forecast. On the other hand, Markov operates from two years of input.

According to Uchwat and Macleod (2012), the advantages of regression analysis techniques include:

- Straightforward calculations
- Historical datasets enable forecasting
- Complex calculations can utilize this method
- Enables multifactor analysis
- The quality of the forecast can be assessed

Regression analysis explores the connection between multiple factors and looks for the underlying connection between the different factors. Next to that, it is able to assess the statistical significance, the certainty, of the underlying connections.

According to Uchwat and Macleod (2012), the advantages of Markov analysis consist of:

- Markov operates from two years of input. Regression needs multiple years of input to forecast.
- Works with lower data quality
- Enables integration of other prediction methods
- Calculated variables are not affected by shifting calculation ranges
- Does not require extensive applications of regression for secondary variables

The variable's present state is what counts. The variable's next state is determined only by its present state and the transitional probabilities that determine how the next state is going to develop. The transitional probabilities are computed by calculating the change between the present and previous state. Multiple years of data points are needed to reach a similar success with a regression analysis.

Cumlaude.ai developed a mathematical model that provides parameters for workforce transitions through the organization which could be used to predict future workforce occupation. This model

builds on the Markov chain theory and offers a theoretical framework for strategic workforce planning. Taekema, M., a data engineer, data scientist and mathematician laid the foundation for this model.

According to the internal documentation, determining personnel flow can be done in an unspecified number of ways. The methodology explained here is based on several restrictions that the personnel development must meet, whereby the personnel development can be drawn up implicitly.

According to the internal documentation, it can help solve the following problems:

- Incomprehensible insight into staff
- Incomprehensible insight into the consequences of current personnel change
- Limited management and insight into the consequences of management on personnel change

The underlying question is if the personnel change can be modelled. This can be done in an explicit way:

The search for a suitable comparison is done by iterating explicitly over the related figures. This is a direct method → Markov chain

Or in an implicit way:

The search for a suitable comparison is done by drawing up criteria that a comparison must meet. Indirectly via the imposed restrictions a general equation can then be found → differential equation

The mathematical restrictions for the model are that it is a stable function, has current workforce occupation, outflow-% and personnel influx as parameters, the independent variable is time, and the dependent variable is the workforce occupation. It is a criterion that the change in occupancy can be expressed in the difference between inflow and outflow.

A differential equation tells where and how a variable develops over time, at what speed it happens and in which direction it belongs.

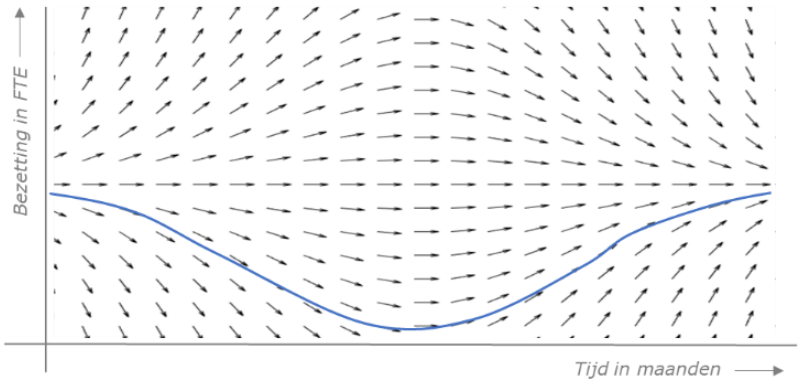


Figure 5: Example of a differential equation

A partition of the personnel flow can be made from every point x(ti), representing the occupation x at time ti. The personnel flow can split into personnel influx and personnel outflow. The difference

between the two gives the difference in workforce occupation. In other words, the degree of occupancy change is a function of inflow and outflow.

It can be described as follows:

$\frac{dx(t)}{dt} = -ax(t) + b$,

where a is the percentage of personnel outflow and b is the amount of personnel inflow.

This can be characterized as a first-degree normal linear differential equation. Therefore, it is relatively easy to solve it via the separation of variables technique:

$$dx(t)dt = -ax(t) + b,$$
$$dt = 1 - ax + b\,dx,$$

$$Z\,dt = Z\,1 - ax + b\,dx,$$

$$t + C0 = -1\,a \log -ax + b,$$

$$-at + C1 = \log -ax + b,$$

$$C2e - at = -ax + b,$$

$$C2e - at - b = -ax,$$

$$x = C3e - at + b\,a,$$

$$x = Ce - at + b\,a$$

Then only the constant C must be determined. This is done by filling in the initial requirement x(0) = xH, where xH represents the current occupancy so that at time t = 0 the current occupancy is included. This results in:

$$x(0) = xH = Ce - a \cdot 0 + b\,a\,xH = C + b\,a\,,$$

$$C = xH - b\,a$$

And so, the final solution is:

$$x(t) = xH - b\,a\,e^{-at} + b\,a$$

The final solution allows a dynamic, adjustable, and scalable method for calculation and analysis which can be integrated in other Business Intelligence reports or tools and could enable strategic decision making.

3 Method

To further investigate the context of the business problem and to find answers to the proposed sub questions and central research question, a suitable methodology and research strategy is required. Robson (2002) suggests that most research questions cannot be answered using theory alone, because often there is no literature available, the literature is too broad, or the literature proposes findings from a different context. A solution to this, is to conduct empirical research in which you add real world findings to the existing theory to answer research questions. Therefore, a decision needs to be made between the different empirical research designs: Quantitative research which emphasizes on statistical testing of assumptions, Qualitative research which emphasizes on analysing behaviours, events and artifacts, Design research which emphasizes on developing a useful artifact, Action research which emphasizes on the effect of an intervention or a mixed methods approach which is a combination of the research designs (Robson, 2002). Because this research focuses on discovering a solution to a specific business problem, the most appropriate research method appears to be design research.

3.1 The Creative Technology Design Process

The Creative Technology Design Process (CTDP) enables to "design products and applications that improve the quality of daily life in its manifold aspects, building on Information and Communication Technology" (Mader & Eggink, 2014, p. 1). The CTDP allows for a user-centred design by applying principles from Industrial Design, Interaction Design and Engineering Design. In relation to the research, it enables the assessment of applications of technology with user-centred approach.

The CTDP is a blend of 'Divergence', 'Convergence' and 'Spiral' models, which are frequently utilized in the design and engineering field. The Divergence phase is where multiple ideas are generated for the explored subject, while in the Convergence phase the ideas are tightened down to one invention. The Spiral model allows for iterative design process but not iterative steps in a specific order. The CTDP consists of four phases: ideation, specification, realisation, and evaluation. The CTDP is shown in Fig.3. In the ideation phase multiple ideas are created and designed. In the specification phase, requirements are set, and the best design concepts is specified. In the realisation phase, the actual model is designed corresponding to the requirements. In the evaluation phase, the design gets tested and evaluated.

In the solution and evaluation design, semi-structured interviews were conducted with experts in the field of the proposed solution to utilize their expertise in developing an appropriate solution and evaluation. The interviews are semi-structured in that a clear outline is followed to systematically uncover the necessary information, but that there is also room for elaboration by the interviewee (through probing) and room for follow-up questions by the interviewer through the conversational style of interviewing, which allow for more complete insights than through the more strictly managed structured interviews.

Semi-structured interviews provide the researcher with insights directly from the actors in the organization, allow for more freedom to elaborate than a survey and have a higher likelihood to reap more unbiased insights from multiple perspectives compared to a focus group (Ip et al., 2018). Dybå et al. (2011) add to this by suggesting that semi-structured interviews are often used

in situations where objective knowledge about the phenomenon is known, but subjective knowledge is lacking. However, interviews often assume much more time of both the interviewer and interviewees as well as create a larger disruption in the workflow of the organization because of the absence of employees on the work floor during the interview, which should be taken into consideration (ITC e-learning, 2022).

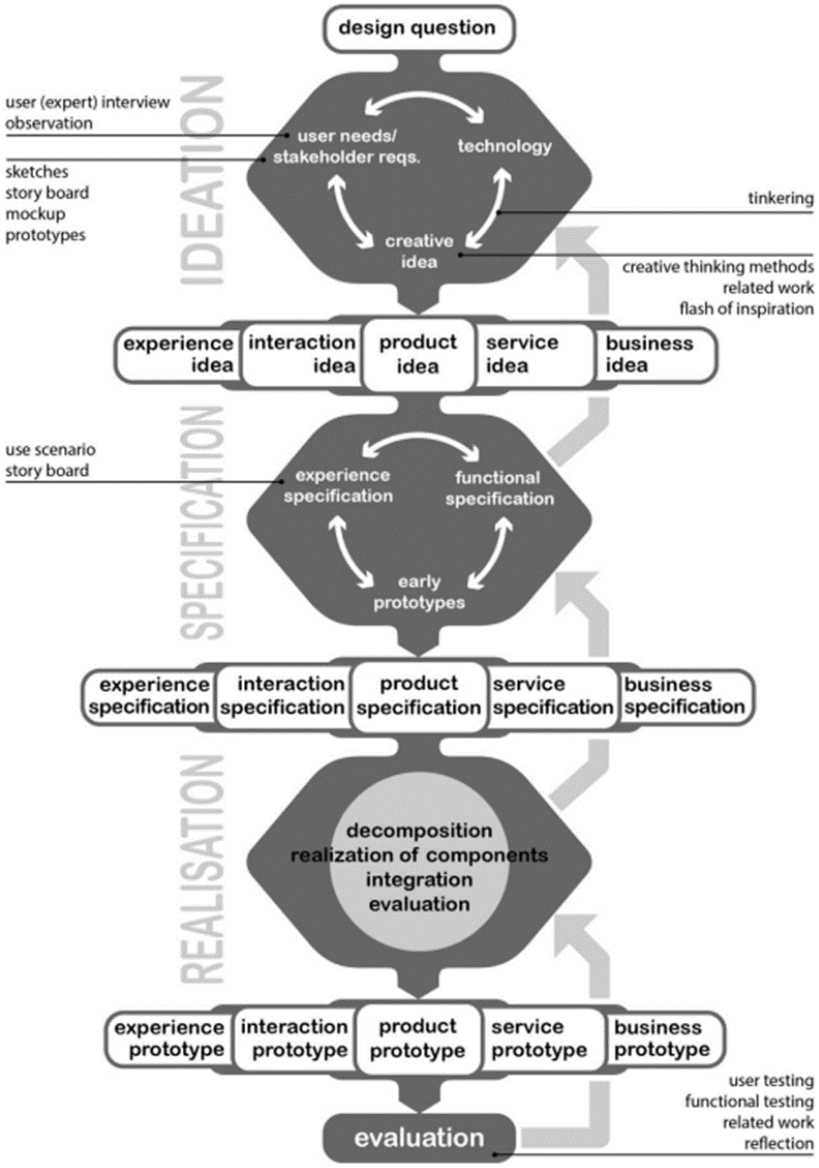


Figure 6: The Creative Technology Design Process

3.2 Ideation

Tinkering is a term that is used to describe the method to identify new applications for present or pioneering technology (Mader & Eggink, 2014). This method has the goal to connect the user requirements with technology. In the user-centred design field, mock-ups, sketches, scenarios, and storyboards are well-known methods to assess user requirements. The assessment of concepts with users early in the development process utilizes comparable qualities. Early interviews aid the identification of the problem, user, and functional requirements. The goal of the Ideation phase is to generate a more complete problem and design understanding. Next to that, ideas of user perception and interaction are generated (Mader & Eggink, 2014).

Expert interview

To gain insight into the current work processes of end users, an expert interview was conducted with an expert in the field of strategic personnel planning models, the realization and implementation of Business Intelligence solutions at private and public organizations and advising in the field of personnel recruitment.

The interview setup is described in Appendix B. User stories, personas, stakeholder requirements and user requirements are based on the expert interview.

In the Creative Technology Design Process, these components are part of the Ideation because they elaborate the project idea and the problem requirements. These components could be included in the results chapter in conventional research methods.

User stories enable the identification of requirements of based on the perception of potential users. User stories consist of the user role, goal, and benefit. According to Nielsen (2013), the use of personas will aid the explanation of the experiences, objectives, requirements, actions, and empathize with the potential users. Next to that, it will aid to identify the differences in requirements and assumptions between the different user groups. Personas will help improve ideating, designing, and developing requirements that fit the target groups. The user scenario is a description of the hypothetical use of the strategic workforce planning model and can help understand the user behaviour and interaction with the product. This can be used in the design of the product. In context to design research, these techniques allow user requirement identification, user experience design and user interaction design.

User Stories

A user story is a brief description of what a user wants. User stories are used when developing software or products. A user story consists of a few sentences stating what the user does, must do, expects or desires in relation to the product. User stories usually follow the following structure: As X (a user role) I want Y (goal) so that Z (benefit). Earlier in the introduction of the problem and in the underlying literature, provisional requirements for the new strategic workforce planning model were identified. Based on these requirements, the following user stories were identified:

As X (user role)	I want Y (goal)	So that Z (benefit)
Analyst	Analyse based on historical organizational data	Make decisions based on organization specific scenarios
HRM director	Execute strategic workforce planning on an irregular basis	Act on change or progress within a system or process
Analyst	Interactively modify underlying assumptions	Identify impactful drivers
IT / purchase manager	Operate with basic and complex datasets	Implement despite technological knowledge or infrastructure
Board	Integrate in other Business Intelligence tools	Merge with existing reports or analyses
Analyst	Forecast organizational developments	Predict future workforce
Manager	Identify gaps between preferred workforce occupations and the current situation	Manage progress and set the focus

Table 2: User stories based on the introduction and theory

The following additional user stories are based on the expert interview:

As X (user role)	I want Y (goal)	So that Z (benefit)
Analyst	Study current workforce occupation per department or function	Identify potential strategic workforce planning cases
Analyst	Study recent and historical personnel flows	Identify potential strategic workforce planning cases
Analyst	Interactively modify preferred workforce occupation	Analyse scenarios based on various assumptions
Strategic director	Know desired personnel influx, taking current personnel influx into account	Set goals to reach the preferred workforce occupation
HRM director	Know desired personnel outflow, taking current personnel outflow into account	Set goals to reach the preferred workforce occupation

Analyst	Change the underlying variables	Execute strategic workforce planning based on different historical parameters
Strategic director	Follow the development of the current occupation in relation to the desired occupation	Manage progress and adjust the focus on time
HRM director	Adjust the scope of the strategic workforce planning model	Manage progress over different departments or teams and address responsible managers

Table 3: User stories based on the expert interview

By collecting the requirements of the users in a structured manner, it was possible to identify new requirements. These user requirements are collected at the end of this section.

Personas

Personas can be described as "fictional characters, which you create based upon your research to represent the different user types that might use your service, product, site, or brand in a comparable way" (Nielsen, 2013). According to Nielsen (2013), the use of personas will aid the explanation of the experiences, objectives, requirements, actions, and empathize with the potential users. Next to that, it will aid to identify the differences in requirements and assumptions between the different user groups. Personas will help improve ideating, designing, and developing requirements that fit the target groups.

Personas were prepared in collaboration with the expert as part of the expert interview to create reliable and realistic representations of the key target groups. This was done by brainstorming about the possible goals, motivations, frustrations, bottlenecks, business questions and influences of potential users. A description and story have been drawn up to add context. The following personas are based on the expert interview and user stories:

Michelle

Business controller

Age: 42

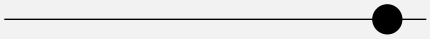
Challenge: limited possibilities to analyse data

TECHNOLOGY SKILLS

Beginner **Expert**

ORGANISATIONAL KNOWLEDGE

Beginner **Expert**



Anna's situation

Goals and motivation

- Proactively advise management in defining agreements in the areas of finance, customers, business processes, organizational development, and people.
- Making connections between objectives and results.

Frustrations and bottlenecks

- Data is distributed over various sources.
- Limited depth in data to investigate underlying reasons for deviations from the norm

Keywords
Independent, convincing, collaborative.

Anna advises management on risks and improvement potential, based on analysis

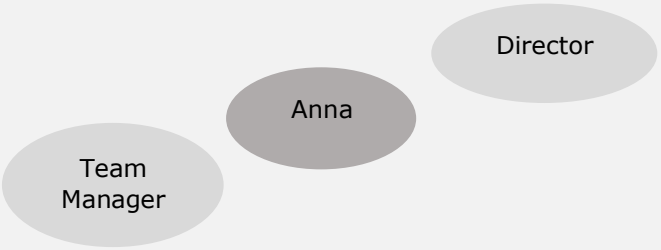
It is difficult to make cross-sections and to understand why results and objectives are not being achieved.

How will Anna use the model?

Questions:

- Why is a metric above or below the norm?
- What will happen to the organization if I change certain variables?
- What will happen to the organization after certain decisions?
- What are the efforts and performance of teams?
- What are the largest cost items that cause (possible) budget overruns?
- Is the budgeted budget spent on the appropriate cost items?

Influences



Anna's story

Anna collects and analyses data within the organization and communicates insights in a straightforward way to management and colleagues. She has an initiative-taking role in noting improvement potential in projects and operations. To put together a complete story of the situation, Anna must obtain information from various business controllers and separate documents - which is not always complete.

Anna not only analyses data from the past and present, but also makes various analyses about the impact of probable future scenarios. She makes connections between objectives and their implementation and oversees the trans-organisational consequences of policy. She participates in setting up effectiveness and efficiency measurements to monitor whether and why objectives are or are not being achieved.

Lucas

HR Business Partner

Age: 38

Challenge:

TECHNOLOGY SKILLS

Beginner **Expert**

ORGANISATIONAL KNOWLEDGE

Beginner **Expert**

Lucas' situation

Goals and motivation

- Actively contribute to achieving organizational objectives from an HRM perspective.
- Predicting quantitative and qualitative need for personnel capacity in relation to internal and external developments.

Frustrations and bottlenecks

- Complicated software to gain insight into data.
- Difficult to connect qualitative insights with quantitative data.

Keywords

Environmentally aware, confidence inspiring, collaborative.

Lucas is the HRM expert within the management team

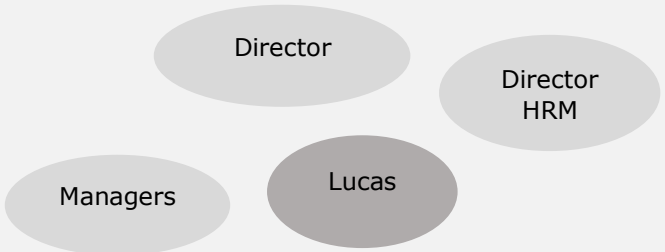
Lucas supports managers to strengthen their qualitative knowledge with collected quantitative data, so that data-driven management can be done at a strategic level.

How will Lucas use the model?

Questions:

- Where in the organization will people leave?
- What is my current occupation?
- How do people move within the organization, e.g., how long are they in a position before they move on, and where are they going?
- How vital is the department regarding absenteeism and job satisfaction?
- Which resources and knowledge are required in line with the (future) needs of the business?

Influences



Lucas' story

Lucas can look inward from the outside: what the outside world demands of the organization he can translate into the resources and knowledge necessary to meet that demand.

Within the organization Lucas applies quality measurements to HRM activities to make timely adjustments. In addition to the available data, he analyses the impact of probable future scenarios to predict the need for personnel. He advises the management team on HR issues and ensures the implementation of HR policy.

Lucas stimulates communication within the organization and makes difficult topics open for discussion.

Kai

Director

Age: 51

Challenge: busy schedule

TECHNOLOGY SKILLS

Beginner **Expert**

ORGANISATIONAL KNOWLEDGE

Beginner **Expert**

Chris' situation

Goals and motivation

- Achieving results and objectives, with the option to intervene in the event of disappointing results.

Frustrations and bottlenecks

- Available information focuses on the current situation; colleagues think in the short term
- Not clear from wealth of data which aspects need attention

Keywords

Result-oriented, inspiring, diplomatic, decisive.

Chris is responsible for strategy, policy, and execution for a department

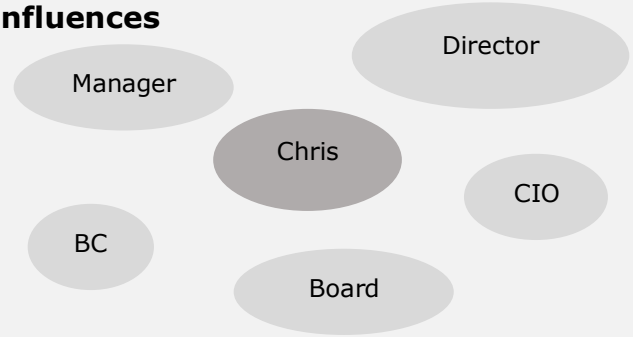
Chris currently has no overview of the data: he has no view of the long-term situation to be able to adjust in time, and he cannot oversee when something needs further attention.

How will Chris use the model?

Questions:

- How is the department doing?
- Does something within the department require further attention?
- How good or bad is the department doing?
- How did we come to this situation?
- Can I look ahead to see what will happen within the department?

Influences



Chris' story

Chris sets objectives for the assigned portfolio and is responsible for the realization of these objectives. He proactively takes measures and decisions based on risks and changes in course to achieve the desired results.

As director Chris distances himself from daily practice and focuses more on the key features and the long term.

Chris is accountable to the CIO and has an organization-wide responsibility along with the CIO and other departments to keep challenges on track.

Chris also has a role to motivate others in setting ambitious but achievable goals. He actively consults with other departments and uses his network within the organization to approach relevant people to achieve objectives.

By identifying personas in a structured approach, it was possible to identify new requirements and initiate the ideation on potential target groups. The user requirements and target groups based are collected at the end of this section.

User scenario

The user scenario is a description of the hypothetical use of the strategic workforce planning model and can help understand the user behaviour and interaction with the product. This can be used in the (re-)design of the product.

As director HRM you have been employed by the organization for quite some time. During the last monthly management team meeting in October, you and your colleagues discussed the figures for the month of August. In it the following emerged:

- Autonomous increase in costs by number of departments
- High absenteeism
- High outflow of employees with essential skills

It is striking that several departments also achieve better results than expected. However, due to the design of the monthly reports, it is not possible to compare different departments side by side. Together with the management team, you are disappointed that there are only limited possibilities to zoom in on the different cost types. For further specifications, information must be requested from the analysis department, but that takes a considerable turnaround time due to the manual processing of data. A follow-up question again takes a considerable turnaround time.

You are also aware of the substantial number of overtime hours in the month of August. You informed the management team about this, but the financial consequences are not yet visible in the data. This is because this data is only made available later due to manual enrichments.

Overall, forecasts for this year have been revised downwards. After several talks with managers within the organization, the figures in September are also disappointing. You are disappointed that you had not previously gained insight into the developments within the organization and that you are now behind the times.

Initiatives for the use of strategic workforce models have been discussed several times in recent years. That just didn't get off the ground because most colleagues were fine with continuing to make decisions based on intuition and their own ideas. In addition, the organization has only recently noticed the effects of a large outflow of personnel, a changing labour market and the request for necessary skills to operate the organizational activities.

At the start of your career, you gained three years of experience within an IT organization. Specifically, you have set up a data warehouse and HR dashboard in Power BI. You therefore decide to do your own research into the possibilities within Business Intelligence. You want to acquire a reporting tool for strategic workforce planning and present it to the team. The aim is to enthuse the team and get them involved in a movement towards Business Intelligence where information is correct, timely and completely available.

Stakeholder requirements

Cumlaude.ai developed a mathematical model that provides parameters for workforce transitions through the organization which could be used to predict future workforce occupation. This model builds on the Markov chain theory and offers a theoretical framework for strategic workforce planning. The current model lacks an accessible, dynamic, adjustable, and scalable method for calculation and analysis which can be integrated in other Business Intelligence reports or tools and enables strategic decision making. The following stakeholder requirements can be defined based on the expert interview:

- The strategic workforce planning model should be operational with basic employee administration datasets (i.e., function, department, team, start date, contract status, salary, and contract hours).

- The strategic workforce planning model should be integrated in a Power BI report so that the organization can implement it in the HR or management reports of clients.

- The strategic workforce planning model should be designed in such a way that it enables cross-sectional analysis.

- The strategic workforce planning model should be designed in such a way that the client organizations can adjust certain assumptions (i.e., historical context, preferred workforce, amount of personnel change and planning trajectory) through self-service.

Target groups

Four user groups can be defined based on the user stories, persona's, user scenario and stakeholder requirements:

- **Board of directors.** These users are responsible for the strategic management of the organization, which implies setting a direction for the organization and employees in its future existence and collaborating with the executive leadership to set the objectives, implement, manage, and review progress.

- **Human Resource Management.** These users are responsible for recruiting, hiring, onboarding, training, engaging employees and develop human resource strategies.

- **Management.** These users are responsible for the operation of departments, teams and employees while executing and implementing organizational objectives to procreate strategical progress.

- **Analysts.** These users are responsible for advising strategic and executive management on progress, risks and improvement potential based on research and analysis.

User requirements

The goal of the Ideation phase was to elaborate the project idea and problem requirements and compose user groups, experiences, interactions, and stakeholder requirements.

The Introduction, Theory, and Ideation phase result in the following overview of user requirements for the strategic workforce planning model:

1. Utilize historical organizational data. The model should process historical data that is extracted from the administration systems of organizations.

2. Enable dynamic execution. The model should enable non-momentary execution to facilitate that it can be executed every moment of the day.

3. Modify underlying assumptions with interaction. The model should allow users to modify assumptions by interacting with parameters. For example, the users must be able to determine the planning period.

4. Operate with basic and complex datasets. The model should not be limited by the complexity or structure of the extraction from the administration systems of organizations.

5. Integrate in other Business Intelligence tools. The model should allow integration in existing Business Intelligence reports or tools to prevent being a standalone solution and improve usability.

6. Forecast organizational developments. The model should predict the future workforce development.

7. Identify gaps between preferred workforce occupations and the current situation. The model should compare the preferred workforce occupation with the predicted workforce occupation based on the current situations, to identify gaps.

8. Study current workforce occupation per department or function. The model should allow application to selections of or smaller datasets.

9. Study recent and historical personnel flows. The model should visualize personnel development.

10. Modify preferred workforce occupation with interaction. The model should allow the user to modify the preferred workforce occupation by interaction with parameters.

11. Return desired personnel influx, taking current personnel influx into account. The model should visualize the desired personnel influx, based on the preferred workforce occupation, taking current personnel influx into account.

12. Return desired personnel outflow, taking current personnel outflow into account. The model should visualize the desired personnel outflow, based on the preferred workforce occupation, taking current personnel outflow into account.

13. Visualize the development of the current occupation in relation to the desired occupation.

14. Enable adjustment of the scope. The model should allow users to modify the planning period.

15. Integrated in a Microsoft Power BI report.

16. Enables cross-sectional analysis. The model should not only be able to study current workforce occupation per department or function but also between cross-sections.

17. Adjust certain assumptions (i.e., historical context, preferred workforce, amount of personnel change and planning trajectory) through self-service. The model should allow users to modify assumptions by interacting with parameters in the Microsoft Power BI Report.

Prototypes

The mathematical model, which provides parameters for workforce transitions through the organization which could be used to predict future workforce occupation, is described in the Theory chapter. The current model lacks an accessible, dynamic, adjustable, and scalable method for calculation and analysis which can be integrated in other Business Intelligence reports or tools and enables strategic decision making. The first step is to develop a first prototype that uses Markov modelling, discover current limitations and possibilities.

The first prototype, which is shown in table 4, follows basic Markov modelling and consists of a probability matrix where personnel change variables, current workforce occupation, yearly acquisition and start occupation can be entered. This results a future workforce prediction over a five-year period and comparison to the start occupation. This model can be elaborated with more functions, a different period and varying personnel acquisitions and personnel change assumptions. This prototype introduced the basics of Markov modelling and potential parameters that should be adjustable (period, current workforce occupation, yearly acquisition, personnel change variables). Although this model returns a future workforce prediction, it does not process a dataset and requires manual adjustments to adjust the values and parameters. Extending this model is limited by the function used to perform the Markov calculation.

The second prototype, which is shown in Figure 7, recreated and integrated the calculation method of the first prototype in Microsoft Power BI. The MMULT function within Microsoft Excel was used in the first prototype for iterative calculation. This function is not available within Microsoft Power BI, but can be reconstructed. Developing a method to mimic this feature required a lot of time and large queries. Like the first prototype, it does show a prediction, but retains the same issues. On the other hand, with this prototype a start is made for the integration in Microsoft Power BI and initiated the search for a way to calculate according to the formula from the Theory.

The third prototype, which is shown in Figure 8, repeated the calculation method to enable planning over multiple years. Next to that, a Microsoft PowerApps application was used to adjust the workforce occupation and probability matrix. This initiated the search for parameters within Microsoft Power BI. In this prototype, the first integration of a dataset was achieved by linking the calculation to workforce occupation per function. After this prototype, it was time to move to another calculation method that processed datasets, made the calculation more accessible, dynamic, adjustable, and scalable.

Markov chain for Strategic Workforce Planning

Probability-Matrix

	F1	F2	U
F1	0,9	0	0
F2	0,05	0,95	0
U	0,05	0,05	1

Acquisition

F1	5
F2	10
U	0

Start Occupation

F1	90
F2	120
U	0

SPP 1	Acq. 1	BPU 1
81	5	86
118,5	10	128,5
10,5	0	10,5

SPP 2	Acq. 2	BPU 2
77,4	5	82,4
126,4	10	136,375
21,2	0	21,225

SPP 3	Acq. 3	BPU 3
74,2	5	79,16
133,7	10	143,676
32,2	0	32,1638

SPP 4	Acq. 4	BPU 4
71,2	5	76,244
140,5	10	150,45
43,3	0	43,3056

SPP 5
68,6
146,7
54,6

-21,4	Persons less in function 1
26,7	Persons more in function 2
-54,6	Persons left

Table 4: Prototype 1

Probability Matrix

Index	Column1	Column2	Column3
1	0,90	0,00	0
2	0,05	0,95	0
3	0,05	0,05	1
Total	**1,00**	**1,00**	**1**

Start occupation

Index	Column1
1	90
2	120
3	0
Total	**210**

SPP 1

Row	1	2
1	81,00	
2	118,50	
3	10,50	
Total	**210,00**	

Figure 7: Prototype 2

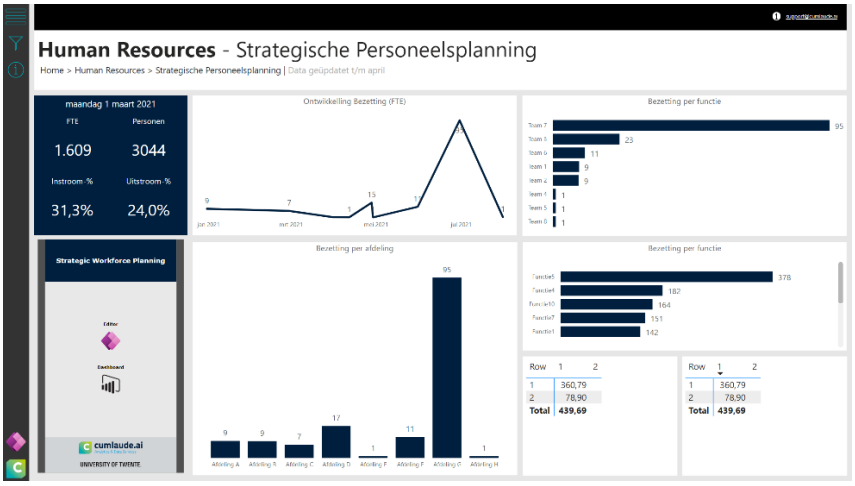


Figure 8: Prototype 3

3.3 Specification

In the previous chapters different concepts were explored and evaluated. In this section the functional development will be described, along with the final concept.

Microsoft Power BI

In the Ideation phase the user requirement that the strategic workforce planning model should be integrated in a Microsoft Power BI report was defined. "Power BI is a collection of software services, apps, and connectors that work together to turn your unrelated sources of data into coherent, visually immersive, and interactive insights" (Microsoft, 2022a).

Power BI enables connecting to various data sources, creating visualizations, and distributing to whoever needs to have access to the information. Power BI consists of the following five components, which are developed to build, distribute, and utilize business analytics:

- Power BI Desktop.
- Power BI Service.
- Power BI Report Builder.
- Power BI Report Server.

- Power BI Mobile Apps.

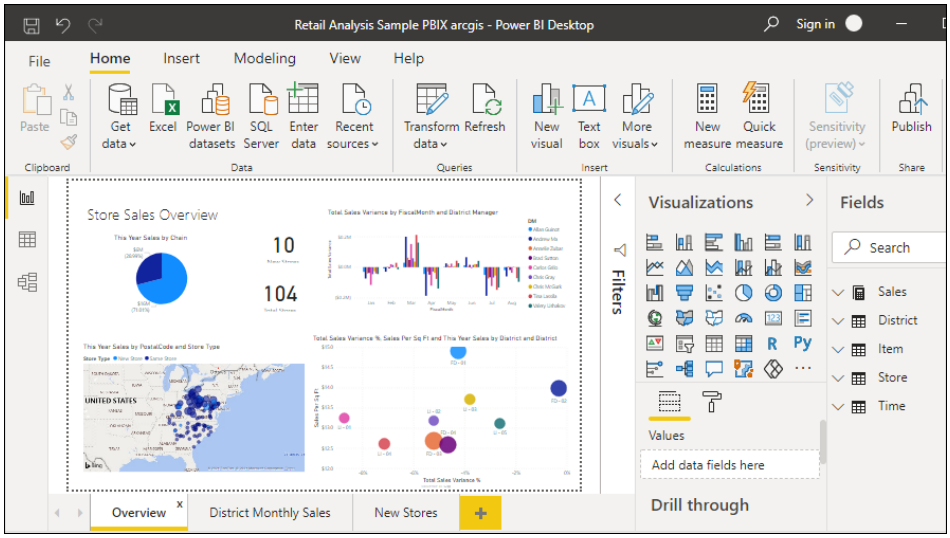


Figure 9: The Microsoft Power BI Desktop Interface

Leading research firm Gartner praises Microsoft Power BI for its "alignment with Office 365, Teams, and Azure Synapse. Such a broad portfolio, which includes visual-based data discovery, augmented analytics, and interactive dashboards, demonstrates a comprehensive vision and ambition. Alongside this, the market analyst also highlights the price and value of the Microsoft solution as a significant differentiator" (Kronz et al., 2022). The Magic Quadrant for Analytics and Business Intelligence Platforms is shown in Figure 10. This quadrant displays the positioning of Microsoft in relation to competitors and shows that Microsoft is the leader on Analytics and Business Intelligence Platforms.

Figure 10: Magic Quadrant for Analytics and Business Intelligence Platforms

Data Analysis Expressions (DAX)

"Data Analysis Expressions is a collection of functions, operators, and constants that can be used in a formula, or expression, to calculate and return one or more values" (Microsoft, 2022b). DAX enables the ability to add insights based on available information. It is possible to create reports in Microsoft Power BI without the use of DAX, but it provides capabilities for more complex analytics and insights. DAX-measures respond to interacting with visuals or filters, which enables on the spot analysis. DAX can also be utilized to calculate new columns, which could improve processing time.

Star schema data model

Microsoft Power BI builds on the dimensional modelling theory from Kimball et al. The Data Warehouse Toolkit: The Definitive Guide to Dimensional modelling was introduced in 2013 and offers a technique optimized for performance and usability.

The dimensional modelling method 'Star schema' is acknowledged and used frequently for data warehousing (Microsoft, 2022c). Fact and dimension tables structure the model. Dimension tables consist of organizational entities, e.g., departments, locations, or dates. These tables consist of a column with an identifier and columns with descriptions. These tables are often very dense. Fact tables contain metrics which are subject to changes. These tables consist of a column with an identifier and columns with numeric values. The column with unique identifiers will be related to the dimension tables. These tables are often exceptionally large.

In Figure 11, an example of a star schema in Power BI is shown.

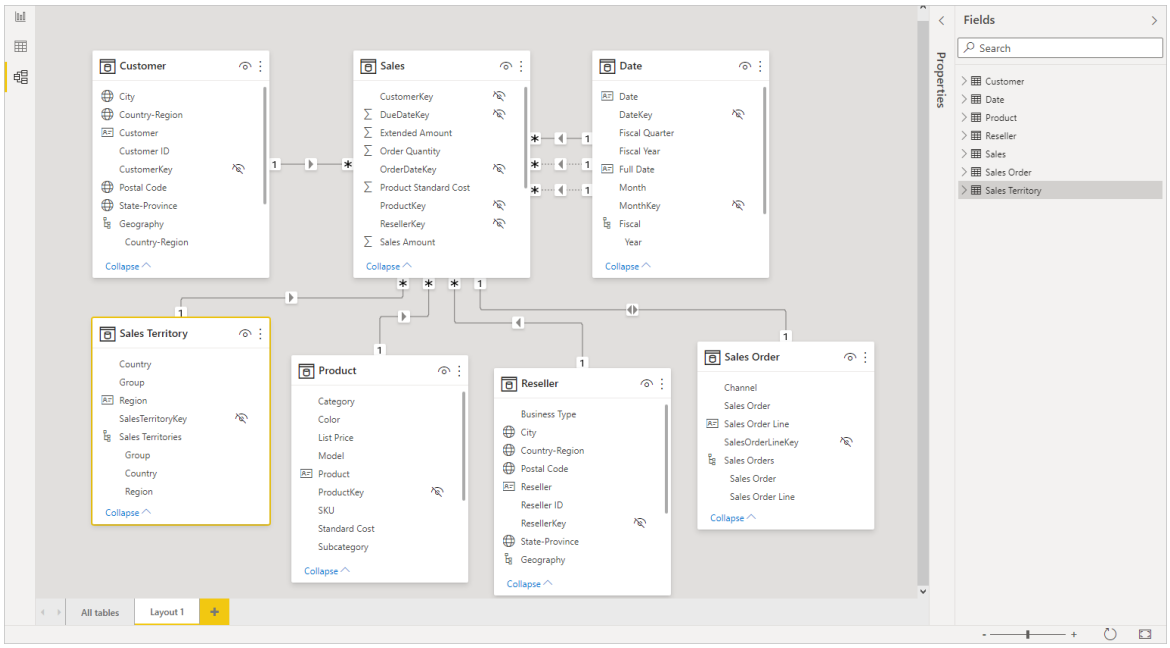


Figure 11: Star schema in Power BI modelling view

User requirements specification
User requirements were defined in the previous section. In this subsection it is the goal to specify per user requirement if the functional speciation allows inclusion of the user requirement in the final concept design and set the scope of the strategic workforce planning model. The final concept is described and shown after this specification.

User Requirement	Included in final concept
Utilize historical organizational data	Yes
Enable dynamic execution	Yes
Modify underlying assumptions with interaction	Yes, change in calculation method required
Operate with basic and complex datasets	Yes, change in calculation method required
Integrate in other Business Intelligence tools	Yes, change in calculation method required
Forecast organizational developments	Yes
Identify gaps between preferred workforce occupations and the current situation	Yes, change in calculation method required
Study current workforce occupation per department or function	Yes
Study recent and historical personnel flows	Yes
Modify preferred workforce occupation with interaction	Yes, change in calculation method required
Return desired personnel influx, taking current personnel influx into account	Yes
Return desired personnel outflow, taking current personnel outflow into account	Yes
Visualize the development of the current occupation in relation to the desired occupation	Yes
Enable adjustment of the scope	Yes, change in calculation method required
Integrated in a Microsoft Power BI report	Yes
Enables cross-sectional analysis	Yes, change in calculation method required
Adjust certain assumptions (i.e., historical context, preferred workforce, amount of	Yes, change in calculation method required

personnel change and planning trajectory) through self-service.	

Figure 12: Functional specification per User Requirement

The specification of the user requirements taught that the calculation method from the prototypes needs to be further adjusted to enable modification, interaction, integration, and cross-sectional analysis. Microsoft Power BI, DAX and the star schema support these adjustments and requirements, but the calculation method needs a redesign.

Final concept design
If the user requirements are clustered, the following dashboard designs can be developed:

- Current workforce occupation, shown in Figure 13.
- Personnel change (influx and outflow), shown in Figure 14.
- Predicted future workforce occupation, shown in Figure 15.
- Desired workforce occupation, shown in Figure 16.

The realization of the final concept will be described in the next section.

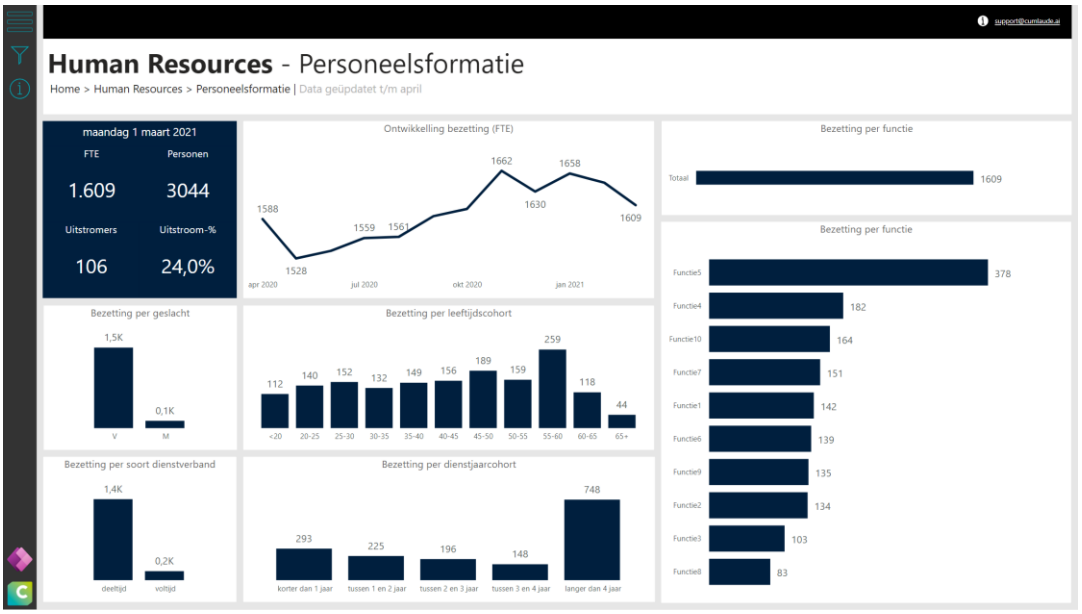


Figure 13: Dashboard design - Current workforce occupation

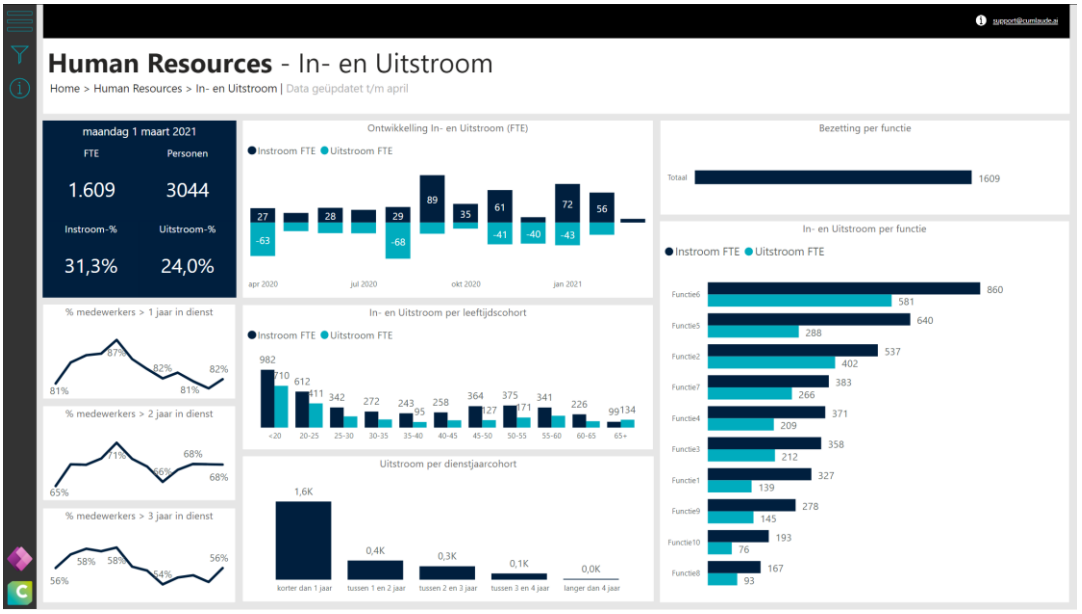


Figure 14: Dashboard design - Personnel change (influx and outflow)

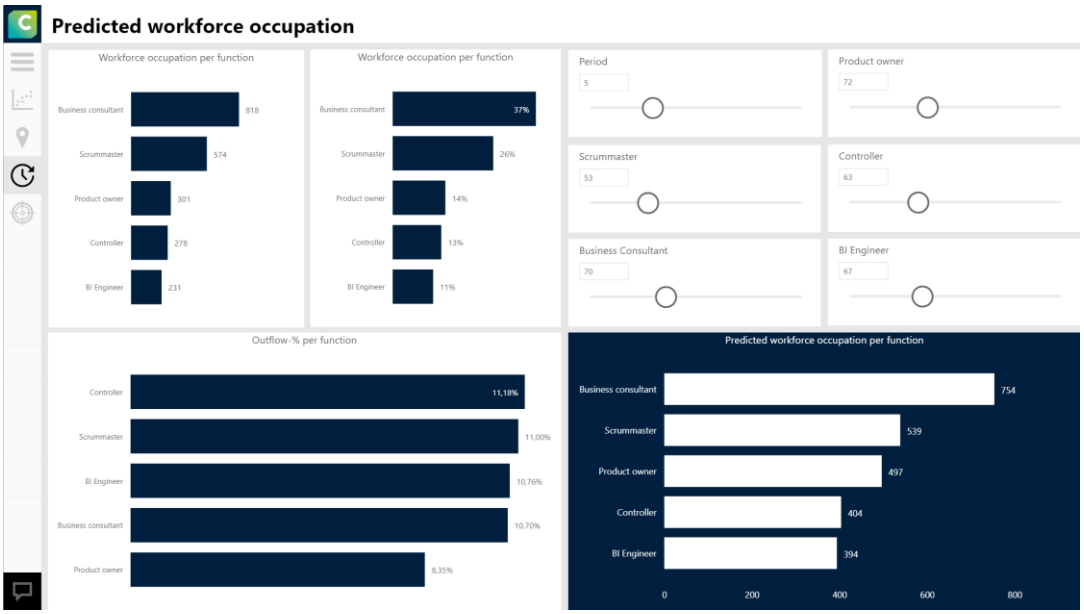


Figure 15: Dashboard design - Predicted workforce occupation

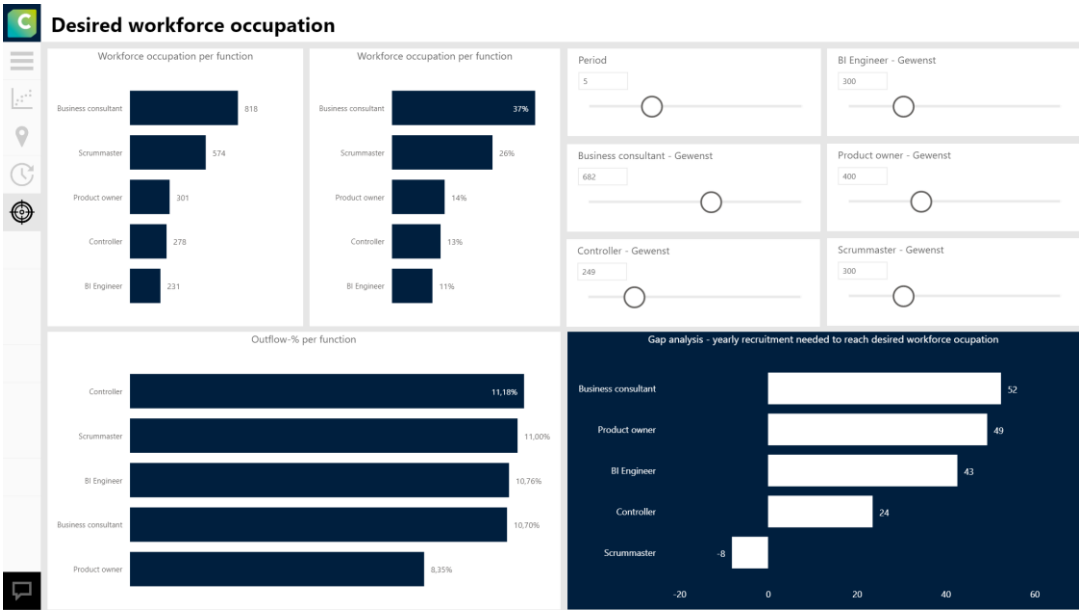


Figure 16: Dashboard design - Desired workforce occupation

3.4 Realization

In the previous sections the concepts for the final protype were described. The realization of the final prototype is described in this section. The data model, parameters, DAX-measures, and the final prototype of the strategic workforce planning model in Power BI will be described.

Data model
In the previous section we learnt about the star schema data modelling technique which improves performance and usability of Power BI dashboards.

The dataset consists of the following columns:

- Contract hours
- Gender
- Retirement date
- Department
- Start date
- Age
- Type of employment
- salary scale
- Start date function
- ext./flex rate
- Location
- Job title
- Job group
- Function scale
- Contract expiration date
- Expected Contract End Date
- Supplier

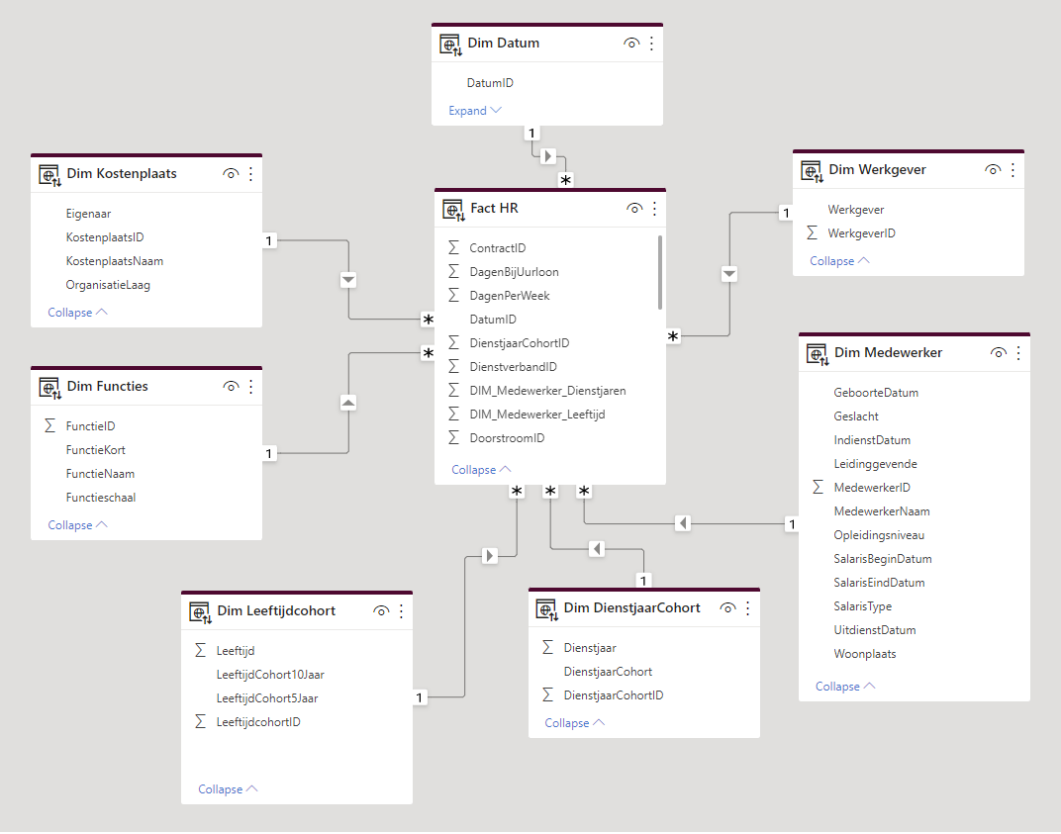


Figure 17: Data model in the final prototype

Parameters

Variables must be defined within Power BI to adjust the underlying assumptions, yearly acquisition, and preferred future workforce occupation. This is done with what-if parameters that can be changed by the users. A relationship between these parameters and the data model is created to enable interaction and cross-sectional analysis.

Data Analysis Expressions (DAX)

DAX provides capabilities for more complex analytics and insights. The following DAX-measures are created to enable the desired insights:

- **Current workforce occupation.** Calculation of the current full-time equivalent (FTE) based on the contract hours.
- **Influx FTE.** Calculation of the FTE that entered the organization.
- **Outflow FTE**. Calculation of the FTE that left the organization.
- **Influx-%.** Calculation of the FTE that entered the organization in the last twelve months in comparison to the average FTE in het last twelve months.
- **Outflow-%.** Calculation of the FTE that left the organization in the last twelve months in comparison to the average FTE in het last twelve months.
- **Future workforce occupation.** Calculation of the future workforce occupation based on the yearly acquisition (parameter) over a period (parameter).
- **Desired workforce occupation.** Calculation of the necessary yearly acquisition based on the desired workforce occupation (parameters) over a period (parameter).
- **Expected occupation versus current occupation.** Calculation of the expected future workforce occupation in comparison to the current workforce occupation.
- **Current personnel influx versus necessary acquisition.** Calculation of the current personnel influx in comparison to the necessary yearly acquisition to reach the desired workforce occupation.

Strategic workforce planning model in Power BI – Final prototype

The final prototype for the predicted workforce occupation dashboard is shown in Figure 18. The final prototype for the desired workforce occupation dashboard is shown in Figure 19.

Figure 18: Final prototype - Predicted workforce occupation

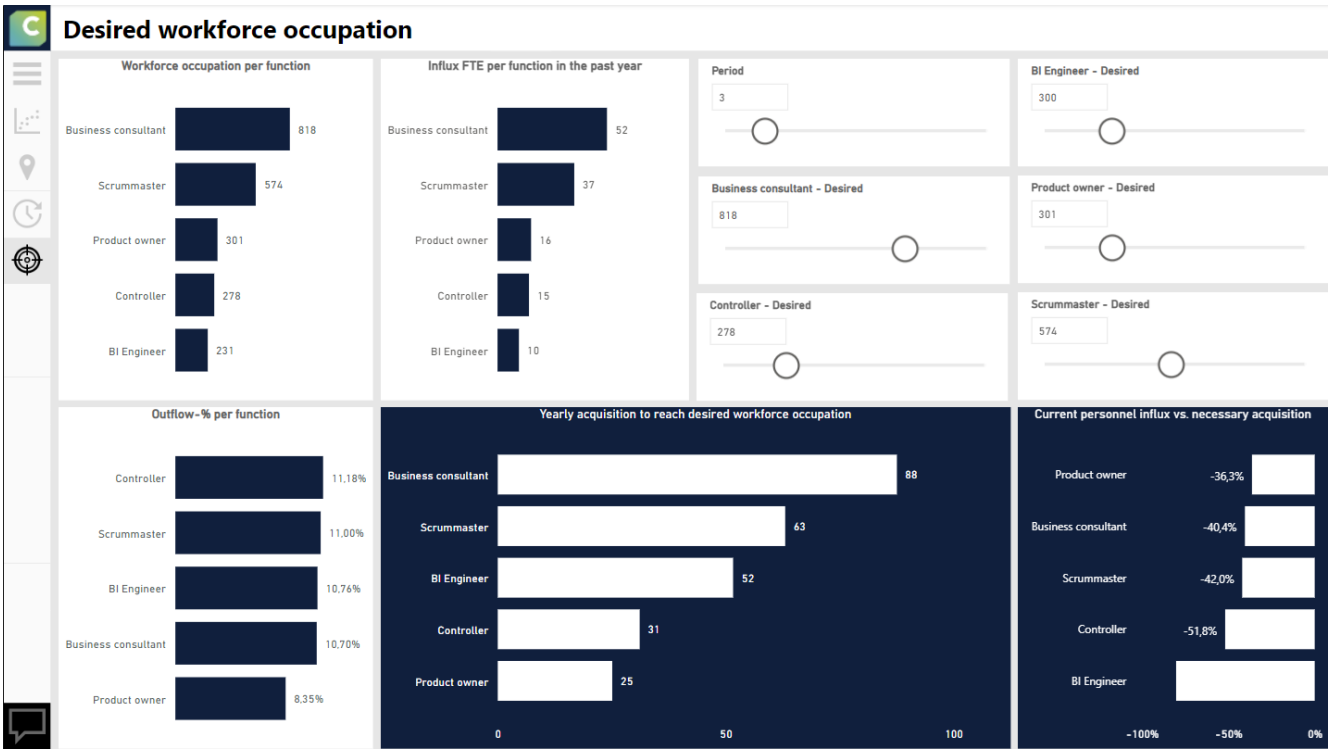


Figure 19: Final prototype - Desired workforce occupation

3.5 Evaluation

The goal of het Evaluation phase is to get the design assessed and evaluated. In the realization phase, functional testing of the design is involved. It could as well be involved in the evaluation phase and could reflect on previous requirements. At least, the original requirements from the Ideation phase should be evaluated (Mader & Eggink). "User testing is the most obvious method to verify whether the decisions taken satisfy the user requirements and facilitate the experience intended" (Mader & Eggink, 2014, p. 5).

Next to assessing the user requirements, the design will be evaluated to answer the research questions:

Main research question:

1. **How can the integration of Markov chains in Business Intelligence enable Strategic Workforce Planning?**

Sub research questions:

2. **What is strategic workforce planning?**
3. **How can Markov be integrated in a new strategic workforce planning model?**
4. **How can the model be integrated in a Business Intelligence solution for strategic workforce planning?**

Qualitative research distinguishes itself by focusing on creating a theoretical framework based on the evaluation of the collected information and tries to logically describe the findings. Next to that, qualitative research does not focus on assessing a hypothesis (Dybå et al., 2011).

Semi-structured interviews are conducted to research with an emphasizes on analysing behaviours, events, and artifacts. These interviews were conducted with experts in the domain of the diagnosed problem. To reach an extensive insight, the interviews follow a clear outline to systematically discover the essential information but offer possibilities for elaboration by the interviewee and follow-up questions by the interviewer.

When interpreting semi-structured interview transcripts as the primary document, the appropriate method of extracting information is by coding the data through content analysis." Content analysis is a data collection method in which variables are constructed by coding a set of primary documents to say something about (a) unit(s) of analysis."

There are six steps in coding analysis:

1. Formulate a research question with variables & units of analysis.
2. Select primary documents.
3. Developing an operationalization, a 'coding scheme.'
4. Code the text (update the coding scheme, inductive coding)
5. Draw conclusions
6. Report your methods and findings

This content analysis allowed for meaningful findings (quotes) to be extracted from the raw interview data (ITC e-learning, 2022). Inductive coding, creating theoretical constructs using primary documents, will be applied in this evaluation.

3.5.1 Setup

In Table 2, a general overview of the evaluation setup is shown with a description of the research question, participants, method, materials, and procedure.

Research Question	How can the integration of Markov chains in Business Intelligence enable Strategic Workforce Planning?
Participants	The research population consists of five managers or people that participate in the workforce recruitment/planning process.
Method	The participants are asked in semi-structured interviews to answer questions on the current recruitment/workforce planning process at their organization. After that, they will be shown an introductory presentation of a digital product and answer questions about this product and in relation to the recruitment/workforce planning process at their organization.
Materials	Power BI dashboard according to description in the Realization section.
Questions	Semi-structured interviews will be conducted. The questions are attached in Appendix G.
Procedure	Before conducting the interview, participants receive a brief explanation about the research. They receive an information brochure for further details about the research background, procedure, participation, data selection and storage and contact details for more information, independent advice or to file a complaint. They also sign a consent form and receive a copy of the consent form. The consent form and information brochure are attached in, respectively Appendix E and F. The tests will be done via a web conference application. For the interview, a semi-structured interview will be conducted. The participants are asked to answer questions on the current recruitment/workforce planning process at their organization. After that, they will be shown an introductory presentation of a digital product and answer questions about this product and in relation to the recruitment/workforce planning process at their organization.

Table 5: Evaluation setup overview

4 Results

In final phase of the CTDP it is evaluated "whether all the original requirements identified in the ideation phase are met. User testing is the most obvious method to verify whether the decisions taken satisfy the user requirements and facilitate the experience intended" (Mader & Eggink, 2014, p. 5). The goal of qualitative research is to provide a theoretical framework that allows for a logical explanation of the research findings and builds on the evaluation of the data collected throughout the research (Mader & Eggink, 2014).

The table below shows the collected results of the interviewees for the user requirements that were part of the final prototype.

User Requirement	#1	#2	#3	#4	#5
Utilize historical organizational data	Yes	Yes	Yes	Yes	Yes
Enable dynamic execution	Yes	Yes	Yes	Yes	Yes
Modify underlying assumptions with interaction	Yes	Yes	Yes	Yes	Yes
Operate with basic and complex datasets	?	?	No	Yes	Yes
Integrate in other Business Intelligence tools	?	?	Yes	Yes	Yes
Forecast organizational developments	Yes	Yes	Yes	Yes	Yes
Identify gaps between preferred workforce occupations and the current situation	Yes	Yes	Yes	Yes	Yes
Study current workforce occupation per department or function	Yes	Yes	Yes	Yes	Yes
Study recent and historical personnel flows	Yes	Yes	Yes	Yes	Yes
Modify preferred workforce occupation with interaction	Yes	Yes	Yes	Yes	Yes
Return desired personnel influx, taking current personnel influx into account	Yes	Yes	Yes	Yes	Yes
Return desired personnel outflow, taking current personnel outflow into account	Yes	Yes	Yes	Yes	Yes
Visualize the development of the current occupation in relation to the desired occupation	No	No	No	No	No
Enable adjustment of the scope	Yes	Yes	Yes	Yes	Yes
Integrated in a Microsoft Power BI report	Yes	Yes	Yes	Yes	Yes
Enables cross-sectional analysis	Yes	Yes	Yes	Yes	Yes
Adjust certain assumptions (i.e., historical context, preferred workforce, amount of personnel change and planning trajectory) through self-service.	Yes	Yes	Yes	Yes	Yes

Table 6: User requirement evaluation results

The user requirements evaluation results show that the five interviewees undivided assess that 14 out of the 17 user requirements are included in the final prototype. On the other hand, the user requirements "operate with basic and complex datasets," "integrate in other Business Intelligence tools" and "visualize the development of the current occupation in relation to the desired occupation" cause disagreement. For some interviewees, the user requirements "operate with basic and complex datasets" or "integrate in other Business Intelligence tools" cannot be judged due to lack of knowledge of the model or different datasets and tools. All interviewees agree that the final prototype lacks the possibility to "visualize the development of the current occupation in relation to the desired occupation."

The semi-structured interviews are analysed for significant remarks, coded, and grouped into recurring topics. Subsequently, the topics are clustered into themes which results in the coding-scheme of the semi-structured interview evaluation below:

Themes	**Categories**	**Codes**
Innovation	Digitalization Modernization	"This report is a **scenario tool at hand**" "This report allows me to **work data-driven**" "I could use this as an **example report** for other Power BI reports" "This is an **addition on current reports** used in my department" "It allows me to look in the front view mirror (**predictive reporting**)"
Automation	Data processing Manual work Efficiency	"I like that we can use this **dataflow** for multiple departments" "This is where we should move to on **data science** in the organization" "We are working on loading similar datasets to a **database** which can be

		connected to this model" "We are setting up a **data warehouse** for these kind of reports" "Our current reporting is very **Excel-intensive**" "We are setting up **capacity** to work on Power BI" "The **data processing** and calculation seems **reliable**"
Standardization	Definitions Methodology Data processing	"This could be my **quantitative analysis** tool, next to the qualitative analysis" "**Unambiguous definitions** that can be applied" "The dashboard can be managed in a **centralized** way"
Customization	Adaptable Variable	"I like that I can adjust the **parameters and measures**" "I like that it can be **organization-specific**" "Could this model be used for other predictions? Is it **problem-specific?"**
Development	Demographics Labour market Sick leave	"I would like if the model could take developments in the **economy, society or labour market** into account"

		"Can you add parameters for **internal work demand**?" "How does it deal with **personnel flow in the organization**?" "I would like if the model could take **demographic developments** in into account" "We did a strategic workforce planning analysis with the use of **colour profiles**, so it would take **personalities** into account" "I would like to add parameters for **retainment, conversion ratio's** and **leave reasons**"

Table 7: Coding-scheme of the semi-structured interview evaluation

The semi-structured interview evaluation results show that the integration of the mathematical model in the Power BI tool enables innovation, automation, standardization, customization, and development in relation to strategic workforce planning. The model contributes to innovation by accelerating digitalization and modernisation. This is achieved by setting an example for BI reporting, allowing data-driven operation, and adding to current reports (integration and predictive analytics). Three out of five emphasized that they already want to use this model for their data on human resources.

"It allows me to look in the front view mirror instead of trying to steer through the rear-view mirror" – Interviewee 1

The model contributes to automation by automatising data processing, limiting manual work and increasing efficiency by using a structured dataflow, reliable solution and unlocking capacity. It contributes to standardization by using centralized definitions, methodologies, and data processing. This way it can be used as an unambiguous quantitative analysis tool for entire organizations.

"Internally, a lot of time is wasted on preparing, discussing and resolving data differences" – Interviewee 4.

The model contributes to customization by offering room for changes in parameters, variables, measures, and goals while offering organization-specific insights.

"This dashboard gives me a scenario tool with which I can show others a separate way of thinking" – Interviewee 5.

The interviewees endorse that the model alone cannot replace the entire process or strategic workforce planning. There are many aspects that are often nuanced or require more in-depth research than a quantitative analysis. The interviewees indicate that the model can contribute to the further development of strategic workforce planning and add multiple directions and ideas. There is a desire to add insights in the field of demographics, labour market and sick leave. This is how they think of adding analyses on economy, society, labour market, internal work demand, personnel flow in organizations, demographics, personalities, retainment, job application ratios and reasons for leave

"With this method you have gold in your hands but now the trick is to go from a calculation tool to a management tool" – Interviewee 4

5 Discussion and conclusion

5.1 Key findings

The goal of the research is to assess how the integration of Markov chains in Business Intelligence can enable strategic workforce planning. It is important to understand what strategic workforce planning consists of, how Markov chains can be integrated into a mathematical model and how the mathematical model can be used for analysis, strategic decision making and strategic workforce planning. Strategic workforce planning implies governing that "the right people with the right competencies are in the jobs at the right time" (Willis et al., 2018, p. 3). The difficulty of workforce management should be captured in strategic workforce planning research, along with the creation and application of models to advise strategies for workforce management. This consists of horizon scanning, scenario generation, workforce modelling and policy analysis. The challenges of strategic workforce planning indicate the knowledge gap in realizing a strategic workforce planning model that enables analysis, strategic decision making and strategic workforce planning while incorporating different needs and applications in an effective approach. There is a gap in the research field of the Markov model and its possibilities and applications. There are no publications on the application of Markov in business intelligence, its integration into mainstream analytics tools, or how it could enable strategic workforce planning. According to the Creative Technology Design Process that consists of an Ideation, Specification and Realization phase, a Business Intelligence solution with an integration a mathematical model based on Markov chains is developed in the Microsoft Power BI application. This solution visualizes the current workforce occupation, personnel change, predicted future workforce occupation and the onboarding targets to reach the desired workforce occupation. The solution is analysed through semi-structured interviews with potential users of Strategic Workforce Planning tools or products to identify how the solution could enable strategic workforce planning.

The semi-structured interview evaluation results show that the integration of the mathematical model in the Power BI tool enables innovation, automation, standardization, customization, and development in relation to strategic workforce planning. The model contributes to innovation by accelerating digitalization and modernisation. The model contributes to automation by automatising data processing, limiting manual work and increasing efficiency by using a structured dataflow, reliable solution and unlocking capacity. It contributes to standardization by using centralized definitions, methodologies, and data processing. This way it can be used as an unambiguous quantitative analysis tool for entire organizations. The model contributes to customization by offering room for changes in parameters, variables, measures, and goals while offering organization-specific insights.

The interviewees endorse that the model alone cannot replace the entire process or strategic workforce planning. There are many aspects that are often nuanced or require more in-depth research in addition to quantitative analysis. The interviewees indicate that the model can contribute to the further development of strategic workforce planning and enable organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented.

The results of the research contribute to the literature in two important ways. First, the research reduces the gap in the research field of the Markov model and its possibilities and applications. It makes a first attempt at integrating Markov into business intelligence, a mainstream analytics tool, and explores its contribution to workforce analytics.

The challenges of strategic workforce planning indicated the knowledge gap in realizing a strategic workforce planning model that enables analysis, strategic decision making and strategic workforce planning while incorporating different needs and applications in an effective approach. This research makes a first attempt at reducing this knowledge gap in workforce planning literature.

It offers a solution to the problems it faced before as it improves accessibility, agility, adaptability, scalability and into other Business Intelligence reports. It adds to the potential to become the go-to solution for organizations seeking standardized, automated, repeatable, repetitive, and customizable solutions for the entire organization.

5.2 Limitations

Within this study, there are several limitations. The first limitation is concerned with the sample size. The number of interviewees during the research adds up to six people. One person was interviewed in the Ideation phase and the other five were interviewed during the evaluation. Because these interviewees come from different organizations, there is a risk that the evaluation will remain too generic and limit its application to the organization. In addition, the current population consists of people in a management position, while it would be relevant for this research to include HR employees or analysts since the solution focuses on the quantitative analysis of strategic workforce planning. This leads to the second limitation. The semi-structured literature review for strategic workforce planning showed that mathematical models are, most of the time, simplifications of complex workforce situations. Since this research focuses on the integration of Markov chains in Business Intelligence it is a challenge for this research is to take all stages, horizon scanning, scenario generation, workforce modelling and policy analysis, of workforce planning into account while analysing how the integration can enable strategic workforce planning. It limits the contribution to the complete strategic workforce planning process since the solution and evaluation focuses on the quantitative analysis of strategic workforce planning. The third limitation is the fact that only one mathematical model has been explored in this research. This approach increases the risk of tunnel vision and limits the significance of the contribution to the mathematical theory and predictive analytics in general. The final limitation of the research is the lack of scientific and methodological discussion. The involvement of the supervisors and their knowledge for advice on the method to improve or discuss the research, which is one of the core properties of scientific research, could add to the scientific significance of the research.

5.3 Future research

Deriving from this research, areas for further research have emerged that could be addressed. Based on the research limitations, future research could look at specifying this solution's contribution to strategic workforce planning within a single organization, involving HR staff or

analysts in the development or evaluation, covering the entire workforce planning process, and questioning the scientific methodology used.

In addition, future research could compare the current solution with other solutions, conduct an accuracy analysis or integrate other components. The interviewees indicate that the model can contribute to the further development of strategic workforce planning and add multiple directions and ideas. There is a desire to add insights in the field of demographics, labour market and sick leave. This is how they think of adding analyses on economy, society, labour market, internal work demand, personnel flow in organizations, demographics, personalities, retainment, job application ratios and reasons for leave. The solution enables organizations to gain insight into anticipated workforce gaps and gain opportunities for the correct solutions to be implemented

Finally, future research could evaluate how the organizational transitions of employees and strategic workforce planning are affected by human resource procedures, organizational goals, and organizational strategies.

5.4 Practical implications

The research makes a first attempt at integrating Markov into business intelligence, a mainstream analytics tool, and explores its contribution to workforce analytics. It offers a solution to the problems it faced before as it improves accessibility, agility, adaptability, scalability and into other Business Intelligence reports. It adds to the potential to become the go-to solution for organizations seeking standardized, automated, repeatable, repetitive, and customizable solutions for the entire organization. The evaluation showed that final prototype complies with fourteen out of seventeen user requirements that were identified. The fourteen user requirements are listed below:

1. Utilize historical organizational data. The model should process historical data that is extracted from the administration systems of organizations.
2. Enable dynamic execution. The model should enable non-momentary execution to facilitate that it can be executed every moment of the day.
3. Modify underlying assumptions with interaction. The model should allow users to modify assumptions by interacting with parameters. For example, the users must be able to determine the planning period.
4. Forecast organizational developments. The model should predict the future workforce development.
5. Identify gaps between preferred workforce occupations and the current situation. The model should compare the preferred workforce occupation with the predicted workforce occupation based on the current situations, to identify gaps.
6. Study current workforce occupation per department or function. The model should allow application to selections of or smaller datasets.
7. Study recent and historical personnel flows. The model should visualize personnel development.
8. Modify preferred workforce occupation with interaction. The model should allow the user to modify the preferred workforce occupation by interaction with parameters.

9. Return desired personnel influx, taking current personnel influx into account. The model should visualize the desired personnel influx, based on the preferred workforce occupation, taking current personnel influx into account.
10. Return desired personnel outflow, taking current personnel outflow into account. The model should visualize the desired personnel outflow, based on the preferred workforce occupation, taking current personnel outflow into account.
11. Enable adjustment of the scope. The model should allow users to modify the planning period.
12. Integrated in a Microsoft Power BI report.
13. Enables cross-sectional analysis. The model should not only be able to study current workforce occupation per department or function but also between cross-sections.
14. Adjust certain assumptions (i.e., historical context, preferred workforce, amount of personnel change and planning trajectory) through self-service. The model should allow users to modify assumptions by interacting with parameters in the Microsoft Power BI Report.

This solution visualizes the current workforce occupation, personnel change, predicted future workforce occupation and the onboarding targets to reach the desired workforce occupation. Three out of five interviewees emphasized that they already want to use this model, and this led to the fact that this model, after further development, will be integrated into the strategic workforce planning processes of two organizations, responsible for employing and managing 24000 employees. The research has therefore not only led to a theoretical analysis and an evaluated solution but will be applied in practice. This opportunity adds to the potential to become the go-to solution for organizations seeking standardized, automated, repeatable, repetitive, and customizable solutions for the entire organization.

References

Accenture. (2016). *The Strategic workforce planning finally gets strategic*. https://www.accenture.com/t20161118T003127__w__/us-en/_acnmedia/PDF-36/Accenture-Strategy-Strategic-Workforce-Planning-POV.pdf

van Beek, D., & van der Steen, E. (2018). *De intelligente organisatie*. Macmillan Publishers.

Biswal, A., Borah, M. D., & Hussain, Z. (2021). Music recommender system using restricted Boltzmann machine with implicit feedback. *Advances in Computers*, 367–402. https://doi.org/10.1016/bs.adcom.2021.01.001

Centraal Bureau voor de Statistiek. (2018, March 14). *Meer mensen wisselen van beroep*. https://www.cbs.nl/nl-nl/nieuws/2018/11/meer-mensen-wisselen-van-beroep

Deloitte. (2021). *Developing a robust predictive workforce planning model*. https://www2.deloitte.com/za/en/pages/strategy/solutions/strategic-workforce-planning.html

Deloitte. (2017). *The importance of strategic workforce planning, especially now*. https://www2.deloitte.com/nl/nl/pages/human-capital/articles/the-importance-of-strategic-workforce-planning-especially-now.html

Dybå, Tore & Prikladnicki, Rafael & Rönkkö, Kari & Seaman, Carolyn & Sillito, Jonathan. (2011). *Qualitative research in software engineering*. Empirical Software Engineering. 16. 425-429. 10.1007/s10664-011-9163-y.

Ip, R. H., Ang, L. M., Seng, K. P., Broster, J., & Pratley, J. (2018). Big data and machine learning for crop protection. *Computers and Electronics in Agriculture*, *151*, 376–383. https://doi.org/10.1016/j.compag.2018.06.008

ITC E-Learning. (2022, June 20). *Data collection methods- Content analysis* [Video]. Vimeo. https://vimeo.com/203982646

Kenton, W. (2021, 14 februari). *Markov Analysis*. Investopedia. https://www.investopedia.com/terms/m/markov-analysis.asp

Kimball, R., & Ross, M. (2013). *The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd Edition* (3rd ed.). Wiley.

Kronz, A., Schlegel, K., Sun, J., Pidsley, D., & Ganeshan, A. (2022, 22 maart). *Gartner Magic Quadrant for Analytics and Business Intelligence Platforms 2022*. Gartner. https://www.gartner.com/doc/reprints?id=1-28YOGKB6&ct=220201&st=sb

Lacey, M. (2012). Workforce Challenges-and Solutions-Abound. *Journal - American Water Works Association*, *104*(8), 2. https://doi.org/10.1002/j.1551-8833.2012.tb08838.x

Llort, N., Lusa, A., Martínez-Costa, C., & Mateo, M. (2018). A decision support system and a mathematical model for strategic workforce planning in consultancies. *Flexible Services and Manufacturing Journal*, *31*(2), 497–523. https://doi.org/10.1007/s10696-018-9321-2

Mader, A., Eggink, W. (2014). A DESIGN PROCESS FOR CREATIVE TECHNOLOGY.

McIver, D., Lengnick-Hall, M. L., & Lengnick-Hall, C. A. (2018). A strategic approach to workforce analytics: Integrating science and agility. *Business Horizons*, *61*(3), 397–407. https://doi.org/10.1016/j.bushor.2018.01.005

Microsoft. (2022a, January 29). *What is Power BI? - Power BI*. Microsoft Docs. https://docs.microsoft.com/en-us/power-bi/fundamentals/power-bi-overview

Microsoft. (2022b, May 7). *Learn DAX basics in Power BI Desktop - Power BI*. Microsoft Docs. https://docs.microsoft.com/en-us/power-bi/transform-model/desktop-quickstart-learn-dax-basics

Microsoft. (2022c, 4 mei). *Meer informatie over stervormige schema's en het belang daarvan voor Power BI - Power BI*. Microsoft Docs. https://docs.microsoft.com/nl-nl/power-bi/guidance/star-schema

Nielsen, L., (2013). *Personas*. In: Soegaard, Mads and Dam, Rikke Friis (eds.). *The Encyclopedia of Human-Computer Interaction*, 2nd Ed. Aarhus, Denmark: The Interaction Design Foundation, 2013: https://www.interaction-design.org/encyclopedia/personas.html

Patra, Y., & Tripathi, S. (2017). Work Force Planning, Literature Analysis: Digitization compels for a Conceptual Model for Data Driven Decisions. *Work Force Planning, Literature Analysis: Digitization Compels for a Conceptual Model for Data Driven Decisions*, *19*(11). https://doi.org/10.9790/487X-1911060111

Robson, C. (2002). *Real World Research: A Resource for Social Scientists and Practitioner-Researchers* (2de editie). Wiley-Blackwell.

Sinclair, A. (2021). Workforce Planning: a literature review. *Institute for Employment Studies*. https://www.studocu.com/en-gb/document/college-uk-further-and-higher-education/business/workforce-planning-a-literature-review/14329808

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Statline, Central Bureau for Statistics. (2021, November 16). *Werkzamen beroepsbevolking; wisseling van beroepsklasse*. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83120NED/table?ts=1622408788083

Uchwat, C., & Macleod, D. (2012). Case Studies of Regression and Markov Chain Models. *2012 Conference and Exhibition of the Transportation Association of Canada*, 1. https://trid.trb.org/view/1249439

Verma, Y. (2021, October 8). A Guide to Markov Chain and its Applications in Machine Learning. Analytics India Magazine. https://analyticsindiamag.com/a-guide-to-markov-chain-and-its-applications-in-machine-learning/

Wikipedia. (2021, July 28). *Markov model*. Wikipedia. https://en.wikipedia.org/wiki/Markov_model

Willis, G., Cave, S., & Kunc, M. (2018). Strategic workforce planning in healthcare: A multi-methodology approach. *European Journal of Operational Research*, *267*(1), 250–263. https://doi.org/10.1016/j.ejor.2017.11.008

Appendix

Appendix A – Strategic Workforce Planning

Publication Report – Strategic Workforce Planning

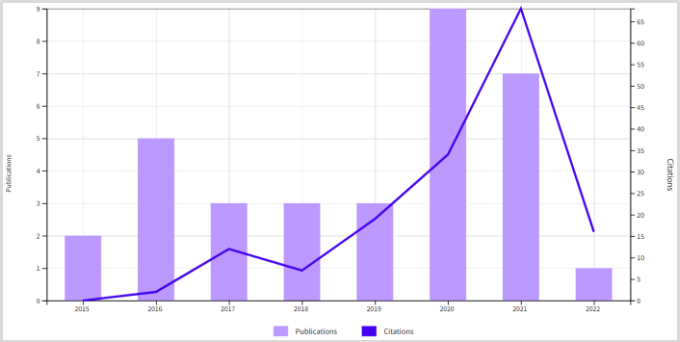
Database

Web of Science

Search terms

Strategic workforce planning (Topic)
OR
Workforce occupation (Topic)
AND
Business intelligence (Topic)
AND
Model (Topic)
AND
2015-2022 (Year Published)

Times Cited and Publications Over Time



Publications

33

Citations

158

Appendix B – Expert interview

Overview

Research Goal	Gain insight into the current work processes of end users
Participants	Expert in realizing and implementing Business Intelligence solutions
Method	Semi-structured interview
Materials	
Procedure	Briefing Interview Debriefing

Briefing

- Explanation of the goal of the session
- Explanation of the data processing
- Informed consent

Interview questions

General information

1. What are the main activities of the potential organizations?
2. How are these organizations organised?
3. How many employees work within these organizations? Which functions are distinguished?
4. What are the key strategic objectives for these organizations?
5. Which KPI's are being managed?
6. What does the current management information look like?

Information about the project

1. Who are the intended users of the Strategic Workforce Model?
2. Suppose the model would not be there in two years, where would the biggest problems occur?
3. If personal data is processed in the organization, has a DPIA been drawn up? Who takes care of this aspect?

Information about the data

1. What data sources are available/needed?
2. What is the most important data that can be found in this system?

Information about the product

1. What is the most important data that can be found in this system?
2. What are their roles?
3. How is user data knowledge estimated?

Information about current information gathering

1. What format are the reports in? (PowerPoint, Excel, Word)
2. What do the current reports look like? What data is presented herein?

Debriefing

- Explanation of the next steps
- Questions

Appendix C - Consent form

This consent form is based on the 'Informed consent form template for research with human participants (Dutch)' from the University of Twente. Accessible through: informed-consent-formulier-bms-nederlands-2022.docx (live.com)

Informatieblad voor onderzoek 'Integratie Markov Chains in Strategische Personeelsplanning'

Doel van het onderzoek
Dit onderzoek wordt geleid door Timo Petersen.
Het doel van dit project is het onderzoeken hoe de integratie van Markov chains in een BI oplossing Strategische Personeelsplanning mogelijk kan maken. De onderzoeksgegevens zullen worden gebruikt voor een afstudeeronderzoek voor de master Business Administration (Digital Business) aan de Universiteit Twente.

Hoe gaan we te werk?
U neemt deel aan een onderzoek waarbij we informatie zullen vergaren door:

- U te interviewen en uw antwoorden te noteren/op te nemen via een audio-opname/video-opname. Er zal ook een transcript worden uitgewerkt van het interview. Na het opstellen van een transcript, zullen de audio/video-opnames direct worden verwijderd.

Potentiële risico's en ongemakken

- Er zijn geen fysieke, juridische of economische risico's verbonden aan uw deelname aan deze studie. U hoeft geen vragen te beantwoorden die u niet wilt beantwoorden. Uw deelname is vrijwillig en u kunt uw deelname op elk gewenst moment stoppen.

Vergoeding
U ontvangt voor deelname aan dit onderzoek geen vergoeding.

Vertrouwelijkheid van gegevens
Wij doen er alles aan uw privacy zo goed mogelijk te beschermen. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen. Voordat onze onderzoeksgegevens naar buiten gebracht worden, worden uw gegevens zoveel mogelijk geanonimiseerd.

In een publicatie zullen anonieme gegevens of pseudoniemen worden gebruikt. De audio-opnamen, formulieren en andere documenten die in het kader van deze studie worden gemaakt of verzameld, worden opgeslagen op een beveiligde locatie bij de Universiteit Twente en op de beveiligde (versleutelde) gegevensdragers van de onderzoekers.

De onderzoeksgegevens worden bewaard voor een periode van 10 jaar. Na het opstellen van een transcript, zullen de audio/video-opnames direct worden verwijderd. Uiterlijk na het verstrijken van deze termijn zullen de gegevens worden verwijderd of worden geanonimiseerd zodat ze niet meer te herleiden zijn tot een persoon.
De onderzoeksgegevens worden indien nodig (bijvoorbeeld voor een controle op wetenschappelijke integriteit) en alleen in anonieme vorm ter beschikking gesteld aan personen buiten de onderzoeksgroep.

Tot slot is dit onderzoek beoordeeld en goedgekeurd door de ethische commissie van de faculteit BMS.

Vrijwilligheid
Deelname aan dit onderzoek is geheel vrijwillig. U kunt als deelnemer uw medewerking aan het onderzoek te allen tijde stoppen, of weigeren dat uw gegevens voor het onderzoek mogen worden gebruikt, zonder opgaaf van redenen. Het stopzetten van deelname heeft geen nadelige gevolgen voor u of de eventueel al ontvangen vergoeding.
Als u tijdens het onderzoek besluit om uw medewerking te staken, zullen de gegevens die u al hebt verstrekt tot het moment van intrekking van de toestemming in het onderzoek gebruikt worden.

Wilt u stoppen met het onderzoek, of heeft u vragen en/of klachten? Neem dan contact op met de onderzoeksleider.

Timo Petersen
Voor bezwaren met betrekking tot de opzet en of uitvoering van het onderzoek kunt u zich ook wenden tot de Secretaris van de Ethische Commissie van de faculteit Behavioural, Management and Social Sciences op de Universiteit Twente via ethicscommittee-bms@utwente.nl. Dit onderzoek wordt uitgevoerd vanuit de Universiteit Twente, faculteit Behavioural, Management and Social Sciences. Indien u specifieke vragen hebt over de omgang met persoonsgegevens kun u deze ook richten aan de Functionaris Gegevensbescherming van de UT door een mail te sturen naar dpo@utwente.nl. Tot slot heeft u het recht een verzoek tot inzage, wijziging, verwijdering of aanpassing van uw gegevens te doen bij de Onderzoeksleider.

Door mondelinge toestemming te geven voorafgaand aan het interview erken ik het volgende:

1. Ik ben voldoende geïnformeerd over het onderzoek door middel van een separaat informatieblad. Ik heb het informatieblad gelezen en heb daarna de mogelijkheid gehad vragen te kunnen stellen. Deze vragen zijn voldoende beantwoord.
2. Ik neem vrijwillig deel aan dit onderzoek. Er is geen expliciete of impliciete dwang voor mij om aan dit onderzoek deel te nemen. Het is mij duidelijk dat ik deelname aan het onder- zoek op elk moment, zonder opgaaf van reden, kan beëindigen. Ik hoef een vraag niet te beantwoorden als ik dat niet wil.

Naast het bovenstaande is het hieronder mogelijk voor verschillende onderdelen van het onderzoek specifiek toestemming te geven. U kunt er per onderdeel voor kiezen wel of geen toestemming te geven. Indien u voor alles toestemming wil geven, is dat mogelijk via de aanvinkbox onderaan de stellingen.

1. Ik geef toestemming om de gegevens die gedurende het onderzoek bij mij worden verzameld te verwerken zoals is opgenomen in het bijgevoegde informatieblad.	JA	NEE
2. Ik geef toestemming om tijdens het interview opnames (geluid / beeld) te maken en mijn antwoorden uit te werken in een transcript.	JA	NEE
3. Ik geef toestemming om mijn antwoorden te gebruiken voor quotes in de onderzoekspublicaties.	JA	NEE
4. Ik geef toestemming om de bij mij verzamelde onderzoeksdata te bewaren en te gebruiken voor toekomstig onderzoek en voor onderwijsdoeleinden.	JA	NEE
Ik geef toestemming voor alles dat hierboven beschreven staat.	JA	NEE

Naam Deelnemer:

Naam Onderzoeker:

Timo Petersen

Datum:

Appendix D - Information brochure

This information brochure is based on a template from the University of Twente.

UNIVERSITEIT TWENTE.
FACULTY OF BEHAVIOURAL, MANAGEMENT AND SOCIAL SCIENCES

Informatieblad & Toestemmingsformulier Onderzoek

Informatie brochure voor Interview over Strategische Personeelsplanning

Via deze brochure willen we u informeren over het onderzoek waaraan u heeft aangegeven mee te willen doen.

Onderzoeker: Timo Petersen

Adres:

Tel.:

E-mail:

UNIVERSITY OF TWENTE.

Achtergrond

Het doel van het project is om te onderzoeken hoe de integratie van Markov ketens in Business Intelligence strategisch personeelsplanning mogelijk kunnen maken. Markov is een wiskundige theorie die kan worden gebruikt om toekomstige bezetting van het personeel berekenen.

Het ontwikkelde model maakt het mogelijk om:

- Dynamisch de toekomstige bezetting van organisaties te voorspellen, gebaseerd op historische data.
- Recruitment adviezen te geven op basis van de gewenste bezetting per functie.
- Het effect van recruitment op andere componenten inzichtelijk maken.
- Strategische Personeelsplanning te integreren in BI-rapportages.

Onderzoeksprocedure

Het onderzoek vindt plaats in de periode van juni en juli 2021 via een online vergadering. Het interview zal maximaal één uur duren.

De deelnemers worden gevraagd om vragen te beantwoorden over het huidige recruitment- en/of personeelsplanning proces bij hun organisatie. Nadat ze een inleidende presentatie van het digitale product heb gekregen worden er vragen gesteld over het product in relatie tot het recruitment- en/of personeelsplanning proces bij hun organisatie.

Het onderzoek is beoordeeld en goedgekeurd door de BMS Ethics Commissie.

Participatie

De deelnemer kan op elk moment in de loop van het onderzoek besluiten te stoppen zonder dat dit

gevolgen heeft voor uzelf en zonder opgaaf van redenen. De deelnemers worden niet betaald. Aan het einde van het gehele onderzoek kan de deelnemer, indien de deelnemer dit wenst, door middel van een debriefing geïnformeerd worden over de verkregen resultaten.

Data selectie en opslag
We zullen informatie vergaren door u te interviewen en uw antwoorden te noteren/op te nemen via een audio-opname/video- opname.

Er zal ook een transcript worden uitgewerkt van het interview. Na het opstellen van een transcript, zullen de audio/video-opnames direct worden verwijderd.

Wij doen er alles aan uw privacy zo goed mogelijk te beschermen. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen. Voordat onze onderzoeksgegevens naar buiten gebracht worden, worden uw gegevens zoveel mogelijk geanonimiseerd.

Meer informatie en onafhankelijk advies
Indien de deelnemer onafhankelijk advies wil over deelname aan dit onderzoek, of een klacht wil indienen, kan de deelnemer contact opnemen met de ethische commissie.

Dit is een commissie van onafhankelijke deskundigen en is bereikbaar voor vragen en klachten over dit onderzoek.

Voor overige vragen kan de deelnemer contact opnemen met de onderzoeksleider.

Contact details ethics committee

Faculty of BMS

University of Twente

Appendix E – Semi-structured interview questions

Opening questions

- Could you briefly describe the work you do?
- What kind of tasks do you perform?
- What kind of decisions do you have to make?
- Based on what information do you make these decisions?
- How do you get that information now?
- Where do you get this information? Various sources?

Information

- Do you ever find that necessary information is not available? How do you deal with this?
- Are you also looking at information in the future? How do you deal with this? Are you assuming multiple scenarios what could happen?
- How often/What part is data analysis part of your work? How often do you look at data? How often would you like to look at data?
- What tools do you currently use? Think of applications, but also pen/paper, Excel, Word,
- Are you also dependent on others to get data?
- What do you compare current numbers with, with the standard, numbers from last year?
- Are you more interested in current numbers, average over a certain period, or the trend of numbers for a certain period?

Strategic workforce planning

- How is strategic workforce planning done in your organization?
- What is your experience with the way in which strategic workforce planning is done within your organization?
- Do you recognize the issues mentioned in the introduction? Are there other issues?
- Where does data come from?
- To what extent does data play a role?
- How is data processed? And refreshed in the meantime?
- How are results presented? Through what medium?

Strategic workforce planning model

Use case #1: predicted workforce occupation → what happens if the policy remains the same?

- Is it understandable for you as a user what you are looking at (per visual)?
- Is it understandable where you can enter parameters as a user and how you influence the situation/model with this?
- Are there any visual elements you would like to add for usability/comprehensibility?
- Are there any interaction components/parameters you would like to add?
- Does this provide the desired insights?

Use case #2: desired workforce occupation → where do we want to go and what does our recruitment policy look like?

- Is it understandable for you as a user what you are looking at (per visual)?
- Is it understandable where you can enter parameters as a user and how you influence the situation/model with this?
- Are there any visual elements you would like to add for usability/comprehensibility?
- Are there any interaction components/parameters you would like to add?
- Does this provide the desired insights?

User requirements

- Are the following user requirements included in the use cases?

User Requirement	Included in final concept
Utilize historical organizational data	
Enable dynamic execution	
Modify underlying assumptions with interaction	
Operate with basic and complex datasets	
Integrate in other Business Intelligence tools	
Forecast organizational developments	
Identify gaps between preferred workforce occupations and the current situation	
Study current workforce occupation per department or function	
Study recent and historical personnel flows	
Modify preferred workforce occupation with interaction	
Return desired personnel influx, taking current personnel influx into account	
Return desired personnel outflow, taking current personnel outflow into account	
Visualize the development of the current occupation in relation to the desired occupation	
Enable adjustment of the scope	
Integrated in a Microsoft Power BI report	
Enables cross-sectional analysis	
Adjust certain assumptions (i.e., historical context, preferred workforce, amount of personnel change and planning trajectory) through self-service.	

Use cases

- Welke componenten ontbreken in deze use cases?
- Wat voor andere use cases zijn belangrijk in SPP?
- Wat zijn toekomstige onderzoeksrichtingen?