Supporting Workforce Planning With a Simulation Based Tool

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Abstract. An organizations workforce is one of its most important strategic assets. Getting the right workforce at the right time is a very hard job in a constantly changing labor market. To make this job a little bit easier a workforce planning tool has been developed. This tool supports Human Resource Specialists with giving insight into how an organizations workforce will develop in the near future. The tool has been developed, building on the expertise of field experts and it has been validated in several different ways. This tool will enable fast informed decision making that with the help of the tool’s Excel interface can be easily communicated to the organizations management.

Keywords: Simulation, Workforce Planning, Decision Support
1 Introduction

Workforce planning is one of the hottest topics in the field of human resource management research [1]. It is a forward looking process aimed at improving management decisions regarding an organization’s workforce [1].

Every organization that needs employees operates in a labor market. A labor market is subject to many influences, and because of this is a dynamic environment. The supply and demand of employees is dependent on economic fluctuations [2]. Besides economical forces the labor market is also influenced by the changing characteristics of potential employees that inhabit a modern day labor market.

Aging of the workforce in the labor market is an issue in many countries [3-5]. Older workers have different needs and skills than young workers. Therefore aging has a great impact on how an organization should do job design and organize worker training [6].

Another trend workforce planner will have to deal with is an increasing flexibility of potential employees [7, 8]. The increased flexibility of employees has both an advantage and a disadvantage for workforce planners. It is easier for a planner to anticipate on changes that increase or decrease an organizations demand for employees. On the downside labor costs will increase. New personnel always requires some amount of training and leaving employees always take valuable organization specific knowledge with them that new employees can only develop over time.

This paper will only review workforce planning done in organizations defined by Mintzberg as a professional bureaucracy [9]. Professional bureaucracies use standardization of skills and coordination between employees as main organizational mechanisms. The focus will be on professional bureaucracies because for these organizations workforce planning is most challenging. They need highly skilled employees that are always in short supply.

Also, professional bureaucracies are often semi-large to large organizations. The size of an organization increases the complexity of workforce planning. A large organization will have to use multiple levels of hierarchy in its structure. A single manager does not have the span of control to keep track of hundreds of professionals. Having multiple levels creates problems of its own however.

Given its productivity and amount of levels of hierarchy there is an optimal size for a firm. [10]. It is in the organizations best interest of reaching a certain organizational profile (pyramid) that is optimal, because this will create the best cost to productivity ratio. Reaching this optimum might prove difficult. A dynamic environment, in which an organization commonly operates, constantly shifts the optimal form of the organization. Reaching a good organizational structure requires insight into the environmental dynamics that influence the shape of the best organizational profile.

Uncertainties surrounding this problem are not limited to the future developments of the labor market, but also include the effect of an organization’s internal human resource policies on the organizational profile. For instance:

- What happens to the population of the higher tiers in five years if an organization hires a lot of low level employees today?
- What is the effect on the lower tiers if promotion continues but recruiting targets are at a minimum?
• What is the effect an adjustment to the promotion policy on the lower and higher tiers?

These are a few examples of many possible questions a human resource manager could have. To give an answer to these and many other questions a workforce planning tool will be developed. The tool will be based on simulation as that technique is suited to make predictions over time within complex and dynamic situations.

Developing only a simulation model will not be enough. The simulation is to be used within an organization by users with a minimal amount of training while providing an optimal user experience. To achieve this goal an easily usable stand alone software application is needed.

This application will assist in reducing the uncertainty by looking ahead in time given certain policy parameters, and constantly adjusting to a changing environment. The impact on the organization of specific sets of parameters can be estimated thus reducing uncertainty, enabling better decision making.

Section two discusses using simulation and decision support systems (DSS) for workforce planning. Section three elaborates the design choices made to make the workforce planning tool a reality. Section four explains how the validation of the simulation model at the core of the tool was done. Section five explains about the value of the tool for organizations.
2 Using Simulation Based Decision Support for Workforce Planning

This section will discuss using simulation and decision support for an ill-structured problem like workforce planning.

2.1 Simulation for Ill Structured Problems

A problem can be well structured or ill structured [11]. According to Goel an ill structured problem can be distinguished from a well structured problem based on five characteristics [12]. Per characteristic we will evaluate if the problem described in the previous paragraphs is a well structured or ill structured problem.

Stopping Rules and Evaluation Functions: This characteristic leans toward ill structured. It is not clear when a tool for workforce planning would be finished. There are always features that can be improved or added.

Memory Retrieval & Inferences: This characteristic leans toward ill structured. The constraints on a design problem are non-logical.

Direction of Transformation Function: This characteristic leans toward ill structured. A design problem has fluctuating constraints and goals. This is why a project can shift in the direction it is headed.

Solution Decomposition: This characteristic is undecided. At this stage it is impossible to say how many modules and interconnections there are within this project.

Development of Solution: This characteristic leans toward ill structured. To reach a solution to this problem an incremental approach will be necessary.

Four characteristics indicate that the problem described in paragraph 1.1 is ill structured and one characteristic is undecided. From now on workforce planning will be regarded as an ill structured problem.

According to Mitroff the problem solving process consists of four stages as shown in figure 1.1. The arrows emphasize the different activities. The four stages are the: Perceived Problem, Conceptual Model Empirical Model and the Solution. The activities are: Conceptualization, Specification, Solution finding, Implementation, Consistency Check and Correspondence Check.
The activities that make up a specific problem solving process can be supported with a structured set of instruments, called an inquiry system [14]. Sol advocates simulation as the preferred inquiry system for solving ill-structured problems.

The beginning of the paragraph established that the problem described in paragraph 1.1 is an ill-structured problem, thus simulation will be used as a method of inquiry for this thesis. Simulation is defined as the process of designing a model of a real system and conducting experiments with this model for the purposes of either understanding the behavior of the system or of evaluating various strategies for its operation [15].

**Decision Support for Workforce Planning**

According to Keen and Sol [16] a good decision-making process has both an analytic element and a social element. The Analytical element consists of: information gathering, modeling, reporting and evaluation all of which benefit from formal methods and tools. The social element consisting of: leadership, collaboration, consensus-building communication and mobilization. Developing an analytical tool will not be sufficient for this project. The social element also needs to be covered.
Keen and Sol argue that a studio should be developed to support the analytical element as well as the social element [16].

A computer based tool that helps people make decisions is called a decision support system. A decision support system is defined by Sol as: “interactive computer-based systems which help decision-makers utilize data bases and models to solve ill-structured problems” [17]. A simulation based decision support tool will cover the analytical element.

The effectiveness of a decision support system can be expressed by the three Us: usefulness, usability and usage described by Jacobs [18] as:

- **Usefulness**: The usefulness of decision support tools expresses the value they add to a decision making process. It thus relates to the analytic models embedded in the decision support system.

- **Usability**: Usability expresses the mesh between people, process and technologies. Usability depends mainly on the interface between users and the decision support technology. Usability expresses among others, the responsiveness, flexibility, adaptability and ease of interaction and collaboration with the system

- **Usage**: Usage expresses the flexibility adaptively and suitability of a DSS for organizational, technical or social context. The main question concerning usage is: How is the system embedded in the decision process.

When with respect to a decision support system all the three Us are regarded of equal importance, the concept of a decision support suite emerges. A decision support suite is a well-chosen set of services and recipes for interconnectivity to support a decision making process. A studio is a (Virtual) environment in which suites are deployed.

Developing an environment for solving workforce planning related issues is out of the scope of this project. This project will feature a decision support suite that enables better and faster decision making regarding workforce planning. Though developing a new environment for this tool is out of scope, getting the tool used is a goal for this project.

### 3 The Tool’s design

Professionals tend to resist the rationalization of their skills [9], therefore technology cannot be leading it has to take on a supportive roll. This is one of the characteristics of a decision support system [16]. In this case the decision support system will be based on a simulation model. The simulation model will be expanded with a database to store input and an elaborate user interface to increase easiness of use.
3.1 Creating a successful tool with the help of its users.

A decision support system is only successful when it is used by its intended users. This may seem trivial but for this to happen, the tool needs to be tailored to its users needs. The users themselves are usually best capable of indicating their needs.

For this project the end users of the tool have been involved in its design. They have given valuable input for understanding the business logic the tool is aimed at supporting but also by validating the tool’s output data.

This approach is described by Barjis as the CPI modeling approach. CPI Stands for: collaboration, participation and interaction [19]. Following this approach has resulted in a more detailed description and a better understanding of the business processes that are supported by the tool.

One of the common pitfalls designers tend to encounter is when they finished a part of their model, evaluate its design and outcomes and to their opinion it behaves correctly. Moving on in the project they will consider that part of the model as working correct while that may not be the case. A user familiar with the business processes that should be supported is in these cases often able to spot errors in the model designer’s choices. With a traditional approach the users of such a tool are rarely involved in its design, thus leaving the opportunity for these improvements untapped.

Involving users into the tool’s design process may also cause some problems. Usually the tool’s users have another frame of mind than its developers. This discordance in insights might be the root of conflict. Weedman describes a case where a difference in design cultures is the base for such a conflict [20].

3.2 The Decision Support Tool’s Architecture

Employees can decide for themselves if they leave the organization or not. The organization does have no control over this decision. In a real organization’s environment, all these autonomous decisions create a system behavior that the organization will have to respond to. From a conceptual point of view, it would be wrong for the model to dictate the employee’s behavior. They should dictate their own behavior. The employees can only dictate their own behavior, operating as individuals in the model.

The individual based approach does not only affect the model form a conceptual point of view. When the employees are modeled accurately, they could show patterns of emergent behavior just like in a real environment. This attribute adds to the realism of the model.

The DSOL (Distributed Simulation Object Library) [18] was used as a platform for the workforce planning simulation suite. DSOL is a java based library aimed at supporting the development of simulation models. One of the reasons why DSOL was picked is because its java basis gives the model developer a lot of flexibility. Simulation is often used to model physical systems. Most simulation packages are tailored to accurately describe these physical systems. Workforce planning is an organizational process, for which most traditional simulation packages have little
support. Enabling an accurate recreation of the organizational environment, the flexibility of the DSOL library turned out to be a great asset.

Another advantage of the DSOL simulation library is its java basis. Java is a common programming language. This means there is a lot of support for both coding problems and interoperability with other software packages. As stated before developing a simulation model was not enough to fit the goals of the project. It needed to be a complete tool. Java’s standardized interoperability with Access and Excel was a great help with achieving this goal. Using Access and Excel prevented the tools developers from having to build the tool’s interface from scratch.

One of the workforce planning tool’s design goals was to enable a future expansion. With this in mind, a 3-tier architecture has been chosen as this enables easier modifications or replacements of parts without effecting other parts of the tool[21]. A picture of the tool’s complete architecture can be seen in figure 1.

![3-Tier Architecture](image)

Figure 2. The architecture of the workforce planning tool

Most simulation models used for problem analysis have input parameters that can be used to assign the experiments properties. Access stores the workforce planning model’s input parameters. Using a database for this purpose has the advantage of
being able to store and reuse multiple experiments, partially or as a whole. Access is a commonly available software package as it is a part of the Microsoft office package. It is however not an application most people are familiar with. Therefore a Graphical user interface was developed to enable easy configuration of the models parameters.

Communication with management is important within a professional environment. The workforce planning tool requires a format for its communication to management, that is familiar to them. Excel has been selected as output interface, to enable easy reporting by the model’s users. Excel is used in many organizations, this has as advantage that many people are familiar with using excel. Retrieving information about experiments done by the simulation model, just by copy pasting graphs from Excel, ensures a very user friendly approach.

The solver application is responsible for converting the settings the user has put into the database into experiments ready to be run by the simulation model. It also has some functionality that enable optimization with the simulation model. The user will have to define a search space for which the solver will create a set of experiments. The results of the experiments can be analyzed so the best set of policy parameters can be found. Currently the solver uses a brute force approach of going through the search space. Future versions might take a more sophisticated approach.

The statistics writer application is a piece of reused code developed for a previous project in which DSOL was used. With some minor adaption the statistics writer was able to translate the models results into an Excel format.

3.3 The Model’s Structure

A part of the DSOL library is dedicated to the DEVS formalism [22]. The workforce planning model has been created with the DEVS formalism. The model is divided into separate parts that communicate with each other by passing messages. This creates a separation between what the model does and when it does it.

This effectively creates loose parts within the workforce planning model each responsible for executing their own part of the logic. Figure 2 shows the workforce planning models structure. The loosely coupled parts enable an easy way of testing all the parts of the model separately. It also enables easier updates to the logic or even extensions to the model.
Figure 3 shows three paths that messages can follow. The first path is from managed attrition to banding, the second path is from managed attrition to promotion, the third path is from managed attrition to transfer.

The model advances time with steps of one month. Every month it takes one of the three paths described above, based on which month the simulation time is at. The time advance in months is chosen because the organization for which the workforce planning tool was developed uses month as a time unit for its business process.

The model’s structure has been developed with the help of HR (Human Resource) Specialists. With their expertise on how workforce planning is done, several activities have been identified: Hiring, Attrition, Transfers and Promotions. Assigning bandings is an exception to this rule. This activity is used in the organization for which this workforce planning tool has been developed, but is not relevant for organizations that do not use the banding system.

The hard part about workforce planning is how to match the internal demand of an organization with the external supply of new employees. External supply is a parameter that has to be set by the model’s users. The job market is a dynamic environment so that means it is impossible to determine a fixed job supply. The demand a parameter just like the supply since the demand for employees by the organization varies the same way depending on the economic state of the organization.

Hiring is a process used within organizations to attract new employees. In the workforce planning model hiring is the process that is executed last because no other process is directly dependent on how much hiring is done. In the business processes Hiring is dependent on attrition and promotion. For instance if ten people get promoted from tier 1 to tier 2 and there are 11 people needed on tier 2 only one new employee will be hired in tier 2. Promotion is leading here and hiring is adjusted to promotion.

Transfers are used as a leveling process. It is gap based, this means it looks at the wanted amount of employees and compares it to the current amount. If workforce A
has a shortage its HRManager\(^1\) makes a transfer request to the HRManager of workforce B and he returns a list of transfer candidates if there is a surplus of workers. HRManager A picks the most suitable transfer candidates from the list.

Promotion offers career possibilities to an organization’s employees. It is also the most important process regarding the natural growth of an organization. It is the biggest supplier of employees to the upper levels in the organization. Promotion also has an effect on unmanaged attrition. Employees often leave an organization if they are not promoted, when they expect to be. In the organization this effect results in double the attrition in the month directly after promotions are done. Since the employees make their own decisions it is impossible to dictate that twice as many employees should leave. The model takes this effect into account by tweaking the behavior of the employees, doubling the likeliness of them leaving the month directly after the promotions have been done.

Attrition is a natural process for any organization. It is used to remove underperforming employees, refreshing the workforce of an organization. Attrition could also be used for a negative growth strategy. Managed Attrition is the process that is executed first. Organizations tend to take into account who they know will be leaving the company. By doing attrition first, it is prevented that someone who got promoted recently will be flagged for attrition the same month. This behavior is extremely unlikely to happen in the real world and thus should be avoided in the model. For the model employees flagged for attrition still count towards the population but cannot take part in any activity such as promotion.

The banding system is a quality measurement system of employees relative to their peers. The banding of an employee is also used in various parts of the model. Highest banding gets the first chances of promotion. Lowest bandings are the first up for managed attrition.

Unmanaged attrition is the process that is executed by the employee. The HRManager in the model has no influence over the unmanaged attrition which is in concordance with reality. Employees might have all sorts of reasons of leaving company (better job offer other company, death, retirement, not satisfied about a promotion). These reasons are very diverse, thus it is very hard to accurately model them. Therefore a reduction has taken place. The employees will leave based on a draw. If the drawn number is lower than the likeliness with which an employee will leave, the employee leaves.

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\(^1\) A HRManager is the part of the model that controls all the workforce planning decisions for the organization.
4 Verification, Validation and testing of the tool

This section will describe various methods of validation that have been used for the workforce planning tool.

4.1 Face Validation

According to Balci, face validation can be described as: “The project team members, potential users of the tool, people knowledgeable about the system under study, based on their estimates and intuition, subjectively compare tool and system behaviors under identical input conditions and judge whether the tool and its results are reasonable.”[23]. The face validation of the model was done in two steps. The first step was testing the behavior of individual parts of the model as shown in figure 2. The second step was testing the behavior of the model as a whole.

For the first step a specially developed testing mode has been used. This testing mode was able to isolate different parts of the model so separate pieces of logic could be tested without interference from the rest of the model. This type of testing was used to check the basic behavior of the logic. For instance hiring should never result in employees leaving the organization.

<table>
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<tr>
<th>Policy_Set_ID</th>
<th>Unmanaged Attrition Rate</th>
<th>Managed Attrition rate</th>
<th>Attrition type</th>
<th>Attrition delay</th>
</tr>
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<td>44.6%</td>
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<tr>
<td>MCIM Consultant</td>
<td>17.3%</td>
<td>2.3%</td>
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<tr>
<td>MCIM Manager</td>
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<tr>
<td>MCIM Senior Executive</td>
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<td>1.5%</td>
<td>Percentage</td>
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<tr>
<td>MCIM Senior Manager</td>
<td>10.0%</td>
<td>4.5%</td>
<td>Percentage</td>
<td></td>
</tr>
</tbody>
</table>

Figure. 3. Database settings for the Attrition test

Figure. 4. Attrition testing graphs

An example test can be seen in figures 3 and 4. Note that the managed attrition rate of the analysts is a lot higher than the rate of the other levels. This is reflected by the models results as a faster declining analyst population. Furthermore all levels show a
steady decline in population which is to be expected considering all other parts of the models logic are turned off.

For the second step the behavior of the whole model was tested including interaction of the different parts of the model. Because these tests mainly used mock up data it was possible to validate general behavior patterns. Therefore these tests were valuable as a first step in the validation process, but for more accuracy additional tests were required.

4.2 Expert Validation

Law [24] describes that subject matter experts (SMEs) should be used to evaluate the output of the simulation. He does state however: “care must be taken in performing this exercise, since if one knew exactly what output to expect, then there would be no need for a model” [24] p45. One should be aware that results that seem unreasonable may be the result of a correct simulation.

In the development process of the model extensive use of the knowledge of HR experts has been made. During specially planned meetings these experts were consulted on their opinion about the behavior and result of the model. Another important role that these experts fulfilled was checking the assumptions that are at the core of the models logic.

4.3 Interface Analysis

According to Balci Interface Analysis can be described as: “The interface analysis category consists of several techniques that are especially useful for verification and validation of interactive and distributed simulations. (p360)” [23]. In this case interface validation has been used to check the interface between the simulation part of the workforce planning tool and the database part. It is important to check if the tool gets all the correct input parameters from the database.

For this purpose, logger software has been developed. These loggers write the simulation tools settings to a text file. If the parameters in the text file have the same value as in the database, it is assumed that the simulation tool reads the data correctly

5 The Tool’s Value for Organizations

5.1 Better and Faster Decision Making

Organizations often still use an ad-hoc decision making process regarding any decision about their workforce. When an organization will be using the workforce planning tool to improve their strategy they will be forced to think about what certain
decisions will mean for their future workforce. The fact that there is often not much structure in workforce planning will make improving the decision making quality a quick win for the workforce planning tool. The fact that it is able to analyze a large number of scenarios in a short amount of time will result in much faster and better informed decision making.

5.2 Portability of the Tool Between Organizations

Creating a tool that is applicable to every organization out there is nearly impossible, even if the targeted organizations are limited to professional bureaucracies. Nevertheless this tool has been designed to provide the maximum amount of portability form one organization to another. This means the tool is flexible on many points regarding organizational structure. It is for instance capable of handling between one and an infinite number of hierarchical levels. The most prominent exception to this rule is with regard to the banding system. When the workforce planning tool is to be used in an organization that uses another system than the banding system to measure the quality of its employees additional development will be required.

Another problem might occur is that even though the activities that are executed in an organization are the same, every organization does hiring for instance, the way they do it might be different. This means that the internal logic and assumptions used to execute the hiring process in the model might not be the same.

Portability to other organizations without doing extra development is expected to be limited. If the portability of the tool should be increased some extra research should be done on how other organizations grade their employees and how that compares to the banding system. Another point of attention would be how portable the logic of the current tool actually is.

5.3 The Tool as Means of Communication

An issue that especially large organizations face is lack of communication. The people responsible for the business strategy might be heading in another direction than the people responsible for the HR strategy. The workforce planning tool could play a big part of aligning these two groups in an organization. The management reports that can be produced with it can be used as a transparent way of communication the effects of certain strategic choices.

For instance, the strategy part may claim they need x new employees but the organizations recruiters can maximally recruit \( \frac{1}{2}x \) new employees, because hiring too many new employees will result in too many promotions that will increase the organizations operating costs. In this case the workforce planning tool could be used to report to the strategy department that the maximum amount of new recruits is \( \frac{1}{2}x \) and show them why their demands cannot be met.
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