A workload measurement framework for determining staffing needs

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Abstract

Determining workforce demand is an integral part of the workforce planning process - determining workforce size, composition, organization, and deployment. It analyzes the current and forecasts the future levels of workload required to fulfill the organization's mission and the factors that influence the workload. But the lack of reliable sources of actual task durations is the most significant difficulty in determining the workload. This paper proposes a workload measurement framework. Its purpose is to measure the workloads of tasks managerial, professional, and technical employees perform at the workplace.

Our approach suggests a detailed description of work processes and an elementwise time study using a specially designed web application.

The proposed workload measurement framework was successfully implemented in the study to determine staffing needs for local government employees. More than 1800 state employees responded to the time study. The proposed workload measurement framework provided quality data for workload analytics.

The proposed workload measurement framework has two benefits. Firstly, it provides the workload model developers with the actual task duration data, thus making the workload models more accurate and less dependent on subjective inputs. Secondly, it decreases the labor-intensity of the data collection and analysis processes, thus reducing the workload model development lead times.

Keywords: Determining staffing needs, Tasks, Workload, Time study
JEL Codes: J01, J23, J22

1 Introduction

Determining workforce demand is an integral part of the workforce planning process - determining workforce size, composition, organization, and deployment. It analyzes the current and forecasts the future levels of workload required to fulfill the organization's mission and the factors that influence the workload (Vernez et al., 2007). A workload model is defined as a result of this analysis. Organizations can use workload models to predict potential gaps between the available human resources and the human resources required to fulfill their mission. Accurate and reliable workload

models are essential for successful workforce planning (Emmerichs et al., 2004).

Approaches used for workforce supply and demand planning are subdivided into qualitative and quantitative according to the methods of obtaining and analyzing data. According to the technical rationale, these approaches are subdivided into those that involve a detailed study of work processes (Bottom-up approach) and those based on mathematical modeling. In practice, approaches to determining staffing needs are frequently combined. Their choice depends on the available historical and statistical data and the time that subject-matter experts (SME) can devote to researchers (Nataraj et al., 2014; Schulker et al., 2020).

Compared to approaches based solely on mathematical modeling, the Bottom-up approach is more objective in determining staffing needs and has rationalization potential. The Bottom-up approach is more intuitive than those based on mathematical modeling as it increases the transparency of work processes for decision-makers. A detailed study of work processes can reveal their imperfections and initiate a search for more efficient work methods. This approach can help detect unproductive use of work time and the underperformance in crucial areas of work caused by understaffing or misallocation of duties, negatively affecting overall productivity (Birkinshaw and Cohen, 2013; Schulker et al., 2020).

However, the bottom-up approach also has significant drawbacks. The bottom-up approach is much more labor-intensive and complex than those based on analyzing historical and statistical data. Another disadvantage is that determining staffing needs for managerial, professional, and technical employees relies heavily on subjective inputs that are difficult to verify. As a result, this may adversely affect the quality of the staffing model.

This paper proposes a workload measurement framework. Its purpose is to measure the workloads of tasks managerial, professional, and technical employees perform at the workplace. It suggests a detailed description of work processes and an elementwise time study using a specially designed web application.

The proposed workload measurement framework has two benefits. Firstly, it provides the workload model developers with the actual task duration data, thus making the workload models more accurate and less dependent on subjective inputs. Secondly, it decreases the labor-intensity of the data collection and analysis processes, thus reducing the workload model development lead times.

2 Literature review

In the scientific literature, various techniques are used for workforce planning. Researchers in the field used different approaches to classify these

techniques. For example, Bryant, Maggard, and Taylor (1973) subdivided workforce planning techniques into four categories: Judgemental techniques, Matrix models, Quantitative techniques, and Computer simulation. Safarishahrbijari (2018) subdivided workforce planning techniques into seven categories: Qualitative, Time series analysis, Optimization models, Generic mathematical models, Statistics and regression, Analytical stock and flow models, and Simulation modeling. Borba et al. (2019) subdivided quantitative workforce planning techniques into Mathematical programming and Computational intelligence.

2.1 Quantitative techniques

Under quantitative techniques, the literature mainly describes the application of operations research methods which can be divided into three broad categories: Optimization, Simulation, and Statistics and Probability.

Optimization approaches involve finding solutions by minimizing inputs or maximizing outputs under existing limiting factors. Optimization also suggests comparing potential options and choosing the most acceptable. Traditionally, Linear programming, Objective programming, Mixed integer linear programming, Dynamic programming, and Data envelopment analysis are used for optimization. Alternatively, the literature mentions applications of Computational intelligence (e.g., Fuzzy logic and Evolutionary computing), Queuing modeling, Stochastic programming, and Robust optimization (Souto Anido et al., 2018; Turan et al., 2021; Liu et al., 2019; Bastian et al., 2020).

It is not always possible to choose mathematical methods for business problems that would have an explicit analytical solution. In such cases, Simulation modeling can be used. Simulation modeling utilizes computers to replicate the behavior of real business systems in a simplified form. Simulation modeling imitates essential elements of business systems and the logic of interaction between these elements. System dynamics is the most frequently used technique in workforce supply planning (Safarishahrbijari, 2018). In System dynamics, business processes are modeled using three types of elements (stocks, flows, and information) that can interact with each other using feedback loops and allow time delays between inputs and outputs (Wang, 2007).

The third major category of Operations research techniques used in workforce planning is Statistics and probability. This category of techniques involves the application of mathematical methods to data to identify patterns, forecast, and test hypotheses. Time series analysis falls into this category. The main idea of time series analysis is to extrapolate past trends into the future, considering the main trends, cyclicality, seasonality, and other recurring and continuous patterns. A subgroup of Time series analysis includes Box-Jenkins, exponential smoothing, vector error correction, and Markov

modeling (Wong, Albert, and Chiang, 2005; Hsu, Chen, and Hsien, 2012; Wong, Albert, and Chiang, 2007; Belhaj and Tkiouat, 2013).

Regression is another technique used in workforce planning. Regression approximates an analytical relationship between the dependent variable and the independent variables. In workforce demand planning, the dependent variable is the number of workers demanded, and the independent variables can be various workload drivers. Performance indicators of a particular enterprise, industry, or microeconomic indicators can be used as workload drivers (Meehan and Ahmed, 1990; U.S. Department of health and Human Services, 2008).

2.2 Other quantitative techniques

In workforce planning, less sophisticated quantitative methods can also be used. For example, Nataraj et al. 2014, in addition to the aforementioned quantitative approaches, describe the use of Benchmark analysis, Input-output modeling, and Ratio analysis techniques.

2.3 Qualitative techniques

Qualitative techniques for workforce planning suggest the use of expert judgment. Individual judgments of managers and experts are collected and analyzed in this approach. Qualitative techniques include the Direct managerial survey (Ward, 1996), the Delphi method (Dakley and Helmer-Hirschberg, 1962), the Nominal group technique (Delbecq and Van de Ven, 1971), and Scenario analysis. The Delphi method is an iterative process in which experts evaluate each other's judgments to reach a consensus. Unlike the Delphi Method, in which experts give their assessments independently, the Nominal group technique involves live communication and exchange of opinions between experts. Scenario analysis is a strategic management technique in which the decision-makers generate several discrete future states of the business, each contingent on assumptions about the future organization’s internal and external environment.

2.4 Combining qualitative and quantitative techniques

In practice, the approaches used for workforce planning often combine quantitative and qualitative techniques. This is because there is frequently a lack of reliable and systematic data to get by with only quantitative techniques. Utilizing qualitative techniques alone may adversely affect the validity of the workforce model since expert judgments may have bias. On the other hand, collecting and analyzing reliable expert assessments can be very costly. We will briefly describe two approaches combining quantitative and qualitative techniques: the Top-down and Bottom-up approaches.

The Top-down approach uses regression analysis to approximate the analytical relationship between the number of workers required on the workload drivers. But the workload drivers may not accurately determine the number of workers, as they may contain elements with different workloads.

To improve the model's accuracy, workload drivers can be subdivided into different workload categories using expert assessments.

The Bottom-up approach involves a detailed description of work processes, identifying the workload of each element, and determining the required number of workers based on the overall workload.

2.5 Essential elements of the Bottom-up approach

The latest published study on determining staffing needs using a bottom-up approach is Schulker et al. (2020). In the study to determine staffing needs for administrative, professional, and technical workers in the U.S. Secret Service, the authors have described the most important aspects of applying the bottom-up approach. And we would like to describe the main methodological techniques of the bottom-up approach using this example.

Description of work processes. A detailed description of work processes is the basis of the bottom-up approach in developing a staffing model. Schulker et al. (2020) refer to the well-documented processes as process maps. Process maps are formed by studying work processes and interacting with the process owners. It is crucial to document all processes and their most essential elements.

The level of granularity in the description of work processes. Work processes should be documented with a sufficient level of detail in such a way as to reflect the main features that are important for building an adequate model. Researchers should avoid overly detailed descriptions of work processes due to the following considerations. A high level of detail requires more time for subject-matter experts to assess the task durations and frequencies. Work processes without excessive detail are better perceived and more convenient to apply and update. Elements of some generalized work processes can be used in the construction of other work processes. On the other hand, overly generalized work processes are difficult to assess regarding their workload. Depending on the situation or complexity, the frequency and duration of executing these elements may vary.

An assessment of the frequency and duration of execution of work process elements. The average workload of a job element can be determined as the product of the mean frequency and the mean duration of its execution. The total workload of the work process is determined by identifying the workload of each element. This is perhaps the most crucial and complex process of the bottom-up approach since the quality of a staffing model depends on how accurately the assessment of the workload is done.

Highly variable task durations. When analyzing a work process, the duration of some of its tasks can be challenging to predict because of the large spread in the values. Schulker et al. (2020) suggest the following solutions in such situations: (i) despite the large spread in the values, use the mean value based on the expert opinions; (ii) introduce complexity categories into the

staffing model; (iii) refine the staffing model with objective, measurable, realistic, and articulated performance standards (quality, timeliness, or cost-effectiveness).

3 Methodology

Our workload measurement framework involves a detailed description of work processes and time study using a web application that resembles a timesheet. Employees keep track of work time by selecting tasks and fixing the start and end times of their execution in chronological order. Employees pick out the tasks they perform at work from a predetermined list. This approach enables the subsequent analysis and generalization of data from the time study. Before conducting the time study, we prepared comprehensive lists of tasks based on job descriptions and interviews with the work process owners.

3.1 Developing exhaustive lists of job tasks for the time study

We prepared a separate comprehensive list of tasks for each functional unit - a group of interchangeable employees performing homogeneous tasks. In other words, a functional unit is a structural unit of an organization. We developed exhaustive lists using job descriptions. And we used relevant instructive documents for the groups of professionals whose work processes were regulated by law.

We structured and ordered exhaustive lists in such a way that the respondents could easily comprehend them. To achieve this goal, we adhered to the following presentation principles: (i) eliminating task duplicates; (ii) breaking down large tasks into more specific ones; (iii) presenting tasks in semantic sequence (e.g., by technology, by chronology, from most important to least important); and (iv) grouping tasks according to their meanings. Thus, an exhaustive list of tasks should resemble a process map.

Since job descriptions do not always cover the entire range of responsibilities, we refined the lists of tasks together with managers and subject-matter experts in interviews.

3.2 Time-study web-application

A time study web application helps get objective data on actual task durations. It significantly improves the quality of data and the coverage of respondents.

Our web application can be used on mobile devices. The application has an intuitive interface. In addition to filling out timesheets, we provided respondents with additional functionality that allowed them to analyze their data, control subordinates, set assignments, etc. These features minimize distractions for employees during the data collection process.

The web application allows the researchers responsible for conducting the time study to administer the data collection process. This includes: (i)

creating accounts, (ii) uploading and updating the comprehensive lists of tasks, and (iii) assisting respondents with any questions that arise. The application provides the researchers with the feature to monitor the data collection progress and access various data slices.

The application was designed to account for non-productive time (rest breaks, meetings, workplace preparation, etc.).

3.3 Initiating the time studies

Before conducting the time study, we determined a name list of respondents. Next, we created accounts (login and password) for each respondent. The manager had access to the data of his subordinates for monitoring and setting assignments. Respondents were grouped into functional units. Each unit consisted of a manager and subordinated employees with a single comprehensive list of tasks. All employees of the unit who were present at the time of the study participated in the study. We strictly observed this condition for the study data to be unbiased.

We began the time studies with a briefing for respondents to inform them about the goals, objectives, and timing. During these briefings, we trained them on how to use the application. We reserved some time at the end of the briefings to answer questions from respondents. In total, the briefings lasted no more than 45 minutes.

Immediately after the study launched, we had to answer numerous requests from respondents on various issues of using the application and other technical nuances. Usually, on the second day, the number of requests decreased noticeably, and on the third day, respondents used the application confidently. At the start of the study, we were at the client's office to assist respondents. As a rule, the most frequent difficulties faced by respondents were account access problems and updating the lists of tasks.

3.4 Time study duration

We conducted time studies for two weeks (10 subsequent workdays).

3.5 Description of the sample

We conducted time studies among the employees of Kazakhstani local governments. The studies involved 1,804 local government employees. We selected three regions for the study: Almaty City (247 respondents), the Karaganda region (835 respondents), and the North Kazakhstan region (722 respondents). The time study among the employees of local governments was carried out from late 2018 to early 2019.

4 Results

This section describes the generic uses of time study data.

4.1 Workload structure analysis

Workload structure analysis is the primary way to study the task contents of managerial, professional, and technical employees. It shows the

distribution of the overall workload by tasks as a percentage. This analysis is suitable for the team and for the individual employees. Based on this analysis, management decides to revise (optimize) business processes in such a way as to maximize labor productivity or to reallocate the duties according to the qualifications, abilities, and individual qualities of employees (Birkinshaw and Cohen, 2013). By classifying tasks, we can generalize the workload structures of employees performing heterogeneous functions. An example of such an analysis is the study of routine task contents (Table 1).

Table 1: Workload structures of managerial, professional, and technical employees by ISCO-08 occupation group

Task category	**Task subcategory**	**Managers**	**Professionals**	**Technicians and Associate Professionals**	**Clerical Support Workers**	**Total**
Non-routine	Organizing	12.4%	9.4%	6.6%	4.1%	9.2%
interactive	Coordinating	2.6%	2.7%	1.3%	0.4%	2.3%
	Communicating	9.1%	8.0%	14.9%	9.3%	9.0%
	Controlling and evaluating	10.4%	10.8%	7.2%	9.6%	10.2%
Non-routine	Creating	11.2%	8.9%	5.3%	3.9%	8.5%
analytic	Analyzing	36.9%	37.2%	24.9%	19.6%	34.0%
Routine cognitive	Routine cognitive	17.4%	23.0%	39.8%	53.1%	26.8%
Total		**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

4.2 Uneven distribution of the overall workload across tasks

We summed up the workload per task and arranged them in descending order of their aggregated workload. A fifth of all tasks (20%) generates the lion's share of the total workload (78%). Figure 1 shows the workload distribution across all tasks. Each column represents one-tenth of the total number of tasks arranged in the descending workload order.

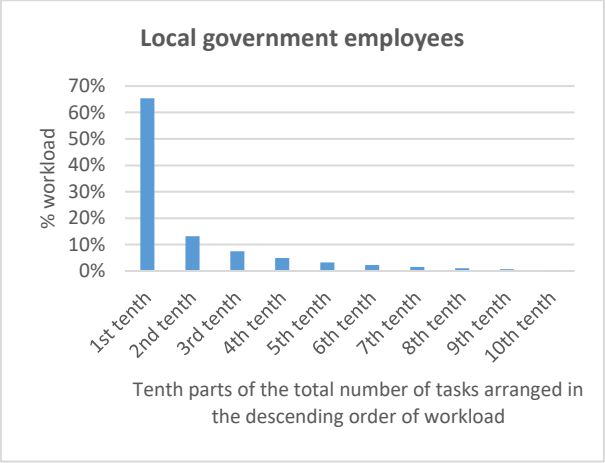

Figure 1. Workload distribution across all tasks. Each column represents one-tenth of the total number of tasks arranged in the descending workload order

4.3 Task execution frequency

There is a direct relationship between task execution frequency and workload. The higher the execution frequency, the higher the workload. So, measuring task execution frequency is essential for evaluating workload. We measure it in the number of days the task was performed. Since the study period is two weeks (10 working days), the maximum frequency is ten days, and the minimum is one day. The general trend is that about 60% of all tasks performed during the 2-week study were executed only 1–2 times (Figure 2). Figure 3 shows a direct relationship between the task workload and execution frequency.

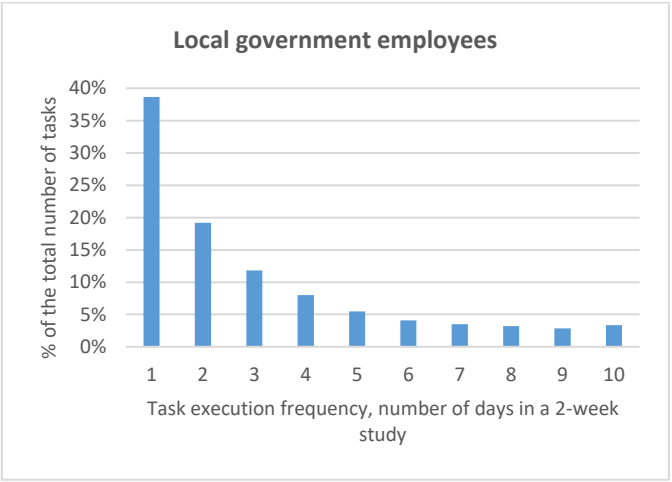

Figure 2. Distribution of the number of tasks executed during the 2-week study by execution frequency

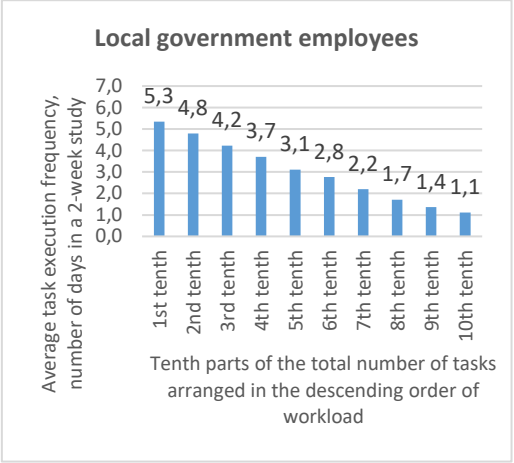

Figure 3. Relationship between the task workload and execution frequency

4.4 Number of employees executing a task

The number of task performers is another indicator that characterizes workload. Since we create an exhaustive list of tasks for a group of employees, the same task can have several performers. The more employees perform it, the higher the workload. The time study web application provides developers with the data to calculate the number of task performers for each task.

5 Discussion

5.1 Theoretical contribution

Prior research on developing staffing models stated that the lack of reliable sources of actual task durations is the most significant difficulty in determining the workload (National Research Council, 2006, 2013, 2020; Nataraj et al., 2014). Therefore, when determining staffing needs for managerial, professional, and technical employees, researchers rely on subjective estimates that are difficult to verify (Schulker et al., 2020).

Because mental labor is hidden from external observation studying the duration of tasks by managerial, professional, and technical employees is a challenge. Considering this feature of mental work, direct observations to estimate the task durations by employees can be severely limited. At the same time, using expert estimates may lead to a significant deviation from the actual task duration (Teter, 2014; Roy et al., 2013; Roy and Christenfeld, 2008, 2007; Goswami and Urminsky, 2014).

We proposed an approach to studying the duration of the task execution based on a detailed study of work processes and conducting time studies using a web application. Our workload measurement framework provides the workload model developers with the actual task duration data, thus making the workload models more accurate and less dependent on subjective inputs.

5.2 Managerial contribution

Developing staffing models is a labor-intensive and painstaking process requiring effort, finances, and time from the researchers and the studied enterprises. Our workload measurement framework decreases the labor-intensity of the data collection and analysis processes, thus reducing the workload model development lead times.

Our approach contributes to increasing the transparency of work processes. The proposed workload measurement framework can help managers to revise (optimize) business processes in such a way as to maximize labor productivity or to reallocate the duties according to the qualifications, abilities, and individual qualities of employees.

5.3 Limitations

In our opinion, the limited duration of time studies is the main limitation of our methodological approach. Because some of the tasks performed by managerial, professional, and technical employees are seasonal or cyclical, two weeks for conducting research is certainly not enough to get an adequate workload structure. So, some judgmental input still would be necessary to assess annual task workloads.

Another limitation of our methodological approach is that in obtaining data, we have to rely on the discipline and conscientiousness of respondents. However, for our part, we tried to provide all possible measures to increase the transparency of the data collection process. For example, in our web application, we have provided options allowing managers to validate the timesheets of their subordinates. We also provided the researchers with the feature to monitor the timeliness of filling out the timesheets.

5.4 Future research agenda/directions

We plan to integrate the NASA Task Load Index (NASA TLX) into our methodology. The NASA TLX Load Index is a widely used subjective multivariate scoring tool that evaluates anticipated workload to assess the efficiency of work task execution, human-machine systems, work groups, or other aspects of performance. We will study the relationship between the subjective workload and the gap between the actual staffing level and the staffing needs determined using the Bottom-up approach. In other words, we plan to test the possibility of using NASA TLX to verify the adequacy of the staffing needs determined using the Bottom-up approach.

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