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ALGORITHMS TO FORECAST WORKFORCE

ABSTRACT

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The author is a PhD student in a full-time form of study at the Department of Industrial Business and Entrepreneurship at the D. A. Tsenov Academy of Economics, Svishtov.

The dissertation is in the volume of 232 standard pages. Structurally, it consists of an introduction, an exposition in four chapters, a conclusion, and a list of references - a total of 114 sources. In support of the above, 102 tables and 19 figures are included. The appendices have volume of 38 pages.

The defence of the dissertation will take place on 01.10.2021 at 10:00 a.m. in the Conference Hall "Rectorate" D. A. Tsenov Academy of Economics, Svishtov, and the Web-based Conference System of D. A. Tsenov Academy of Economics, at a meeting of the scientific jury appointed by order of the Rector of D. A. Tsenov Academy of Economics, Svishtov, composed of:

Prof. Lyubcho Minchev Varamezov, PhD
Prof. Aneta Georgieva Deneva, PhD
Prof. Nikolai Hristov Shterev, PhD
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The materials concerning the defence are available to all interested parties on the website of D.A. Tsenov Academy of Economics, Svishtov: rubric "Procedure for acquiring educational and scientific degree "Doctor".

Content of the abstract

I. GENERAL CHARACTERISTICS OF THE DISSERTATION

1. Relevance of the research

In the 21st century grocery retailing sector, the improvement in the technology and the speed of the information sharing had changed the way of doing business. The need of fast adaptation to response to the change, to satisfy customer needs and to compete with new brands forced companies to work with low margins. By the time passes, it has become harder and harder for the companies to be sustainable in the sector. Therefore, many retail companies are focusing on how to decrease the costs and work with better efficiency values. In the sector, there are mainly three expenses; workforce, rent and transportation (excluding merchandise). As in most of retailing organizations, workforce is the biggest asset and expenditure in the company, workforce optimization is a game changing science, which has a tremendous effect on the operation success. Therefore, achieving the best configuration for the workforce (time, demand and the cost) can provide a fabulous competitive advantage. Thus, there is a business imperative to understand, measure, plan and manage for it properly.

Through the years, human resources department has checked and controlled the manpower costs, however, need of workforce and its distribution to departments mostly decided by store managements. The Retail is a sector, which has the balance of focus between labor costs and revenue. The companies may see the employee as cost intensive assets, but they are the master key to the customer happiness. Happy employees provide quality services, which triggers to higher customer satisfaction and in return the store gains more revenue. Therefore, workforce management has a huge impact on store's success rate. In retail, the life is dynamic due to a rival company's power nearby, municipal road excavation decision, location properties or even weather conditions of the area. Due to organizational change, many store managements might change their stores for the benefit of the company. Therefore, they must experience and learn store characteristic before having efficient decisions in terms of sales, costs, workforce management and margins. Many store managers can manage an efficient workforce planning; however, it would be much easier if the workforce management standardized and programmed so that they don't need to spend time on planning and focus on increasing sales operations.

2. Object and subject of the research

The **object** of the study is *increasing workforce management efficiency in Migros, Turkey's one of the biggest grocery retail company's stores*.

The **subject** of the study *establishing algorithms for workforce requirements per 30 minutes periods and flexible data driven schedules for the departments of Cashiers, Stockers and Butchers with the help of time study observations and sales data analysis with the tools of python and cplex.*

3. Aim and tasks of the dissertation

The **aim** of the study is *having a shared language that connects workforce metrics to business outcomes in terms of helping grocery retailers benefiting of increase in workforce efficiency and lowering workforce costs by establishing algorithms for 30 minutes periods employee requirements and scheduling of Cashier, Stocker and Butcher's departments*.

Achieving the defined goal is related to solving the following research **tasks**:

• Research of theoretical developments and clarification of the essential aspects of the workforce management and scheduling approaches in the literature.

• Identification of daily routine works of cashiers, stockers and butchers with the time study observation methodology through empirical data.

• Analyzing sales data with python program to establish workforce requirement algorithms for each department.

• Establishing algorithm-based scheduling including government regulations and company policies based on the theoretical research, empirical data of time studies and results of workforce requirements algorithms.

• Testing the algorithm-based scheduling results in the stores and comparing with the store management scheduling approaches.

4. Research thesis

The **main thesis** advocated in the dissertation research, is that *having an algorithm-based scheduling for cashiers, stockers and butchers supporting with time study observations' empirical data and the sales data analysis can result efficiency increase in workforce management of these departments, therefore company can lower the employee costs of the operation and get in an advantage position compare to its opponents*.

5. Research methodology and methods

The **research approaches** used in the dissertation are historical, systematic, process, structural, functional, and for research **methods** are selected: time study observation, comparison, modelling and programming.

6. Sources of information and empirical study data collection

The **main sources of information** for the development of the dissertation are publications in specialized periodicals, proceedings of scientific conferences, statistics from the National Statistical Institute, official governmental and non-governmental organizations, associations and industry organizations, Internet, sector analysis reports, company data, articles, scientific magazines etc. The research is based on a study covering 332 hours of in-store observations in period 2018-2019 in three departments and data analysis of 346.610 products transections.

7. Restrictive conditions and limitations the study

Due to scope of the researched issues within the dissertation the following limitations are introduced in theoretical aspect:

- *Restrictions regarding the subject of research:* The study conducted in main departments of a grocery retail store with cashiers, stockers and butchers. It can be applicable to fruit&vegetable, bakery and delicatessen department as well. Having low number of part time employees in the company and having a goal minimizing the numbers year by year due to financial disadvantage, part time employees neglected in the study.
- *Restrictions regarding the object of study:* Migros is operating more than 2.300 stores, therefore due to data privacy policy, data samples of certain months and stores are used in the dissertation to get a general view. The forecast sales used in the Chapter III is received from the sales department and accepted its accuracy rate. The company policy is having 8:30 hours of work time in each day, therefore flexible shifts lengths like 5:30 or 7:00 could not use in the study.

In many cases, technical research on workforce planning focuses very hard on the mathematical model and neglects the real-life implications necessary for the model to perform well. On the other hand, many management studies give a comprehensive description of the human impact of specific management decision cases, but do not provide useful mathematical models for solving workforce planning problems. This study offers a complete solution in terms of having real life implications with time study observations and solid mathematical models with massive data analysis. The literature has enriched about workforce management studies in the last decade, however most of the studies touch mostly on banking, health or manufacturing sectors, the ones with the retailers is mostly focuses on the cashiers. The study outcome will enrich scarce literature on the retail sector and departments; especially having approaches for Stockers, who are responsible of in store replenishment operations and butchers, as an example of service-based department. The study will cover the main department in a grocery retail store; therefore, it provides an inclusive and complete solution for the workforce management.

II. STRUCTURE AND CONTENT OF THE DISSERTATION

Structurally, the dissertation consists of Introduction (5 pages), Chapter I (27 pages), Chapter II (31 pages), Chapter III (48 pages), Chapter IV (61 pages), a conclusion & contribution (4 pages), a list of references (5 pages) and appendix (38 pages) total of 232 pages.

The structure of the development is structured as follows:

LIST OF TABLES
LIST OF FIGURES
TERMINOLOGIES AND ABBREVIATIONS

INTRODUCTION

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1. History of Workforce Management
2. Review on Workforce Requirement
3. Review on Scheduling
4. Review on Time Studies
5. Research and Data Analysis Methodologies

Summaries and Conclusion

CHAPTER II THE HISTORY OF GROCERY RETAIL SECTOR AND COMPANY OF MİGROS

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Summaries and Conclusion

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III. SYNTHESIZED PRESENTATION OF THE DISSERTATION

Introduction

The introductory part presents the general statement of the research topic, outlining the framework for scientific analysis, the degree of development of the problems and reveals the relevance of the development. The object, the subject and the research thesis of the dissertation are successively defined, the aim of the study is formulated, specific tasks for implementation are set and the methodology and the restrictive conditions of the research are indicated.

CHAPTER I. THE LITERATURE REVIEW OF WORKFORCE REQUIREMENT AND SCHEDULING ALGORITHMS

The first paragraph describes the history of workforce management starting with a workforce management description of Reilly P. saying, "A process in which an organization attempts to estimate the demand for labor and evaluate the size, nature and sources of supply which will be required to meet that demand" (Reilly, 1996). The term "workforce management" is new concept and relatively new one compare to much older terms such as succession planning, human resource planning and manpower planning, which is still used in some companies occasionally.

During 1960s and beginning of 1970s workforce planning grew in a stable economy having low unemployment rate and organizations facing with supply shortages forced to have an improvement on labor utilization. It remained a major practice in the biggest HR departments until the economic crisis late in 1980s when the failure to prove the value of workforce plans resulted in many efforts being eliminated (Reilly, 1996). During this period, there were number of factors contributed to the rejection of workforce planning. The traditional method was mechanical in terms of concerning only head count and ignoring head content, which put blocks in the sense of being flexible enough to meet the condition and environmental changes (Castley, 1996). A series of changes in organizational structures and attitudes in the 1980s opposed the practice of workforce planning. There was a backlash against a central corporate power, and organizations began to delegate authority to local units. This made workforce planning more difficult and resulted in the loss of some workforce planning skills. Additionally, the HR agenda has shifted from a quantitative approach to a more qualitative approach, looking at the employee skills with adding value to the company (Reilly, 1996). In the second half of the 1990s, workforce planning began to return to the human resource department agenda. Today it represents a high priority for a growing number of organizations as they realize the need for planning is greater than ever. There is an awareness of the importance of developing skills in an environment that requires adaptability rather than stability. It is recognized that employee contribution needs to be maximized through better utilization and distribution. Finally, there is an understanding of the need for employees to frame their tasks in the context of business plans and make them more challenging for continued business improvement.

Organizations today need to plan their own survival while dealing with: intense competition from home and abroad; labor market factors, recruitment and retention; speed of acquiring and disseminating information; globalization of economic activities; consumerism and the drive for quality at an acceptable price (Reilly, 1996). In today's business world, if an organization makes a mistake, there is no time to catch it – other companies will be there to grab market share directly without doubt. The unpredictable nature of the workforce makes it imperative to think about the future, far from undermining workforce planning. Organizations need to be able to deal effectively with any rise or fall they may face.

In the study of Personnel Scheduling: A literature review, Van den Bergh, Belien, De Bruecker, Demeulemeester and De Boeck (2012) examined the papers with search phrases; workforce scheduling, personnel scheduling, staff scheduling and staffing having 291 articles

from many different sector and industries. The application areas of the articles and as can be seen there are only 5 articles about "retail" sector only 2% total articles. Enriching the literature with this study is another goal of this paper as well.

The second paragraph describes the studies done in the field of workforce requirement in terms of literature review.

Efficiency means, the good use of product, time and energy without wasting any (Dictinary Cambridge, 2019). In other words, efficiency is the relation between the output of the service, or the production compare to the inputs spend during the process. (Gürsoy B., 1998)In a mathematical model efficiency is the ratio of outputs over inputs.

The retail sector has around $24 trillion dollar all over the world (Deloitte, 2021). Hence, the biggest cost in the operation is the employee cost, even slightly increase in efficiency rate in the employee cost ratio can make the companies save money in the long run (McKinsey, 2017). In the grocery retail, the management of the operation is complex by itself due to unexpected events, different requirement for different departments and dynamic life of itself. Managing employees and having the right number of employees in the right time is the key success to have better sales revenues.

Having efficient manpower management becomes harder with parallel to complexity of the operation and sector. In the grocery retail, the operation is running every day, different hours and needed skilled employee for the specialized departments such as meat and fruit and vegetables. The number of employees needed through a day fluctuates due to number of customers, promotion rates and many other variables. Having a complex environment in the sector in terms of manpower planning, resulted few studies on workforce management models, requirement forecasting algorithm and shifts models in the literature.

Industrial revaluation kicked the idea of having systems more automated and efficient. Beginning of 1970s, many researchers focused on manpower scheduling and workforce requirement areas. Manpower requirement may vary from industry to industry even company to company due to way of doing business and company regulations. In the literature, there are many studies and number of articles in call centers, healthcare, manufacturing and other areas but scarce articles in grocery retailing. Managing manpower requires different classifications such as homogenous or heterogenous, part time or full time and skilled and non-skilled. (Valls et al, 2009)

The dynamic life in the retailers pushes the companies often hire temporary or part time employees. In general, part time and temporary employees are paid less. Especially in the season or in holidays, having mixture of full time, part time and temporary employees leverages the company to work with the efficient manpower planning and have satisfied customers. Kesevan, Staats and Gilland (2014) using two years data from 445 shops of a retailer find that having more share in the flexible labor source, has a U-shaped relation with the profit and the store sales.

Kabak, Akta, Ülengin, Topcu, and Ule, (2008) suggest a two-stage shift scheduling model, comprised of a sale driven function modelling hourly store revenue volume as a part of the conversion rate, number of shoppers and the average basket size and finding best solution for the shift schedules based on forecast of store traffic. Following Kabak, Ülengin, Akta, Topcu and Ule (2008) and Chapados, L'Ecuyer, Joliveau, and Rousseau (2014) model the number of employee needed for 15 minutes than the mostly used practice of a daily shifts, and consider the work status of each employee. Applying the model in a retail of medium size chain proves raise of in net profit of approximately between 2 to 3 percent relative to its current solution. Chuang, Perdikaki and Oliva (2016) changed the revenue response function model with a variable elasticity between labor and traffic, relaxing the constant elasticity assumption in the study of Kabak, Ülengin, Akta, Topcu and Ule.

Parisio and Jones (2015) propose a stochastic programming model and apply it to retailers in Switzerland. In the mid-day sudden requirement, store management may take advantage of cross-trained employees and dynamically can change the work department of these employees to multiple tasks. Terekhov and Beck (2009) study shows how to dynamically assign

a mix of cross-trained and specialized workers between different departments in the store. The objectives are to minimize the waiting time of the customer at the checkouts and making sure that other departments have sufficient employees to run the operation. In the different scenarios, Terekhov and Beck (2009) analyses optimal personnel structures and propose a threshold-based policy for allocation of dynamic labor.

Thompson (1995) proposed a model that takes into consideration a linear estimate of the marginal benefit of having additional employees, but not accounting for extra costs of employees. Lam, Vandenbosch & Pearce, (1998) and Perdikaki, Kesavan & Swaminathan (2012) have shown that sales are positively and causally related to level of staffing, therefore having a new aspect to staffing rules based on sales forecasts. Moreover, using a large retailer data set, Ton (2009) finds that increasing the workforce in the store is connected with an increase in profitability through its effect on conformance quality but, unexpectedly, not its impact on service quality. Mani, Kesavan & Swaminathan (2011) find systematic understanding during rush hours in a study with big retail chain, using a structural estimation technique to forecast the contribution of workforce to sales. In addition, in what is probably the most potent case to date for improving scheduling practices, Netessine, Fisher & Krishnan (2010) find| with a large retailer strong cross-sectional relation between workforce practices at different stores and basket values, and observe in their examples that even tiny improvements in workforce scheduling and schedule execution can result in a 3 percent sales increase without any cost.

The third paragraph describes the studies done in the field of scheduling in terms of literature review.

The effect of the globalization and requirement for better margins results most of the sectors growing rapidly and getting in extremely competitive environment. Therefore, companies look for the opportunities to cut down the costs. The employee cost is the one of the biggest costs in the companies and it is wise to act for that costs primarily. According to research called An Inside Look at the Hiring and Scheduling Crisis in the Hourly Workforce done by Workjam (2015) company with the help of more than 500 services managers and 700 full time employees while 39% of the managers are using paper schedules, 28% of the managers use spreadsheets to create weekly schedules. Other 33% either use scheduling tool or software. Paper schedules or spreadsheets methods cannot take the huge amount of data into consideration every time, they consume lots of time and error prone. In the background, it may cause inefficiency of workforce, inequality and injustice between employees and uncertainty for the future and many more unseen problems. Therefore, having a system-based scheduling system is a must for companies aiming to sustain and grow in their sector.

The employee scheduling problems has been addressed with different names in the literatures. These problems can be listed as; employee scheduling Ağralı (2017) with the solution method of mixed integer programing in service industries area; Parisio and Jones (2015) with the solution method of Stochastic Programming in retail outlet area; Brezulianu (2009) with the solution method of Genetic Algorithm in shopping center area; shift scheduling Al-Yakoob (2007) with the solution method of mixed integer programing in work center area; Brunner (2009) with the solution method of integer programming in healthcare system area; Bhulai (2008) with the solution method of iterative method in call center area; workforce scheduling Liao (2013) with the solution method of stochastic programming in call center area; Valls , Perez and Quintanilla, (2009) with the solution method of genetic algorithm in service center area staff scheduling; Soukour (2012) with the solution method of heuristic search; Zolfaghari (2009) with the solution method of genetic algorithm in retail sector. As described in the previous paragraph, workforce scheduling has different names and mathematical approaches in the literatures. The use of exact methods differs from the sectors to the need of the company as well. In this study a grocery retail company's cashier, stockers and butchers' departments are considered as a case study to demonstrate the proposed model for the scheduling.

Bard, Binici, and deSilva. (2003) states that the accelerating growth of the retail industry and the increasing cost of labor have led to refocus interest on personnel scheduling. Workforce management and planning are critical activities for businesses profitability and the customer satisfaction especially in the sectors where employees are directly in touch with the customers. Workforce scheduling areas include the health sector (nurse scheduling), the retail sector (market employee scheduling) and the production sector (worker and machine scheduling).

Scheduling models may change according to sectors, activity, and job-specific situations. So, analyzing and simplifying scheduling problems should be considered accordingly to the sector and the company. Four researchers in the operations research field analyses staff scheduling in six steps (Ernst, 2004); First step is, "Demand modeling": determining how many staff members are required at any given time. Second step is, "Days off scheduling": choosing patterns of working and rest days. Third step is, "Shift scheduling": choosing shifts to be worked and the number of employees per shift. Fourth step is "Line of work construction": designing sequences of shifts valid for an employee. Fifth step is "Task assignment": assigning activities to shifts and last step is "Staff assignment": assigning employees to shifts.

Jones and Nolde (2013) tell that non-efficient scheduling causes under-over planning in certain time periods through fluctuated customer number. From this point, Jones and Node develop a model for the Swiss market. Research based on weekly schedules. Every week, employee-specific constraints can be changed by store managers. Also, the objective of the model is minimizing the under-over planning while covering customer demand. The Swiss Migros is using this system in their mid-scale branches with 10 to 100 employees and they provide two types of constraints in terms of store and employee level. In the store-level, they are the minimum and the maximum number of employees, opening and closing time, etc. In the employee-level, they are the length of shifts, breaks, hired employee specific constraints, vacations - absences, etc. Their discrete time model includes not just time interval-periods also possible activities so employee specific constraints becoming more significant because of assignment priorities.

Lam, Vandenbosch and Pearce (1998) derived a simple, computer-aided scheduling method based on store traffic estimation. As the consumer response to the availability of the sales force can change over time, their methods evaluate this sales response function to maximize the retailer's profits. They view traffic as a sales opportunity, considering the active role that salespeople play in capturing this potential. Their work also evaluates customer shopping behavior and provides an economic analysis of sales force size.

Menezes, Kim and Huang (2006) developed a model efficiently manage the workforce in a group of retail stores, belongs to the same retail chain. In practice, employees of a same company geographical area are considered an indistinguishable pool, in which employees can be reallocated between stores to maximize the total profit of that region. Staff allocation problem dissolves within a series of stores to identify the most suitable workforce that each store needs on a weekly basis.

Pastor and Olivella (2008) proposed a two-stage procedure on the workforce management. In the first stage, a standard work schedule is assigned to each employee using a mixed integer linear program. In the second phase, these standard schedules are modified so that the minimum number of employees (60 minutes or 30 minutes) per term is met. Working hours during periods when initially required capacity is exceeded are eliminated or reassigned. Finally, if necessary and possible, the programs are expanded to meet the under planning. The results of the two-step procedure are compared with manually scheduling results by store managers.

According to Sauer and Schumann (2007) among the requirements of solving workforce scheduling problems are: The number of personnel must fit the demand, the qualification of the scheduled staff must fit the needs, the different types of contracts have to be regarded. Also, the legal regulations must be obeyed, e.g., Staff should not work longer than specified in contract,

staff should not work more than one shift per day, holidays must be regarded. Lastly, different shift models may occur (one, two, three shifts, etc.).

Various methods are used in modelling and planning scheduling problems, and these are simulation, mathematical modeling and manual planning. When using the simulation modeling method, a simulation-based analysis is performed, as stated in Kabak , Ülengin, Akta, Ule, and Topcu, (2008) considering the inadequacy of the calculations made by considering only the average demand, customer input and sales response error values are generated with the help of distribution functions that will be suitable for a simulation-based analysis. Simulations are used to verify the functionality of the sales response and to revise the simulation model for better output. Considering that distribution functions are used for customer arrivals and sales response error values in simulation, modeling with simulation will be a difficult factor in the absence of these functions.

The fourth paragraph describes the studies done in the field of scheduling in terms of literature review.

Time study methodology developed by F.W. Taylor in 19th century, in which he is the first person to use stopwatch to observe the work to define a fair day's work. In the literature, he is called the father of time studies with the "Taylor Shoveling Experiment". He observed among 400 and 600 men using their own shovels, which brought from home to haul materials from the mountains of coal, coke and iron ore yards about two miles long. Taylor spotted different sizes of shovels and wondered which shovel was the most efficient and practical. Therefore, he used a stopwatch device and measured everything the workers did. Saved the data for various shovel sizes for each job, the duration of the work, the number of breaks and the number of work hours. He figured out the best shovel model and increased the productivity and the results have been great, which has reduced time, saved workers and money for each year (Meyers Fred E., 1992).

In the time study measurement, there are four different techniques to observe the work. Stopwatch time study technique is the mostly used option, expert opinion standards, predetermined time standards and work sampling standards. Hendrich, Skierczynski, Chow and Lu (2008) used stopwatch technique to study spend time of nurses at hospital. Daniel (1996) used time studies in accident and emergency department.

Stopwatch time study technique is the work measurement approach to determine the current situation and having a baseline for future improvement. Time study stopwatch technique help on understanding each department daily work habit and work breakdown structure. Therefore, there are data about what percentage of work time a butcher spends on preparing meats for the shelves or what percentage of a work time a cashier spends on payment or a Stocker on changing price tags and so on.

The fifth paragraph is about research and data analysis methodologies and tools.

Through this research, observation and data analysis methodologies are linked to each other. In the study, time studies are carried for each department in different stores. The index of the operations may vary from day to day, shift to shift and even to store type. Therefore, to have a solid observation, the sufficient time study numbers for each observation of 8:30 hours for the departments has been done. Having observations for each department guided us in the mathematical approach. Data analysis methodologies are used to understand workforce requirement from sales data. Combining those two outputs helped on establishing an algorithm to forecast workforce requirement. Having manpower need of 30 minutes periods during the day efficiently guides the store to have better scheduling. In the Chapter IV, the store-based scheduling algorithm are established for each department. Having a final version of scheduling program, comparison with old methodology is done and benefits of using algorithm has been established in terms of key performance indicator of SER (Scheduling Efficiency Rate).

The departments have different work structures to be able to perform it is unique requirements. Therefore, each department have its own stopwatch time study guideline. The index of the table can change according to the trail stopwatch observations. Analyzing the current

situation, time study method has been applied. Time study is a structured process of directly observing and measuring human work using a timing device to establish the time required for completion of the work by a qualified worker when working at a defined level of performance.

The retail is, all about how well the company knows their customer and how effective they respond to customer' needs. The primer object of every retailer is to retain existing customer, attracting more and selling more to each customer. In order to be successful in these goals data analytics must be in the roots of the company's business model. The data analytics is used in many different areas such as improved customer experience, better strategic decisions, improvement in operational performance, cost reduction, demand prediction, forecasting trends and many other more. In the study, the data analytics will be used in terms of having better customer satisfaction through efficient and better service quality. In each department, data mining has been done in terms of to explore to relevant key performance indicators to the workforce requirement and scheduling algorithms. Filtering the relevant indicators, the data has used in different methodologies to find the best configuration for the optimal workforce planning.

In *data analysis and interpretation* there are many different approaches to satisfy the needs. Each methodology has its unique solving solution to satisfy the different need of a study. In the *mathematical models*, linear programming, goad programming and mixed integer programming models are intended to use. For data analytics tools R program, Microsoft Excel Program, SPSS Program, Python Program and CPLEX Program are intended to use. For high volume of data interpretation and data analysis Python program is needed. Therefore, for the study classes of python has been taken in May 2020 with certificates via Coursera online education platform from IBM company.

In the sixth paragraph, summaries and conclusion of the chapter has written:

- Workforce management is described by Reilly P. (1996) as "*A process in which an organization attempts to estimate the demand for labor and evaluate the size, nature and sources of supply which will be required to meet that demand*". The terms workforce management is improved itself from 1960s to present in the name of succession planning, human resource planning and manpower planning and finally workforce management.
- Organizations today need to plan their own survival in terms of workforce management while dealing with intense competition from home and abroad; labor market factors, recruitment and retention; speed of acquiring and disseminating information; globalization of economic activities; consumerism and the drive for quality at an acceptable price. Workforce management planning involves analyzing current workforce competencies, identifying future needed competencies, comparing the current workforce with future needs to identify competency under planning and over planning, and drawing up plans for the creation and evaluation of the required workforce.
- A literature review, Van den Bergh, Belien, De Bruecker, Demeulemeester and De Boeck (2012) examined the papers with search phrases; workforce scheduling, personnel scheduling, staff scheduling and staffing having 291 articles from many different sector and industries and only 5 articles 2% of the total is about retail sector and the other articles mostly focuses on health sector with nurses, banking sector with sales representative and factories with blue collar employees. This is one of the key motivators for this study to enrich the literature.
- Time study methodology developed by F.W. Taylor in 19^{th} century is a key approach to understand each department daily work habit and work breakdown structure thus, the work structure distribution percentage will be achieved in the jobs of Cashiers, Butchers and Stockers. The retail is, all about how well the company knows their customer and how effective they respond to customer' needs. The primer object of every retailer is to retain existing customer, attracting more and selling more to each customer. In order to be successful in these goals data analytics must be in the roots of the company's business model. In the study, the data analytics will be used in terms of having better customer satisfaction through efficient and better service quality.

- Only 33% of the managers use tools or software for the scheduling and rest of them mostly uses spreadsheets to keep track of the schedules (Workjam, 2015). Mathematical models and algorithms with the using models of mixed integer programming and software like Python and CPLEX will help to figure out workforce requirement and efficient & balanced scheduling. The retail sector has reached around $24 trillion dollar all around world by 2020 and biggest share of the expenditure comes from the employee cost. Managing the workforce management efficiently is crucial for company profitability rate and to be sustainable in the sector.

CHAPTER II. THE HISTORY OF GROCERY RETAIL SECTOR AND COMPANY OF MİGROS

The first paragraph describes global retail sectors, changes in the sectors and who are the key players and big companies.

The 2010s are the last decade that has really transformed the way of retailing operation with consumer habits, different technologies, and expectations shaping the industry. The consumers' approach to shopping may be a changed in many perceptions compare to how they did 10 years ago, but have retailers kept up with the change. The main street stores are different 10 years on, the expansion of e-commerce has brought significant opportunities and unknown threats to the sector. The brands who did not innovate, not get in a shape based on the customer desire are not any longer relevant for the savvy and smart millennium times consumer. Consumers have grown to expect personalization over the last decade, they are used to websites suggesting items based on their search history so in-store technology that allows this to happen. They want real recommendations that suit their personal preferences not as campaign or general suggestions. Personalization and service time is also critical in the online shopping as well. The omnichannel experience needs to be seamless, smooth and data needs to match up from the online to offline. Consumers expect right stock management so they can purchase products that are actually in stock. In the last decade, retail has changed, transformed and brands that have stayed successful have really needed to innovate, creating a seamless presence across online and offline platforms. In order to stay ahead of the game over the next 10 years, it is likely retailers has have to continue to innovate and must find new solutions and ways to please customers not just using a price option (Retail247, 2020). The coronavirus changed the market in unprecedented ways in 2020 and the momentum of change is still going. The evolving consumer expectations require grocery retailers to adopt new strategies to increase performance and pursue growth. The customers are worried about shopping from brick-and-mortar stores due to risk of Covid 19 viruses, thus many customers chose online shopping as a solution, where online shopping was not part of the lifestyle in the past. The offline shift to the online put a lot of pressure on the companies without having online operations, where it opens a big box of opportunities for the omnichannel and online retailers (Mckinsey, 2021).

The total industry had a major shrinkage in 2020, however e-commerce side of the industry got the once in a lifetime chance to prove itself and reached out many new records during pandemic, which were mostly targeted in five years or ten yeas projections. The global grocery retailing sector has around $22,5 trillion industry all over the world by 2020 and it has grown about 4,5% over the last decade. The brick-and-mortar or in-store shopping channels generated total of $18,5 trillion having 82% of the sales share. The value of e-commerce retail sales estimated to $6,5 trillion by 2024 with the increase rate of 62% in total. (Statista, Statista, 02.2021) . The global e-commerce retail sales grew 27,6% compare to 2019 with the effect of coronavirus pandemic. The globally e-commerce retail share expected to be 21,8% by the end of 2024 with the raise ratio of 21,2% with having fastest growing online retail markets in India, Spain and China (Statista, 04.2021).

The world's top 250 retailers have been grown by 4,4% in fiscal year of 2019. The 22,6% of total revenue have been aggregated in foreign operations (Deloitte, 2021). Although organizational retail percentage has a higher ratio in developed countries, in world vise retailing is a still rapidly

growing sector. The United States, Germany and England companies leads the way in the sector. Seven company out of first ten is from The United States. The top ten has 32,7% of the revenue from total in the top 250 companies. Wal-Mart is in the first place since 2001, however having online grocery options to customer life may change the way of business, such as Amazon is became second biggest retail in the world in 2019 pushing Costco Wholesale to the third place, whereas Amazon was it was 157th in 2001 (Deloitte, 2021). The minimum retail revenue required to be in the top list has been grown from $2,4 billion in 2001 to $4,0 billion in 2019. It has been almost doubled the value. It is a prove of retail sector fast growing pattern and hard competition by the years passes (Deloitte, 2021).

The developed countries have big players in their own market. They face with hard competition and work with low margins. That is the reason why many top retailers are focusing on investing less developed countries, whereas traditional retailers (small shops, local companies etc.) have higher market share. Having many top retailers investing in less developed countries moved to sector to Asia Pacific and Africa/Middle East countries in last decade. In 2006, the total share percentage of the revenue from these countries was 11%, where in 2016 with 5,9% increase, the share has been reached to 16,9% and steal from the European market (Europe Share 2006 39,4% – 2016 33,8%) (Deloitte, 2018).

The top 10 retailer revenue ratio in the top 250 has been increased in last years. It was 29,7% in 2014 (Deloitte, 2016) and each year by small percentage increase, it has become 32,7% by 2019 (Deloitte, 2021). This also shows, how big companies getting bigger by entering new countries and market, where pushes hard competition for smaller companies. In 2016, the net profit margin of top 250 was 3,2%. The increase in online operations and the force of technological change increased the competition, thus by 2017 the net profit margin decreased by 28% and become 2,3% (Deloitte, 2019). The top 10 company of the top 250 holds 32,7% of total revenue which was 30,1% in 2009 (Deloitte, 2011). Besides Kroger and CVS, all other 8 companies have operations in other countries. The top 10 lists comparison of 2009 and 2019 by ten years shows that, there are 5 news players in the 2019 lists with Amazon, Walgreens Boots Alliance, Aldi Group and CVS Health Corporation. This is another proof that the retail sector is very competitive and the ones, who cannot adopt to new changes and the customers new demands must fall in the list. The rising star of the list is Amazon coming from 35th place to 2nd in just 10 years having a total growth rate of 549%.

The second paragraph describes Turkish retail sectors, potential of the sector and the key companies.

The Republic of Turkey with almost 83 billion of mostly young generation has the 19th largest economy in the world. IMF has forecasted 2,2% GDP increase between 2020 and 2024 during slightly slowing economy (USDA Foreign Agricultural Service, 2020). The Turkish retail sector sales have 12% rate in the GDP of 2018 and 62% of the retail sales come from food retail sector. The sector reached around 900 billion TL (Turkish Lira) by 2018. Last 5 years the sector growth was 9% and it is almost two times bigger than country growth rate (PWC, 2018). The retail sector is the one of the biggest engines for the Turkish economy by employing over 1,9 million and expected to grow more and more with the investment of organized retail companies to each city in Turkey (The Business Year, 2019). The transaction from traditional retailing to organizational retailing is going rapidly with the help of shopping malls. First time the total number of malls remained same with the previous year, which is interpreted by the specialist reaching to full saturation in the country. Having coronavirus pandemic and customers be afraid of the being in the crowed places bring a big question mark about the future of the shopping malls (KMPG, 2020).

Well-developed countries have much higher share of organized retailing compare to Turkey. In England, the top 5 grocery retail group holds the 70% of market share of the sector (USDA Foreign Agricultural Service, 2018). In Germany, being the largest economy in the Europe and 4th biggest economy in the world has 72% share of organized retail in the sector

(USDA Foreign Agricultural Service, 2019). In France, the organized retail ratio is 75% (USDA Foreign Agricultural Service, 2019). The well-developed countries have at least 70% organized retailing percentage rate in the sector. Turkish organized retailing companies holds only 47,2% of the sales of the sector by 2019. Turkey's low percentage rate compering to European countries shows, the industry of food retailing has big opportunity and room for improvement for future. The world's one of biggest retail Amazon has started their own operation by end of 2018, where another big retailer AliBaba has invested in Trendyol (one of the biggest online retailer) by the same time. Having two big companies investing on the retail sector is another proof of promising investment for the futures.

Geopolitical instability, relations between countries fluctuating atmosphere and growing power of local and universal competition in emerging markets are forcing multinational retailers to think nonstop about and reshaping their strategies. The study done by AT Kearney company, shows the potential countries in terms on investment for retail sector and in the list, Turkey is in the fourth place after India, China and Malaysia.

There are core factors which makes Turkey's retail environment attractive to the multinational retailers. Having added 1 million of square meters of modern retail in past year made the third highest absolute increase among the list. Having young generation and higher population rate with 1,6% compare to others with 1,1%. 73% of the population lives in the urban areas and 16,5% of the people are between ages of 15 to 24. The discounter's companies BİM, A101 and ŞOK opens nearly 2000 stores each year. The local retailers are getting strong in the sector, however the sector has not reached it potential and e-commerce, m-commerce shopping models are promising in terms of new potential in the sector (ATkearney, 2019).

SWOT analysis of Turkish Retail Sector

● **Strengths:** big market, high and resilient demand; long term GDP and disposable income growth; large population base: young and growing; progress power of organized retail; company and crisis management experience; the appetite for digitization and the drive to be a pioneer; strong infrastructure in logistics; production power of the industry in certain segments; the strength of the agricultural production industry.

● **Opportunities:** the e-commerce and m-commerce demand supported by the young population and large area expansion potential, with the start of the economic recovery process, feeling of meeting the delayed demand, the disappearance of borders with technological breakthroughs and entrance possibility to the new markets, foreign customers supported by depreciating TL "shopping tours", investment appetite for the global arena.

● **Weakness:** domestic and international political challenges, economic instabilities such as exchange rate and inflation fluctuations, decrease in purchasing power of local customers, macroeconomic risks created by geopolitical uncertainties, increase in the overall level of costs as the field narrows the playing field of the local grocery stores.

● **Threats:** the disappearance of borders with technological breakthroughs and the inclusion of new foreign players in the competition, deterioration in the financial structure of the sector and decrease in borrowing ability, geopolitical tensions prevent shopping tourism, the weight given to technology reaches dimensions that operational processes cannot handle, decrease in profit rates, with the growth in e-commerce, the decrease in the growth in the conventional field leads to pressure on profits, presence of repetitive investments in the shopping mall area that has reached saturation.

In Turkey, the sector of grocery retailing has change it is structure in the last decades. The sector was dominated by supermarket and hypermarkets before 2000s years, after having BIM as a discount grocery model in beginning 2000s years, other companies like A101 and ŞOK followed the trend with discount model. In last 5 years, sector is now having new players in online grocery companies like Getir or Banabi, which have no brick-and-mortar stores for the

customers. Although the leaders are still from discount formats mostly, the arrival of e-commerce should not be avoided especially with after coronavirus pandemic.

Table 1. Last 5 Years Store Number Changes of Top 5 Turkish Retailers

The company Name	2016	2017	2018	2019	2020	Change ('20-'19)	Change ('20-'16)
A101	6.300	7.100	8.100	9.000	10.001	11%	59%
BİM	5.602	6.765	7.478	8.152	8.340	2%	49%
ŞOK	4.364	5.364	6.264	7.003	8.143	16%	87%
Migros	1.566	1.858	2.059	2.131	2.289	7%	46%
CarrefourSA	565	625	596	640	692	8%	22%
Top 5 Total	18.397	21.712	24.497	26.926	29.465	9%	60%
New Stores		3.315	2.785	2.429	2.539		

In terms of store number discount retailer A101 is leading the way with 10001 store and has a coverage of every district of Turkey. Although BİM has the second place, it is mostly focusing on new supermarket format File and operations in the out of home country. ŞOK has the highest growth in last five years with 87% and it is expansion is moving nearly 15% of each year. Migros is a supermarket driven company, therefore their new stores numbers are not as many as discount formats. CarrefourSA is also a supermarket driven and having a procedure of reshaping the company in terms of the new necessities of retail sector needs. The top 5 retailers add more than 2500 stores to the ecosystem each year, raising the organizational retail percentage in total. Having coronavirus pandemic and demand on e-commerce and m-commerce impact might change the speed of having new stores (See Table 1).

The third paragraph describes the company of Migros and its operations structures.

In the face of growing population of istanbul and increasing price gap, İstanbul Municipality took a historic decision in 1954 and established an organization in Turkey like Switzerland Migros. Thus, it became possible to present food and necessities to the public at the most affordable price and quality under municipal control. The mobile vending trucks of Migros, which travel from district to district, brought the needs of the people to their home.

In 1975, upon its founder Vehbi Koç's request, Koç Holding Company, Turkey's one of the most important groups, acquired most of Migros' shares and so began the quick process of retailing that would embrace all customers in Turkey over the years, starting from Migros İstanbul. Migros, by opening a giant central warehouse established the necessary infrastructure for a health distribution through its fruit and vegetable purchasing offices so that products can reach to customers fresh and economically. In 1991 Migros became the first publicly traded company in retail. Having investments for increasing great merchandising MM and MMM stores. In 2004, Migros is celebrating its 50th anniversary. Opening the first store in the southeast in Diyarbakır, strengthening its presence in the Black Sea and Southeast of Turkey. Merging the Aegean based retailer Tanşaş, Migros reached 722 stores in the country. Merger of Tanşaş and Migros, it was an important development for the Turkish retail industry in terms of both financial size, geographical coverage, customer volume and human resources dimension. In 2008, Migros continued to tie worldwide with 5 stores per week, reached 1,191 stores. It was transferred to Moonlight Perakendecilik ve Ticaret A.Ş. from Koç Holding Migros ranked 236th in the first time in Global Power of Retail 2009 report, prepared by Deloitte regularly every year. In had the 190th rank in 2010's report and rank 12th among the 50 fastest growing companies between 2002-2007.

Anadolu Holding, which is also one of the Turkey's important and leading holding, took over the 40,25% of the Migros shares.

In 2016, Migros group acquired TazeDirekt, the online shopping brand for natural foods with giving service of even more powerfully under the strong infrastructure and service quality of Macrocenter. Migros reaches a new milestone in its growth journey in the Turkish retail business with buying Tesco Kipa shopping malls and the stores of Tesco in same year. The

acquisition let Migros acquired an additional net sales area of 320.000 m2 including 48 hypermarket, 48 supermarkets, 72 express stores and 26 shopping malls into its ecosystem. Migros has also become one of Turkey's biggest shopping mall investors with total of 30 shopping malls. In 2019, Migros launched Migros Hemen, an online grocery application that bring products to the customers home within 30 minutes. Widespread in many cities in Turkey, Migros Hemen offers more than 2,000 products to customers with Migros prices.

Migros provided uninterrupted service to its customer by keeping the safety of its employees and customers at top of their priories during the coronavirus pandemic in 2020. In this extraordinary period, Migros has made an important contribution to the country's economy by creating 10,000 additional jobs to meet the increasing customer demand and reduce the workload of its employee. In such an uncertain environment, Migros has created a more agile and resilient infrastructure, which has been growing strong for many years by increasing its mobility. During this period, many innovations were also implemented. These innovations have initiated new services that the customers will seek today and tomorrow, while meeting their need through all channels under the current pandemic conditions. During this challenging period, Migros went a few steps beyond digitalization and introduced M Kolay which allows payment in 30 second at the jet cashier tracking fruit and vegetables with Blockchain 24/7 serf service and Money Pay where customers can perform their financial transactions such as payment and quick money transfers easily and securely through the application.

Migros has accelerated its sales through investments in online channels in 2020 and its ability to quickly adapt to pandemic conditions. E-commerce has triple its volume in 2020. The number of orders in Migros Hemen increased 18 times compared to last year. The 13,5 million of active users of Money loyalty card in 2020. Money Card continues to be Turkey's biggest loyalty program. 1 million new members joined the Money Loyalty Program in the last year alone. In addition, while investment in brick-and-mortar store, the number of stores in 81 provinces exceeds 2,300 with 183 new stores opened in during the year with more than 35,000 employees (Migros, 2021).

Turkey biggest loyalty program "Migros Club" reaches millions of Turkish citizens therefore, to be able satisfy all the customer needs Migros is operating stores in different formats according to customer segmentation and location characteristics. There are mainly four different formats and the e-commerce channels of the company.

Supermarkets have small size stores (Mjet-M), very close to urban life, sales area around 40-800 m^2, have and less than 15 employees per store. Medium size stores (MMM-MM) located in centers of the city with sales area of 800-3500 $m^{2\ and}$ less than 45 employees per store. Supermarket of MM and MMM have service departments like meat, delicatessen, fruit and some may have fish and bakery to fulfill the customers all need in terms of food requirement. Mjet and M have much less products to compare to MM-MMM, because they are focused on primarily needed products and located closer to urban life. Their aim mostly competes with the discount store competitors. Supermarket owns the 79% of the total store number, there are Supermarkets in each city of Turkey, therefore you could see Migros stores all over the country.

Hypermarkets have more than 2.500 m^2 sales are and more than 50 employees per store. They are operating 19 cities of Turkey. They have around at least 35000 stock keeping unit with food and nonfood products. After acquisition of Kipa from Tesco, Migros became the company of most owned shopping mall. This let the increase of hypermarkets in the company. Besides service section in MM-MMM, hypermarkets also have food section and places called family club, where Migros employee with local teachers give lectures of cooking, English class, Pilates, guitar courses to develop the local and be beneficial to the own customer. There are 55 stores of hypermarkets holding 17% share of the total store number.

Macrocenter is a high segment class format which have mostly imported products in it is portfolio. It is operating in 7 cities of Turkey. It has total of 64 stores mostly located in big

cities and vacation locations. Wholesales format has 23 stores and mostly focused on bulk shopping customers or people with small restaurant and companies. It is operation 16 cities of Turkey. Migros SanalMarket established in 1997 being first e-commerce company in the grocery retailing. By 2021 operating in more than 500 stores SanalMarket offers service in all cities of Turkey with the same price as in the brick-and-mortar stores. TazeDirekt is an e-commerce channel of basically focuses on mostly fresh and natural products. It gives services 5 big cities of Turkey making sure that customers get natural fresh products for their home. Migros Hemen is a m-commerce channel of Migros, focuses on delivery the products in 30 minutes to customers. IT has more than 2000 products in its portfolio and mostly focuses on fundamental needs of the customers. The company increased the number of stores by 63% in last five years with organic and inorganic, in 2018 Kipa acquisition, growth. The trend was opening stores with smaller m2 and closer to customers, therefore most of the growth comes from Mjet and M formats (See Table 2).

Table 2. The Migros Total Number of Stores in Lat 5 Years

Formats	2016	2017	2018	2019	2020
Macrocenter	38	45	52	59	65
Supermarket	1.293	1.461	1.779	1.967	2.147
Hypermarket	19	21	54	54	55
Wholesales	13	15	18	20	22
Total	**1.363**	**1.542**	**1.903**	**2.100**	**2.289**

Migros manages in-store operations differently based on the format of the store. In basic, there are management, service employees, stockers and cashiers. In Mjet format, there are management department includes white collar employees and there are sales employees who are responsible of both cashiers and stockers duties. Having averagely 5 employee per store pushed the operation to work in multitask operation. The organizational chart basic and lean in this format. In MM and some of M formats have meat, delicatessen and fruit&vegetable department in the store to give customer more variety in terms of products. Therefore, there are butchers, delicatessen employees and fruit&vegetable merchandizers besides cashiers, stockers and the management. In some of the MMM and Hypermarkets there are nuts, fish and food sections depend on size and the sales volume of the store. MMM and Hypermarkets are the biggest stores in term of store size, therefore it tries to give service in terms of all needs of customers with food and nonfood products. Macrocenter is mostly same as with MM formats only in addition it has an appetizer department due to be a service-based format. The departments of Fruit&vegetable, delicatessen and meat offers more variety to the customers especially with the imported products.

In the fourth paragraph, summaries and conclusion of the chapter has written:

- The 2010s are the last decade that has really transformed the way of retailing operation with consumer habits, different technologies, sector initiatives and expectations shaping the industry. The grocery retailing is a critical sector in terms of people life therefore retailers always kept up with the change to sustain in the environment.
- The coronavirus changed the market in unprecedented ways in 2020 and the momentum of change is still going. The evolving consumer expectations require grocery retailers to adopt new strategies to increase performance and pursue growth. The total industry had a major shrinkage in 2020, however e-commerce side of the industry got the once in a lifetime chance to prove itself and reached out many new records during pandemic, which were mostly targeted in five years or ten yeas projections. E-commerce and m-commerce channels grew 27,6% in 2020, where expectation was around 6-7%. The companies investing on online and having efficiency project will be the winner of this decade on the other side companies with no e-commerce or m-commerce channel having troubles.

- The world's top 250 retailers have been grown by 4,4% in fiscal year of 2019. The 22,6% of total revenue have been aggregated in foreign operations (Deloitte, 2021). The United States, Germany and England companies leads the way in the sector. Seven company out of first ten is from The United States. The top ten has 32,7% of the revenue from total in the top 250 companies. The Turkish retail sector sales have 12% rate in the GDP of 2018 and 62% of the retail sales come from food retail sector. The sector reached around 900 billion TL (Turkish Lira) by 2018. Last 5 years the sector growth was 9% and it is almost two times bigger than country growth rate (PWC, 2018). The retail sector is the one of the biggest engines for the Turkish economy by employing over 1,9 million and expected to grow more and more with the investment of organized retail companies to each city in Turkey (The Business Year, 2019).
- Although the transaction from traditional retailing to organizational retailing is going rapidly with the help of shopping malls; the Turkish organizational share is 47,2% and way far low than the developed countries (has more than 70% organizational share), which opens the Turkish market for new opportunities for the investors.
- The world's one of biggest retail Amazon has started their own operation by end of 2018, where another big retailer AliBaba has invested in Trendyol (one of the biggest online retailer) by the same time. Having two big companies investing on the retail sector is another proof of promising investment for the futures.
- In Turkey, the sector was dominated by supermarket and hypermarkets before 2000s years, after having BIM as a discount grocery model in beginning 2000s years, other companies like A101 and ŞOK followed the trend with discount model. In last 5 years, sector is now having new players in online grocery companies like Getir or Banabi, which have no brick-and-mortar stores for the customers. Although the leaders are still from discount formats mostly, the arrival of e-commerce should not be avoided especially with after coronavirus pandemic. BIM and A101 is in the top 250 retailers of the world list in 2019, A101 is also in the fastest growth 50 list. Getir, Banabi and other digitally based grocery retailer companies are racing with sector leaders and peer rival companies to have a bigger share from the sector's profit.
- Migros is the oldest company in the sector and to sustain its leadership again in the sector expanding its operation in both online and offline platforms with new initiatives for customers to be able to give the best customers experiences.

CHAPTER III. DESIGN OF DEPARTMENT BASED WORKFORCE REQUIREMENT ALGORITHMS

The first paragraph indicates the important of having workforce management systems in the companies because through the years, human resources department has checked and controlled the labor costs, however, need of workforce and its distribution to departments mostly decided by store managements. In grocery stores, the life is dynamic due to a rival company's power nearby, municipal road excavation decisions, seasonal effects, location properties or even weather conditions of the area and many other variables. There has been a belief that, store management knows most of the variables, therefore they would do best schedules for the need of the store. The scheduling progress mostly done in weekly intervals, the complexity is high, and it is time consuming for the managements. Considering it is a human made output, there is a high chance of finding errors about the schedules and even it may not be fair in terms of equality in the scheduling for the employees. In the workforce management systems planning data driven perspectives leverages companies in terms of efficiency and lower the time consume of managements' time spends the scheduling.

The output of the chapter is to establish algorithms for each department of cashiers, stockers and the butchers within 30 minutes periods. Having workforce requirement for each period helps scheduling algorithm to be more accurate. Achieving such as purpose, the time studies has been run for each department in different days and formats to capture the nature of

the work. Each work structure of the jobs is analyzed and the work structures distribution in a shift and it is connection to the sales with the data analysis methodology helped to establish an algorithm for each department.

The second paragraph explains the guideline to achieve workforce requirement algorithms on cashiers. Cashiers are the one of the most important employees in the retail sector, because the speed of customer circulation depends on how good they perform in the cash register. Therefore, it is very important to have the right number of employees in the right time. Employee of cash register, whom is responsible to facilitate money transactions for customers by using a cash register. They ring up sales by accepting cash, cheques, coupons, debit or credit.

Analyzing job responsibilities and having a meeting with store manager and couple of cashiers, the cashier work structure breakdown's details and the time study charts prepared.

Time study is a structured process of directly observing and measuring employee work using a timing device to know the precisely time required for completion of the work by an average worker when working at a defined level of performance and it is a necessity in terms of to comprehend a job responsibilities.

Time study measurements have been conducted in 6 different shops with 7 different employees on different days and shift hours observing 60 hours of working time with questioning if the procedure of the cashiers differs for the sub-formats and shifts. From the basic task of an employee to a whole day's total workload, every single step of an employee is tracked and noted.

Cashier work structure breakdown's are Break (B), Idle (I), Multitask Operation (MTO), Receiving Money/Invoice and Checking the amount (ACD), Filing up Cash Reconciliation Form (GCD), Talk with Customer (TC), Scanning Products (SI), Payment (P), Bagging Groceries (BG), Void Time (VT), Business Talk (BT) and Walk (W) total of 12.

Time study guideline with 7 observation helped to understand the current system and the percentage of the task's distribution through a day. Each task's contribution to daily workload has been calculated. For example, on September 19th time study "SI – Scanning Products" has total of 13722 seconds over 29832 seconds. It means that; SI was covering the 13722/29832 = 0,459 = 45,9% of that shift. In Figure 1, every time study is evaluated and the percentage of each task to over total workload has been calculated and finalized.

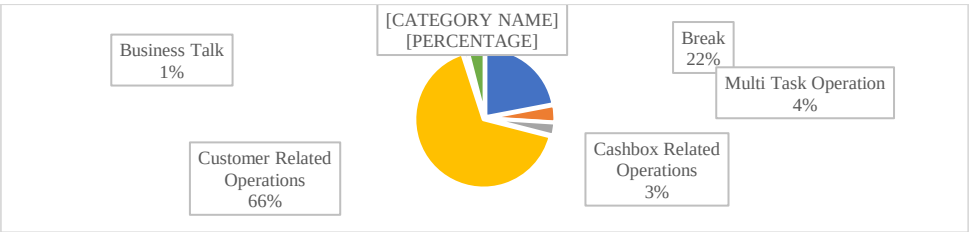

Figure 1. Results of the Cashiers' Time Studies

According to the time study results; the multitask operations are observed mostly in the small size shops, which are operated under either M or MM formats. The idle time percentage is almost 4% of the work time. The total break time of 22% is contain 18% lunch and tea break and 4% of idle time. Each employee has one hour of lunch break and two times of fifteen minutes tea break during in a working day, which makes (1,5 hours / 8,5 hours) 17,6% of their time counted in break. The idle time mainly occurs because mandatory 8:30 hours shifts and mostly in the morning shifts and due to cigarette breaks. Payment methodology changes the customer service time.

Scan time differs according to product's category (If it is a fruit and vegetable, the system must calculate the weight before pricing, or if it is a cigarette then cashier must stand up and reach to the cigarette box to have the product). The breaks are used according to the customer density and not planned before. Cashiers spend 3% of their time in the cashbox related

operations, in which each employee must count the cash, checks and coupons both in the beginning of the shift and the end of the shift to make sure there is no any mistakes.

In the retail companies, sales data is a big asset for the company. Many different analyses can be done from it. In this work, the sales data broke into many different components to be able to verify the need of workforce requirement.

In grocery stores, there are fluctuation in the manpower need in the holidays, weekends even in the normal days because of customers shopping time is not distributed homogeneous. Therefore, working time should be flexible and should be planned according to the customers' density in the store and workforce requirement algorithm should be design for the store based to accomplish the best success rate.

Sales data of one month of a store has been taken from the company's IT department to start on working in the algorithm. The sample data had 15 different KPI's for making an algorithm having transaction beginning and ending time, item scan time, item category and payment time and so on. The value of these variables is used to forecast the manpower needs of cashiers in each date period of 30 minutes. The data is evaluated with the help of Python program due to high amount of data and the flexibility which provided by the program.

The Steps of Cashier Requirement Algorithm

Step 1 – The dataset is manipulated in terms of to get the right results, therefore the cask desk type of "Self-Cash Desk" removed from the dataset, because it is operated by the customer.

Step 2 – The scan time of a product is calculated by the time difference between previous product scan time and current product scan time.

By doing so; for each receipt, products' scan time has been calculated. Hence, first transaction order might include customers other action (such as handing loyalty card, conversation or so on) and there is no previous scanning movement, therefore every first order in each receipt has been excluded. (See Figure 2)

tore_ID	Store_Name	Transaction_Beginning_Time	Transaction_Ending_Time	Receipt_No	Cash_Desk_Number	Transaction_Order	Transaction_id	scan_time
1747	ANADOLU HİSARI MMM MİGROS	1900-01-01 09:03:16	1900-01-01 09:04:18	1426	2	2	43770174702142602	00:00:04
1747	ANADOLU HİSARI MMM MİGROS	1900-01-01 09:03:16	1900-01-01 09:04:18	1426	2	3	43770174702142603	00:00:05
1747	ANADOLU HİSARI MMM	1900-01-01 09:03:16	1900-01-01 09:04:18	1426	2	4	43770174702142604	00:00:01

Figure 2. Finding Each Product Scan Time

Step 3 – Each product has it is own main category. Having enough data to analyze, the average scan time per category found and is used in the forecasting algorithm.

The Figure 3 shows, average scan time of categories calculated from 84867 products scan time.

MAIN_CATEGORY	final_scan_time
FMCG (FAST MOVING CONSUMER GOODS)	2.506944
DELICATESSEN	3.158070
MEAT	3.500000
ALCOHOL AND BEVERAGES	4.100000
NON FOOD PRODUCTS	4.260869
FRUIT AND VEGETABLES	4.648660
OTHERS	10.117647
TOBACCO	23.500000

Figure 3. Average Scan Time of Categories

Step 4 – Each transaction time is total time of scan time and customer time. In step 3, average main category scan time has been found by the store. Reaching for the customer time, the total

scan time should be subtracted from the total transactions time. By doing so, firstly the average scan time to each transactions' first order is inserted. (In Step 2, first order of product was excluded for reaching correct average scan time. The step 4 is putting back the data into the calculation) By python coding, this step run by successfully.

	Store_ID	Store_Name	Receipt_No	Cash_Desk_Number	Transaction_Order	Transaction_id	MAIN_CATEGORY	final_scan_time
0	1747	ANADOLU HİSARI MMM MİGROS	1426	2	1	43770174702142601	DELICATESSEN	3.238461
1	1747	ANADOLU HİSARI MMM MİGROS	1426	2	2	43770174702142602	DELICATESSEN	4.000000
2	1747	ANADOLU HİSARI MMM MİGROS	1426	2	3	43770174702142603	DELICATESSEN	5.000000
3	1747	ANADOLU HİSARI MMM MİGROS	1426	2	4	43770174702142604	DELICATESSEN	1.000000
4	1747	ANADOLU HİSARI MMM MİGROS	1426	2	5	43770174702142605	FMCG (FAST MOVING CONSUMER GOODS)	5.000000

Figure 4. Adding Average Scan Time to the First Transaction of Each Order

As shown in the Figure 4 the transaction id of "43370174702142601" is member of delicatessen group, therefore 3,23 second of group average is used for the first transaction order.
Step 5 – Having scan time for all the products, it is time for the customer time to be measured. Therefore, for each transaction sum of scan times should be calculated and subtracted from the total time.

Store_Name	Receipt_No	Cash_Desk_Number	Transaction_Order	Transaction_id	MAIN_CATEGORY	final_scan_time	sum_of_scan_time	Transaction_Time
ANADOLU HİSARI MMM MİGROS	1426	2	1	43770174702142601	DELICATESSEN	3.238461	18.238461	62.0
ANADOLU HİSARI MMM MİGROS	1426	2	2	43770174702142602	DELICATESSEN	4.000000	18.238461	62.0
ANADOLU HİSARI MMM MİGROS	1426	2	3	43770174702142603	DELICATESSEN	5.000000	18.238461	62.0
ANADOLU HİSARI MMM MİGROS	1426	2	4	43770174702142604	DELICATESSEN	1.000000	18.238461	62.0
ANADOLU HİSARI MMM MİGROS	1426	2	5	43770174702142605	FMCG (FAST MOVING CONSUMER GOODS)	5.000000	18.238461	62.0

Figure 5. Calculating Total Scan Time of Each Order

In the example: The receipt no of "1426" has total scan time of 5 products is 18,23 seconds. The total transaction time is known by the time difference of transaction beginning time and transaction ending time. As the example the customer time can be found by subtracting sum of scan time from transaction time total of 49,17 second of customer time for this example. (See Figure 5)
Step 6 – Customer time is calculated for each transaction in terms of having average time for each cash and credit card payment.

Payment_Type	customer_time
ENTEGRE ORTAK POS	39.798190
NAKİT	14.842832

Figure 6. Average Payment Time of Cash and Credit Card

The Figure 6 shows, the customers pay their shopping with cash (nakit) spend 14,8 seconds whereas they spend 39,8 seconds if they pay with the credit card (entegre ortak pos).

So far, the achievement of finding an products average scan time per main category and a customer transaction time based on the payment type is successfully completed. In the second phase, firstly the amount of sold products in category based per 30 minutes has been examined based on the daily sales data.

Second step is to have 29th of November forecasted data, the last four-week data has been examined and calculated the arithmetic mean of last four weeks of Monday data.

Third Step, finding average total sales of Monday's of last four weeks and compare it to the 29th of sales department's forecasted sales volume to find the percentage difference for able to use in the workforce requirement algorithm.

Each last week of a month, Department of Sales forecasts the daily sales of next month with the help of Regional Sales Managers and then keep track of the performance according to the forecast. The forecast sales for 29th of November are 165.000 Turkish Lira (TL).

Fourth step is to find percentage difference between forecasted data and the average sales.

$$165.000 / 156.833 = 1{,}0520\% \rightarrow 5{,}2\%$$

Forecasting 29th of November, the average number of products from the last four weeks of Monday should be increased by 5,2% ratio.

Fifth step is to forecast number of products will sell in each time period.

Figure 3 has the average scan time of the categories and we have the forecasted number of products forecasted to sold in 30 minutes time interval. Multiplying the number of forecasted products to the average scan time give the total amount to scan the products on the cash desk. For example; the calculation for total scan time needed between time slot of 10:00 to 10:30 can be found in the Table 3 By this calculation each workforce requirement per time slot can be found. However, since it will only have the total scanning time, it is necessary to calculate customer time as well.

Table 3. Example of Total Scan Time Calculation

Total Scan Time Calculation for 29th of November for 10:00 - 10:30			
Categories	Number of Products	Average Scan Time	Total Time in Second
TOBACCO	10	23,50	235
DELICATESSEN	121	3,15	381
FMCG	96	2,51	241
ALCOHOL AND BEVERAGES	21	4,10	86
FRUIT AND VEGETABLES	96	4,64	445
NON-FOOD PRODUCTS	19	4,26	81
MEAT	9	3,50	32
OTHERS	28	10,11	283
Grand Total	**400**		**1.784**

Customer time in the transaction changes according to the payment style. (Figure 6. Average Payment Time of Cash and Credit Card) shows that a customer spends in average 39,8 seconds per credit card payment, whereas cash payment is 14,9 seconds. Therefore, it is a necessity to find the number of customer and percentage of payment type per time slot to calculate the total need of cashiers. The customer, who are using self-check out tills did not take into consideration calculation.

The ratio of forecasted sales to last four weeks average data was 5,6%, as explained in early steps. Therefore, finding forecasted customer number for 29th of November, the data in the Table 4 should be by multiply by 5,6%.

Table 4. Forecasting Average Number of Customer for 29th of November

Payment Type	09:00	09:30	10:00	…..	20:30	21:00	21:30	Total
Cash	5	6	10	…..	12	13	15	371
Credit Card	10	10	14	…..	21	19	17	668
Total Number of Customer	**15**	**16**	**24**	**…..**	**33**	**32**	**32**	**1039**

The time needed per time slot for a customer service can be found by multiplying customers with cash payment with 14,8 seconds and customers with credit card payment 39,8 seconds as described in Figure 6. For example, the workforce needs for 09:30 and 10:00 for customer service is:

6 cash payment X (14.8 Sec) + 10 Credit card payment X (39.8) = 487 Sec

Finalizing the cashier requirement per time slot time the time needed for scanning and customer service should be sum together. Knowing that cashiers spends 66,6% of their time in the cash related operations from the time studies. The total time should be increased by the ratio to include the such as breaks, business talk and walking work structures to be able to forecast the need precisely.

Table 5. Number of Cashier Needed on 29th of November in Capitol Store

Categories	09:00	09:30	10:00	10:30	…..	21:00	21:30	Total
Total Time Need for Scanning Products Seconds	881	1.252	1.648	2.145	…..	2.020	1.588	72.888
Total Time Need for Customer Service	472	487	705	924	…..	949	899	32.077
Total Time Need in Minutes	23	29	39	51	…..	49	41	1.749
Total Workforce Requirement (66%) in Minutes	34	44	59	77	…..	75	63	2.651
Full Time Workforce Requirement	2	2	2	3	…..	3	3	103
Fingerprint Data	2	2	3	3	…..	2	2	110
Difference Between Actual and Forecast	**0**	**0**	**1**	**0**	**…..**	**-1**	**-1**	**7**

As an example, in Capitol store between 09:30 – 09:59 44 minutes of total workforce requirement needed. Hence, one person can work 30 minutes in a thirty minutes slot only, therefore the store needs at least 2 people to cover the work. Even though there is extra of 14 minutes of total work, the algorithm rounds up the requirement to fulfill for the customer satisfaction. Since, the company uses fingerprint system the comparison can be done between actual data and the workforce requirement data. The result of fingerprint data has 7 slots (3:30 hours) more than the forecasted requirement in total. Viewing data in slot base, 11 slots have over planning, and 9 slots have under planning with the fingerprint data. Hence, this result does not have the scheduling algorithm and it does not take into consideration of country workforce regulations and company polices it would not propose a result in terms of efficiency. The Scheduling problem has into consideration in the Chapter IV of the dissertation and efficiency scale is examined and discussed based on the requirements (See Table 5).

Analyzing the data with the support of the time studies leveraged us to be able to forecast how many employees is be needed in any given 30 minutes period of the store. The literature has benefited with the new aspect of a cashier requirement algorithm. The company can manage flexible working hours in scheduling which will be more detailed in the Chapter IV of the dissertation.

The third paragraph explains the guideline to achieve workforce requirement algorithms on stockers. In the food retail store, Stockers are the key employees to run the store in a smooth operation due to most of the sold products are belong to Stockers category to coordinate and decide in terms of replenishment, stock management and giving new order for the products.

A Stocker is someone who's managing products inventory on the shelves and storehouse for leaving no room for stock outs. S/he is responsible of shelves layout and applying company

policies on how products should be displayed to maximize sales, controlling and changing the price tags of the products and making sure there are not out of date product on the shelves.

Analyzing job responsibilities and getting feedback from store management and stockers themselves, time study guideline and work structure breakdowns created to run time studies for understanding all aspects of the operation of stockers.

Time studies run for 13 different shops with 20 different employees on different days and shift hours containing 170 hours of in-store observations to find needed workload in every period and schedule the Stockers according to workforce demand according to the data. Time study solution approach covers all problematic behaviors in the stores related to employees, managers, customers and even operation itself. From the basic task of an employee to a whole day's total workload, every single step of an employee is tracked.

Stocker work structure breakdown's details and the time study charts are in the tables below and 18 different work structures as follow; Break (B), Idle (I), Multitask Operation (MTO), Good Receiving (GR), Product Order (PO), Expiration Date Control (EDC), Storehouse Organization (SO), Price Tag Control (PTC), Price Tag Print (PTP), Price Tag Change (PTCh), Product Load in from Storehouse (PLS), Carry (C), Product Replenishment to the Shelves (PR), Face Correction (FC), Talk with Customer (TC), Business Talk (BT), Walk (W), Other (Ot).

Time study guideline with 20 observation helped to understand the current system and the percentage of the task's distribution through a day.

In Figure 7, every time study is evaluated and the percentage of each task to over total workload has been calculated and finalized.

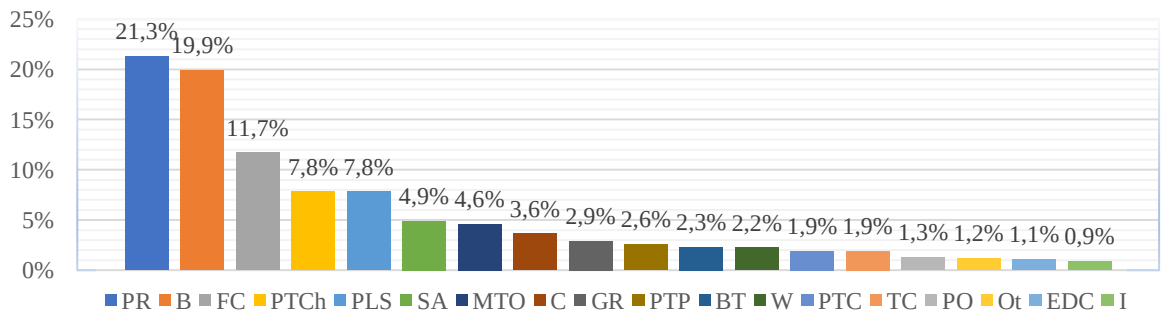

Figure 7. Percentage of Work Structures from 20 Observations of Stockers

Product Replenishment to the shelves has the highest time consumed (21,3%) work in an average shift of the stocker. Approximately a stocker spends one fifth of his/her time for this operation need of store. Second highest work structure is Break. In the company policy an employee should have an hour lunch time break and two times fifteen minutes tea break when working 8:30 hours in a day. In the time study result the "Break" work structures is 19,9% of the working time while it should be 17,6% (1:30/8:30). There is an inefficiency 2,3% of a daily working time with 12 minutes. Face Correction of a product has 11,7% of a shift. The company policy about this work structure is applying in a rigid way, that even when a stocker sees an empty front line while doing another job, s/he pauses the current job and does the face correction for that shelves. The company is also known as fully replenished grocery retailer in the eyes of the customers. Therefore, almost one tenth of the working time spend for this work structure. Price tag change has 7,8% of stockers total time. Hence the company runs mostly based on campaign and promotion in every two weeks most of the products price changes based on the catalog. Price tag change, price tag print and price tag control work structures have 12,3% of the stockers spends that time to make sure that price tags are correct. The work structure of Carry and Walk has 5,8% of a total time and a stocker spends total of 29:34 minutes for these two-work structure in an average shift. The other work structure has been mostly observed in

discount and small supermarkets, because there are not many employees in the store due to sales volume. In the time of absenteeism or a customer rush for the checkout stockers help to the store operation even though it is not priority work for his/her job description.

In the company, stockers are responsible from five main category, which are firstly FMCG- Snack (Fast Moving Consumer Goods-Snacks), which have products like gum, biscuits, chocolate, cookies; secondly FMCG- Basic Needs (Fast Moving Consumer Goods- Basic Needs) which have products like tea, coffee, jams, cans; thirdly beverages, which have products like coke, soda, water, beer, whiskey, wine; fourthly detergent &cosmetics&paper, which have products like toilet paper, clothes detergent and make up products and last one nood-food category which have products like toys, battery, camp material, raw material for construction and etc. The other categories such as meat, fruit and vegetables or delicatessen have their own specialized employees working for that department replenishment operation.

Searching for ideal number of stockers needed in each 30 minutes time slot; the number of products sold in that period and how much time needed to replenish a product should be known. For the average replenishment time for a product, the company's mobile stockers project result is used for this study.

The company had a model called mobile stockers for replenishing in the seasonal stores' shelves. In this model, four of stockers from different stores became a team and they work in the stores after midnight for replenishment. They work for around an hour for each store and visit four stores per night. This model needed because there were too many customers during the day in the stores therefore it was too difficult to replenish the shelves while there are too many customers shopping. To prevent any possibility of customer dissatisfaction and increase the efficiency of workforce the model developed and applied. The stores who are having mobile stockers' help have less stockers in the store during the day, because most of the needed products replenished by the team at after midnight. While applying this model, every stocker scans the product with mobile phone application before replenishing the shelves. The application collects the time stamp of the product scan during the work. The scanning and measurement procedure needed to measure the efficiency of the model and the teams before using for all seasonal stores.

11th of May to 21th of September this operation has been run and all the activities has been stored in the company databased. During 133 days of this study total of 203116 products replenished by the teams and 1844409 seconds (523,4 days of data) recorded in the system. Analyzing the data, the average replenishment time for a product is 9,1 seconds is founded by the help of this model. As shown in the Table 6, each category average product replenishment time is founded.

Table 6. Average Product Replenishment Time Per Categories

Category	**Number of Product**	**Total Time (sec)**	**Average Time per Product (sec)**
FMCG (Snacks)	55.075	378.472	6,9
FMCG (Basic Needs)	53.756	596.024	11,1
Beverages	74.448	624.626	8,4
Detergent & Cosmetics & Paper	12.155	146.553	12,1
Non-Food	7.682	98.734	12,9
Total	**203.116**	**1.844.409**	**9,1**

The total of 523 days of time and 203.116 products scan time gives results in terms of average scan time per products. Hence, knowing average scan time and the number of products sold in every 30 minutes, the requirement workforce for the stockers for 30 minutes slots can be forecasted.

When a product is taken from the shelves by the customers, there are four main work structure to be redone for that product. The four different work structures are C - Carrying, PR-

Product Replenishment to the shelves, FC - Face Correction and W-Walk. According to this, the sum of the works required to replace a sold product from the shelves; consist 38,9% of the total time of a stocker. The study of mobile stockers has the time results of these work structures as well. Therefore, the average times can be used to forecast the total requirements of a stocker in each period.

While forecasting workforce requirement, the past data must take into consideration to see the future and be aware of fluctuation of data. Ideally considering monthly base data in the forecast algorithm is enough to cover all the independent variables effects sales and considering stores have monthly based sales target, it is wise to take into consideration of last 4 weeks. Therefore, forecasting for one day, Monday 1st ,8th ,15th and 22th of April's data output forecasted data is used for the comparison with real data of 29th of April. This calculation has been done for three different size stores to evaluate the efficiency of the forecast requirement algorithm.

First step is having 29th of April forecasted data by the algorithm, the last four-week data should be examined and should calculated the arithmetic mean of last four weeks of Monday data.

Second step, finding average total sales of Monday's of last four weeks and compare it to the 29th of sales department's forecasted sales volume to find the percentage difference for able to use in the workforce requirement algorithm.

Each last week of a month, Department of Sales forecasts the daily sales target of next month with the help of Regional Sales Managers and then keep track of the performance according to the forecast. The forecast sales for 29th of April are 101.000 Turkish Lira (TL).

Third step is to find percentage difference between forecasted data and the average sales.

101.000 / 85.026 = 1,1878% -> 18,78%

Forecasting 29th of April, the average number of products from the last four weeks of Monday should be increased by 18,78% ratio.

Fourth Step is to forecast number of products will sell in each time period.

As mentioned in the Table 6. Average Product Replenishment Time Per Categories, the average replenishment time needed per category is known with the help of mobile stockers model. Multiplying the number of products to the average replenishment time give the requirement workforce needed in that time slot. As shown in the Table 7 "Total Need in Seconds" is total time of 5 categories time requirement for product replenishment.

Table 7. Employee Requirement for 29th of April in Anadolu Hisarı MMM

Number of Employee Needed per Time Slot - Anadolu Hisarı MMM Store							
Categories	08:00	08:30	09:00	…..	21:00	21:30	Total
Total Need in Seconds			745	…..	2676	2613	
Total Need in Minutes			12	…..	45	44	
Total Workforce Need (38,90%)			32	…..	115	112	
Full Time Workforce Need			2	…..	4	4	
The Need Before One Hour	2	2	3	…..	4	4	143
Fingerprint Data	2	2	4	…..	4	4	150
Difference Between Actual and Forecast	**0**	**0**	**1**	**…..**	**0**	**0**	**7**

Having total requirement of replenishment of sold products in minutes, then total requirement can be found. Knowing that stockers spend 38,9% of their time only for a sold products replenishment, therefore the total need of workforce can be found by dividing the total needs in minutes by 38,9% to find the all the workforce need to accomplish all the jobs. As an example, in Anadolu Hisar store between 09:00 – 09:29 32 minutes of total workforce requirement needed. Hence, one person can work 30 min in a thirty minutes slot only, therefore

the store needs at least 2 people to cover the work. Even though there is 2 minutes extra work calculated for 09:00, the algorithm roundup the requirement and calculated 2 employees, due to company desire of not having under planning in the workforce requirement algorithm. The company's other requirement is having full shelves at least one hour before customers shopping time. The need for one hour before line in the Table 7, represents drawn back of one hour of the actual requirement and it is the knowledge of stockers need per time slot for a given day.

The Company uses fingerprint system for shift management; therefore, the comparison can be done between the forecasted need to the actual data. The result is fingerprint data has 7 slot (3:30 hours) more than the forecasted requirement in total. Viewing data in slot base, 10 slots have over planning and 7 slots have under planning with the fingerprint data. Hence, this result does not have the scheduling algorithm and it does not take into consideration of country workforce regulations and company polices it would not be a practical comparison to propose a result in terms of efficiency. The Scheduling Algorithm section has taken into consideration in the Chapter IV of the dissertation and afterwards an efficiency scale has been examined.

The process of Anadolu Hisarı Store is repeated with EthemEfendi M and Ugur Mumcu MM stores to evaluate the results with different size and employee numbers.

By establishing a workforce requirement algorithm, which linked workforce metrics to business outcomes helped grocery retailer benefiting of increase in manpower efficiency and lowering workforce costs. The literature, where do less researches on the stockers compare to other jobs in grocery store, supported by having a different aspect of workforce determination algorithm for the Stockers.

The fourth paragraph explains the guideline to achieve workforce requirement algorithms on butchers. In the grocery retailing companies, the service quality of the fresh departments plays key role especially competing with the mass amount of discount format stores. Customers visit fresh department owned stores to get fresh products and good service quality. Therefore, butchers are the one of the key positions to keep the customer satisfaction level high and happy.

A butcher is someone who's is responsible of meat products management. They prepare the products for the proper sale condition or based on the customer desire. They are responsible of order of products, stock management, expiration date control and price tag management. They mainly focus on increasing the meat category sales and offering other products to the customers.

Analyzing job responsibilities, observing raw material to end users' products journey, conducting a trial time study in a store, and having feedback from store management and butchers themselves, the final time study guideline and work structure breakdowns created to run time studies for understanding all aspects of the operation of butchers with 19 different sub-work structures are; Break (B), Good Receiving (GR), Product Order (PO), Expiration Date Control (EXC), Storehouse Organization (SO), Price Tag Control (PTC), Price Tag Print (PTP), Price Tag Change (PTCh), Product Load in from Storehouse/Shelves (PLS), Carry (C), Product Replenishment to the shelves (PR), Face Correction (FC), Processing the Meat for Shelves (PP), Cleaning Up (CU), Talk with Customer (TC), Preparing the Product for a Customer (PPC), Business Talk (BT), Walk (W) and Other (Ot).

The Time study measurements have been conducted in 12 different shops on different days, shifts and jobs with 102 hours of in-store observations to find needed workload in every period and schedule of the butchers. The distribution of the time studies has been done equally to be able to capture the mainly different stores, shifts and workdays.

The time studies with 12 observations helped to understand the current working environment and the percentage of the task's distribution through a day. In the Figure 8, all time studies are evaluated, and the percentage of each task over total workload has been calculated.

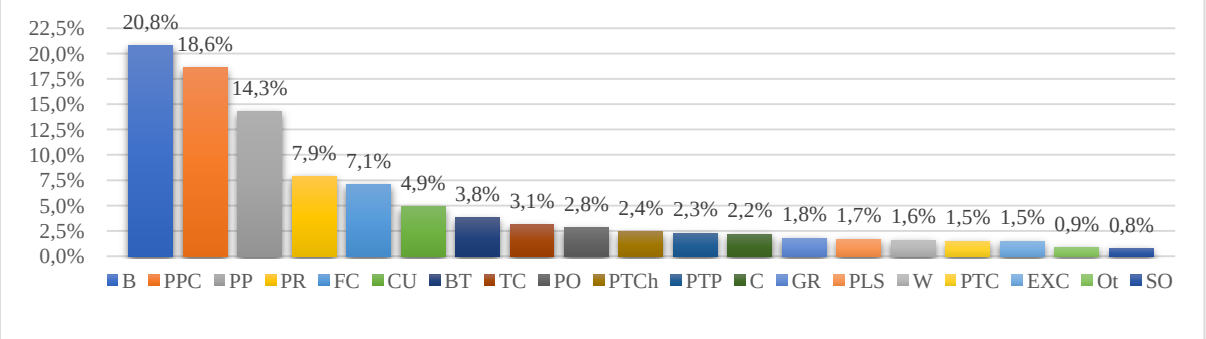

Figure 8. Percentage of Work Structures of Butchers from 12 Observations

In the time study result the Break work structures is 20,8% of the working time where is should be 17,6% (1:30/8:30). There is an inefficiency 3,2% of a daily working time around eight minutes. Preparing the Product for a Customer (PPC) is the second highest work structure because this is the main job of the butcher, where they produce the product from pre prepared products. Processing the Meat for Shelves (PP) is the third highest work structure of the time studies, where employees process the meat, which came from the warehouse, to be ready for the shelves. This progress is done mostly in the morning by senior butchers, when there are less customers. Product replenishment (PR) and Face Correction (FC) are the work structure, which are mostly repeated by the butchers after each customer to make the shelves more representable for the new customer. Product Replenishment (PR), Face Correction (FC), Cleaning-Up (CU), Talking with Customer (TC) and Preparing the Product for a Customer (PPC) are the work structures directly related with the customer and it is 41,6% of a daily working time. This ratio is higher in the afternoon shifts. Excluding breaks 55,5% of the butchers' time, spend on for work structures to serve the customers. Price Tag Change (PTCh), Price Tag Print (PTP) and Price Tag Change (PTC) have 6,2% of butchers' total time. The company price policy runs mostly based on campaign and promotion and in every two weeks most of the products price changes based on the new catalog.

In the company view, meat department is the most important service department, therefore serving best quality in terms of products and customer satisfaction plays a critical role. The company owns the biggest meat process factory in the Turkey; it sells own meat products in the stores and Migros holds the all chain of products from producers to end users. (Migros TV, 2021)The butchers are responsible mainly three subcategories, which are red meats, white meats and packaged meats. The red meats and the packaged meats come from the process factory of the Migros. White meats are bought from the suppliers. The red meat subcategory has products like, lamb meat, roast beef, veal shank, cubed meat and etc.; the white meat subcategory has chicken leg, turkey breast, chicken wings, chicken liver etc.; the last category of packaged meats has meatballs, döner, beef mince and more. The butchers are responsible of all the product replenishment progress of meat department.

The ideal number of butchers needed in each 30 minutes period should be known to have an ideal scheduling program. Therefore, number of products sold and the preparation of each product in groups of subcategories should be known to reach for the workforce requirement need. Company's butcher's performance measurement study results is be used in terms of the calculation of the workforce requirement.

The company run a butcher's performance measurement study in 6 different stores to be able to measure the average butcher performance and which subcategories' product takes how much time to be prepared and research for if there are any room for the improvement of the operation. In the study, the company gave each butchers a device called smart badge. A smart badge is a device which seems like a name tag and employees carry them on their neck and capable off scanning barcodes and items price tags. The flow of the usage of smart badge is; a customer comes to the meat department and gives an order for a products and then a butcher

prepares the product in some time and before giving the end product to the customer, s/he scans the barcode of the final products. The study gives information to the company about how much time a customer spends time in the store from meat department to the cash desk and the time for the preparation of the products as well.

2nd to 22th of December 2019 this study has been run for 3 weeks in 6 different stores. During 21 days of the study total 58627 products of meat department scanned via smart badge through the study. In ideal working environment where the customers is infinitely comes to the meat department and request for a product, then the data obtained from the smart badge can be usable directly measuring the preparation time of the products, however in reality of the store there are 17 minutes or even 22 minutes time difference between preparation of two products with the same employee. This is mostly occurring in the morning shifts where there are not much customers traffic compare to after work hours or if an employee is working in another work structure like controlling or printing the price tags. Thus, to be able to interpret the data correctly the outlier's data has been excluded in the calculation. In the time studies of 12 stores it is observed that, most of the butchers accomplish customers' demands approximately around 2-3 minutes. Thus, the time difference bigger that 180 seconds is not take into consideration of the average preparation time of the subcategories. Due to irregular demand on the customer side, excluding outliers' data action must be done. As shown in the Table 8, only 17,4% of the total scanned products is used to calculate the average preparation time. A product in meat department is prepared by the butchers in 91 seconds (1:31 minutes). The average time for red meat, white meat and the packaged meats will be used in the algorithm to determine the employee requirement for 30 minutes periods.

Table 8. Average Preparation Time of the Subcategories in Meat Department

Subcategories	Number of Total Scanned Product	Number of Total Used Products	Average Preparation Time (in seconds)
Red Meats	25.093	3.915	124
White Meats	23.451	4.362	73
Packaged Meats	10.083	1.946	49
Total	**58.627**	**10.222**	**91**

When a butcher finishes serving a customer, there are mainly 5 main work structure to be redone for the next customer. The five different work structures are Product Replenishment (PR), Face Correction (FC), Cleaning-Up (CU), Talking with Customer (TC) and Preparing the Product for a Customer (PPC) and it is in total 41,6% of a daily working time.

The number of the sold items can be found from the cash register data, however to be able to find the optimum employee requirement for the meat department, the average shopping time of an customer should be known too, because the time of butchers giving serving and the time of the cashiers scanning the items are not same. Butchers give services much earlier than cashier's scanning time. In the butcher performance measurement study, they scan the final products with the smart badge devices, therefore the time of the butcher's serving is known, and the scanning time is also known by cash register data. The average time difference between two data gives the average shopping time of a meat bought customer from the meat department to the cash desk can be found. Inspecting 3 weeks of 6 different stores smart badge data the average shopping time is found by 23:46 minutes. Thus, when calculating the employee requirement for a certain 30 minutes period, the requirement of an employee needed by 23:46 minutes earlier. Hence, the time period is 30 minutes in our study, it is accepted to have the requirement one period before in the algorithm.

Having fluctuating customer demands and independent variables effect of the sales makes harder for retailers to forecast the future. As used in the cashiers and stockers model, the last 4 weeks data will be used to forecast the workforce requirement of the butchers as well. Therefore, as an example 30th of August will be forecasted in Üsküdar MM Store for butchers.

Able to forecast 30th of August, the last for weeks of the same day will be needed in terms of calculating average number of sold items.

Having the quantity of the products and in which periods is sold, helped us to have an arithmetic mean of the last four Fridays of the August to be able for forecast 30th of August. The shows the **first step** of the algorithm to have an averaged last four weeks data.

Second step, finding average total sales of Friday's of last four weeks and compare it to the 30th of sales department's forecasted sales volume to find the percentage difference for able to use in the workforce requirement algorithm.

Each last week of a month, Department of Sales forecasts the daily sales target of next month with the help of Regional Sales Managers and then keep track of the performance according to the forecast. The forecast sales for 30th of August are 16.000 Turkish Lira (TL) for the meat department.

Third step is to find percentage difference between forecasted data and the average sales.

16.000 / 15.209 = 1,0520% -> 5,20%

Forecasting 30th of August, the average number of products from the last four weeks of Fridays should be increased by 5,20% ratio.

Fourth Step is to forecast number of products will sell in each period.

As mentioned in the Table 8. Average Preparation Time of the Subcategories in Meat Department, the average preparation time needed per subcategory is known with the help of butcher's performance measurement study. Multiplying the number of products to the average preparation time give the requirement workforce needed in that time slot. As shown in the Table 9 "Total Time Need in Seconds" is total time of 3 subcategories of meat department time requirement for product preparation.

Table 9. Butcher Requirement for 30th of August in Üsküdar MM

Categories	09:30	10:00	10:30	11:00	…	20:00	20:30	21:00	21:30	**Total**
Total Time Need for Product Preparation in Sec		704	491	2318	…	1997	750	103	980	**3545**
Total Time Need in Minutes		12	8	39	…	33	13	2	16	**59**
Butchers Requirement (41,6%) in Minutes		28	20	93	…	80	30	4	39	**142**
Full Time Workforce Requirement		1	1	4	…	3	2	1	2	**86**
Full Time Workforce half an hour ago	1	1	4	4	…	2	1	2	2	**88**
Fingerprint Data	2	2	2	2	…	3	3	3	3	**71**
Difference Between Actual and Forecast	**2**	**1**	**1**	**-2**	**…**	**0**	**1**	**2**	**1**	**-15**

Having total requirement of preparation of sold products in minutes, then total requirement can be found. Knowing that butchers spend 41,6% of their time only for a sold products preparation, therefore the total need of workforce can be found by dividing the total needs in minutes by 41,6% to find the all the workforce need to accomplish all the jobs. As mentioned, earlier the time of the scan of products is different than the butchers serving time and knowing a customer average rely spends 23:46 minutes from the meat department to the cash register, the requirement should be draw back for a half an hour. In the Table 9, "Full Time Workforce half an hour ago" line gives the actual requirement of the butchers in a given period.

The Company uses fingerprint system for shift management; therefore, the comparison can be done between the forecasted need to the actual data. The result is fingerprint data has 15 slot (7:30 hours) less than the forecasted requirement in total. Viewing data in slot base, 8 slots have over planning and 12 slots have under planning with the fingerprint data. Hence, this result does not have the scheduling algorithm and it does not take into consideration of country workforce regulations and company polices it would not be a practical comparison to propose a result in terms of efficiency. The Scheduling Algorithm section will be taken into consideration in the fourth chapter of the dissertation and afterwards an efficiency scale will be examined.

By establishing a workforce requirement algorithm on butchers, having linked workforce metrics to business outcomes helped grocery retailer benefiting of increase in manpower efficiency and lowering workforce costs. The literature, where there are scarce studies on the butchers also supported by the study.

In the fifth paragraph, summaries and conclusion of the chapter has written:

- The output of the chapter is establishing algorithms for each department of cashiers, stockers and the butchers within 30 minutes periods. Achieving such as purpose, the time studies run for each department in different days and formats to capture the nature of the work. Each work structure of the jobs is analyzed and the work structures distribution in a shift and it is connection to the sales with the data analysis methodology helped to establish algorithms for each department.
- Cashiers are the one of the most important employees in the retail sector, because the speed of customer circulation depends on how good they perform in the cash register. Therefore, it is very important to have the right number of employees in the right time. In the retail store, Stockers are the key employees to run the store in a smooth operation due to most of the sold products are belong to Stockers category to coordinate and decide in terms of replenishment, stock management and giving new order for the products. In the grocery retailing companies, the service quality of the fresh departments plays key role especially competing with the mass amount of discount format stores. Customers visit fresh department owned stores to get fresh products and good service quality. Therefore, butchers are the one of the key positions to keep the customer satisfaction level high and happy.
- 12 different work structures for cashiers, 18 different work structures for stockers and 19 different work structures are observed during time study observations. For the cashiers 7 time studies with the 60 hours, for stockers 20 time studies with 170 hours and for the butchers 12 time studies with 102 hours, total of 39 time studies with 332 hours conducted in different size, shifts and days in the stores for observation to understand job responsibilities and knowing the proportion of the work structures in an average shift. In the cashier's data analysis of the past sales data with the 84.867 number of scan time; the average scan time per 8 different categories and the time average time for payment methodology is achieved. In the stockers the mobile stockers team data collected in 133 days from 203116 product replenishment time helped for finding the average replenishment time for each five categories. The butcher's performance measurement study in 6 different stores for 3 weeks (58627 scanned product) helped to find an average preparation time for three subcategories of the meat department.
- The empirical data of time study results, cash register data, mobile stockers team data and the butcher's performance measurement study helped to generate algorithms to forecast an employee requirement of each department in a 30 minutes periods.

CHAPTER IV. DESIGN OF DEPARTMENT BASED SCHEDULING ALGORITHMS

The first paragraph gives insights about workforce scheduling modelling approach. There are many approaches and solutions to solve the workforce scheduling problems as mentioned previously in the literature part of the scheduling. For the modelling the workforce scheduling an approach is defined by using a mixed integer linear programming model by using IBM CPLEX optimization tool for the departments of cashier, stockers and the butchers. The main of the work is to define the schedules for the department via algorithm-based scheduling and using the demand found in the Chapter III, with the help of empirical data of time study results and the data analysis of the sales data.

The workforce scheduling model is defined according to the government regulation, union rules and the company policies. Afterwards having a mathematical model with the constrains has been applied to each of the departments of cashier, stockers and butchers. Comparing with the schedules made by the store manager, the efficiency increase percentages is calculated. The

algorithm-based scheduling aims to give store management more flexible shifts in a day to be able to cover more under planning periods due to fluctuation of the demands rather than only three or four shifts alternative. Having an algorithm-based scheduling via data driven perspective and the speed and ease of the system gives more time to the store management for focusing on the other works.

The second paragraph indicates the mathematical model of scheduling with all the constraints and equations.

Government regulations and laws, union's requirements and company policies shape the way of working the companies. Therefore, these constrains taken into scheduling model to have the real-life conditions.

Store level constraints are:

● Due to Migros being service focus retail company, there must be at least one person each department at any given time.

● Store opening and closing hours are constraints for working hours.

● Stockers should be ready at least one hour and butchers should be ready half an hour before the customer opening time for preparation of the store for sale.

Employee level constraints are:

● An employee can work 8:30 hours per day.

Due to hourly working cost of part time and full-time employees are almost same and part time employees having high turnover ratio, the company does not want to work with part time employees. Therefore, in the study only full-time employees will be taking into consideration.

● An employee can work at most 51 hours a week. (six day of working).

● An employee can have one hour of lunch break and two of fifteen minutes tea break during a day.

The arrangement of the breaks may differ from department to department based on the crowd of the customers and it is arranged by the mostly by department leaders or store management during the day.

● An employee must have a week off day in a week.

Mathematical Model

Indices:

- k: Working days in a week k: {1,2,3,4, ..., D};

1 represents Monday, 2 is Tuesday and 7 is Sunday.

- j: Shifts in a day and j: {1,2,3,4, ..., P}.

Each employee should work 08:30 hours a day, thus latest became 13:30, later than that, conflict occurs with the requirement of 08:30 working per day constrain.

- i: Employee number and i: {1,2,3,4, ..., W};
- l: Period number and l: {1,2,3,4, …, L).

Having advice from store managers, sales department and human resource departments it would be unpractical to set a minimum working under 30 minutes, because of the efficiency lost changing working environment or work for short time intervals.

Parameters:

- n: Number of periods per hour;
- a_{jl}= 1 if shift "j" covers period "l", 0 otherwise;
- g_{ik}= 1 if an employee "i" has day off at day "k", 0 otherwise;
- d_{lk}: Number of employees required at period "l" at day "k".

Decision Variables

- x_{ijk}= 1 if an employee "i" assigned to shift "j" at day "k", 0 otherwise;
- y_{ik}= 1 if employee "i" is chosen to work at day "k", 0 otherwise.

Objective Function

$$min \sum_{l \in L} \sum_{k \in D} (\sum_{i \in W} \sum_{j \in P} a_{jl} x_{ijk} \; - \; d_{lk})$$

The objective function is minimizing the difference between assigned workforce and number of workers required for each period.

Subject to:

1) Constraint I denote that each employee can be assigned to at most one shift in a day.

$$\sum_{j \in P} x_{ijk} \leq 1 \quad \forall i \in W, \forall k \in D \qquad (I)$$

2) Constraint II ensure that each employee can work only 8:30 hours in a day.

$$\sum_{j \in P} \sum_{l \in L} a_{jl} x_{ijk} = 8{,}5 n y_{ik} \quad \forall k \in D, \forall i \in W \qquad (II)$$

3) Constraint III guarantee that each employee cannot work more than 51 hours (8.5 hours * 6 day) in a week

$$\sum_{j \in P} \sum_{l \in L} \sum_{k \in D} a_{jl} x_{ijk} \leq 51 n y_{ik} \quad \forall i \in W \qquad (III)$$

4) Constraint IV guarantee that in each period assigned total employee number cannot be less than the required worker number.

$$\sum_{i \in W} \sum_{j \in P} a_{jl} x_{ijk} \geq d_{lk} \quad \forall k \in D, \; \forall l \in L \qquad (IV)$$

5) Constraint V ensure that each employee can work at most six days in a week.

$$\sum_{k \in D} y_{ik} \leq 6 \quad \forall i \in W \qquad (V)$$

6) Constraints VI creates a bridge between last week and current week, it looks each employee day-offs in last week and guarantee their day-offs in current week.

$$\sum_{k=b+1}^{7} g_{ik} + \left(b - \sum_{k=1}^{b} y_{ik} \right) \geq 1 \quad \forall i \in W, \quad b = \{1,2,3,4,5,6\} \qquad (VI)$$

7) All binary variables

$$x_{ijk} \in \{0,1\}; \quad y_{ik} \in \{0,1\}; \quad \forall i \in W, \; \forall j \in P, \; \forall k \in D, \; \forall l \in L \qquad (VII)$$

Scheduling Steps:

- The scheduling for a week starts from the day with the highest need of workforce requirement to the lowest requirement. (If there are same requirement the sequence primarily starts from Saturday to Friday).
- Each employee plans for 8:30 hours in each they in the basic planning step.
- The algorithm checks the over planning and under planning according to the PER (Period Efficiency Rate).
- The employee schedules changes according to the SER (Schedule Efficiency Rate).
- The algorithm checks the constraints of country regulations and company policies.
- The algorithm checks if each employee has one day off and have total of 51 hours of total time afterwards finalize the scheduling.

PER (Period Efficiency Rate)

The Stores may have employees from one to hundred or even more for each department and the requirement of an only "one" employee significantly matters based on the number of currently working employees in the department.

$$PER = \frac{(\text{number of planned employees} - \text{number of employee requirements})}{\text{number of employee requirements}} \qquad (VIII)$$

As an example; having a requirement of 2 employees for 09:00-09:30 and another requirement is 10 employees for 18:00-8:30. Accepting there are already "1" employee planned

for 09:00-09:30 and "9" employees planned for the periods. Let's accept each period has a requirement of "one" employee, the question of which period is more critical has an answer with the help of Period Efficiency Rate ratio. The 09:00-09:30 period has ((1-2)/2) = -50% PER and the 18:00-18:30 period has ((9-10)/10) = -10% PER. The lowest PER has always privilege to plan first, because the risk in that period is high due to much less employee.

SER (Scheduling Efficiency Rate)

In the grocery retailing sector, where many companies try to differentiate itself with the service quality having the right number of employees plays critical role. Therefore, comparing the scheduling results with the requirements found in the Chapter III is compared with the SER Scheduling Efficiency Rate.

Scheduling Efficiency Rate is used to measure the difference between store managements schedules and the algorithm-based schedules. Basically, evaluating a period in terms of workforce management there are mainly three possibility; over planning, under planning and fit planning. When the number of planned employees is higher than the employee requirement than over planning occurs, in this scenario it is accepted that there are more employees than required therefore unnecessary increase in the employee cost of the operation. If the number of the planned employees is less than the employee requirement than under planning occurs, in this scenario it is accepted that there might be a chance of loss sale due to not able to give service to customers. Fit planning is where number of planned and required employees are the same, it is the best scenario for the companies. For Migros, since it is one of the primarily objective having a good quality customer service, the under planning is the least wanted option beyond other alternative. Thus, measuring the efficiency between store management version and the algorithm-based scheduling the periods of fit planning and over planning is be counted as a success. The algorithm try to minimize the number of under planning.

$$SER = 1 - \frac{\text{Total number of periods of under planning}}{\text{Total number of periods}} \qquad (IX)$$

The company is using fingerprint system to keep track of the employee working hours. Due to COVID 19 pandemic and the change of working hours by the governments in the scope of lack downs the algorithm-based scheduling system implementation could not finished and run for trials in the stores. However, with the help of fingerprint system the store management scheduling has been reach out and is compared with the algorithm-based scheduling results. In the chapter III, number of employee requirement of the Cashiers, Stockers and Butchers are calculated. The results are used in 3 different stores with the different sales area, customer number and the sales for each department. The scheduling algorithm is tested on non-pandemic or less effected by pandemic weeks to compare the results and indicate the benefit off the using algorithm-based scheduling algorithm.

The third paragraph is about scheduling algorithms tests for the departments. The company uses three shift model (morning, noon and afternoon) during a day. The new scheduling algorithm has proposed more shift alternative to cover the needs more efficiently. As mentioned in the workforce scheduling approach the constraint of government and company policies are used in the scheduling algorithm therefore there is not any excuses in terms of their rules and policies.

The third paragraph's first subparagraph is establishing an algorithm-based scheduling for the cashiers. The algorithm to find the requirement of cashiers per period is found in the Chapter III of dissertation in the cashier requirement algorithm part with the 7 different time studies over 60 hours of observation and the data analysis 84.867 scan time of the products and the sale data. By the employee requirement algorithm for each 30 minutes interval helped on scheduling algorithm with knowing the requirement of an employee for a given period.

The government regulations, company policies and the unions desire as mentioned in the Chapter IV is taken into consideration for cashiers' algorithm-based scheduling. The results of store management scheduling and the algorithm-based scheduling is compared with the indicator of Scheduling Efficiency Ratio (SER) for investigating if the algorithm-based scheduling propose an extra efficiency rather than store management scheduling. The comparison of store management and the algorithm-based scheduling is done in three different size and sales volume store to have a variety to able to cover options. The results have been augmented to all the stores to get an insight of overall improvement in company wise.

For the cashiers, the comparison has done in Kamelya M Store, Kozzy MM Store and Anadolu Hisarı MMM Store for 18th-24th of the November of 2019 data. The results have been examined with SER indicator of store management and the algorithm-based scheduling.

Kamelya M Store has 5 full time cashiers working between 18-24 of November. The daily sale is 52249 TL, has 1162 m2 of sales area and classified as M format, which is the smallest format of the Migros.

The algorithm establish in chapter III for cashiers is used to calculate the employee requirement of the store for week of 18-24 November.

Table 10. Cashier Requirement for Kamelya M Store on 18th of November

Categories	09:00	09:30	10:00	…..	20:30	21:00	21:30	Total
Total Time Need for Scanning Products Seconds	897	1167	961	…..	514	530	227	29399
Total Time Need for Customer Service	941	917	749	…..	472	248	363	27595
Total Time Need in Minutes	31	35	28	…..	16	13	10	950
Total Workforce Requirement (66%) in Minutes	46	53	43	…..	25	20	15	1.439
Full Time Workforce Requirement	2	2	2	…..	1	1	1	61

The cashier requirement algorithm calculates the need of cashiers of 18th November is 61 periods which is shown in the Table 10. Total workforce need for Monday is 30:30 hours (61 periods X 30 minutes of an interval / 60 minutes). The total requirement of 18th – 24th November is 219:30 hours. The highest demand is on Sunday with the need of 35:00 hours of employee and the second highest demand is on Saturday with the 34:00 hours of employee. Hence demand is based on the sales volume sometimes the employee requirement can fluctuate, such as on Monday, there are 3 employees required for 18:30 period and after it is 4 employee and again 3 employees in the 19:30 period. (See Table 11) Since each employee must work at least 8:30 hours a day and each employee can only work one time per day, it is not possible to establish an algorithm which fulfills the all requirement, because of the government and company policies constraints. Instead of reaching for fulfilling all the requirement our aim is to increase the Scheduling Efficiency Rate (SER) compare to the store manager.

Table 11. Cashier Requirement of Kamelya Store between 18th-24th of November

Days	09:00	09:30	10:00	10:30	11:00	11:30	…..	18:30	19:00	19:30	20:00	20:30	21:00	21:30	Total Period	Total Hours
Monday	2	2	2	2	2	2	...	3	4	3	2	1	1	1	61	30,5
Tuesday	2	2	2	2	2	2	...	3	2	2	2	1	1	1	57	28,5
Wednesday	2	2	2	2	2	2	...	3	2	2	2	1	1	1	61	30,5
Thursday	2	2	3	2	1	2	...	2	3	3	2	1	1	1	59	29,5
Friday	2	3	2	3	2	2	...	3	3	2	2	1	1	1	63	31,5
Saturday	1	2	3	2	2	3	...	3	3	2	2	2	2	1	68	34,0
Sunday	1	2	2	2	3	3	...	3	2	2	2	1	1	1	70	35,0

After analyzing fingerprint data of the employees, the schedules of 18th November made by the store management is achieved. Kamelya Store Management plans the cashiers for three shifts. First shift starts at 09:00 (morning shift) and always there must be an employee for that period. Second period starts at 11:30 (noon shift) and last shift starts at 13:30 (afternoon shift).

Store management plans off days of the employee in weekday, where on the weekend all the five employees are working, which is supported by the requirement algorithm having the highest requirements on the weekends. The Management plans an employee in the morning and noon shifts and two employees for the afternoon shift if the days are weekdays. On the weekends, since there are no off days fifth employee plans for the noon shifts. Table 12 contains more details of the schedules done by the store management.

Table 12. Kamelya M Store – Cashier Scheduling Chart Done by Store Management

Employees	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Atay K***	13:30 - 22:00	*Day Off*	09:00 - 17:30	13:30 - 22:00	11:30 - 20:00	13:30 - 22:00	09:00 - 17:30
Funda K***	09:00 - 17:30	13:30 - 22:00	13:30 - 22:00	13:30 - 22:00	*Day Off*	09:00 - 17:30	11:30 - 20:00
Recep C***	*Day Off*	09:00 - 17:30	13:30 - 22:00	11:30 - 20:00	13:30 - 22:00	13:30 - 22:00	11:30 - 20:00
Ayşe Ç***	13:30 - 22:00	11:30 - 20:00	*Day Off*	09:00 - 17:30	13:30 - 22:00	11:30 - 20:00	13:30 - 22:00
Hasan S***	11:30 - 20:00	13:30 - 22:00	11:30 - 20:00	*Day Off*	09:00 - 17:30	11:30 - 20:00	13:30 - 22:00

As mentioned in the mathematical model, the scheduling algorithm uses different shifts rather than just morning, noon and afternoon shifts as used by the store management. Having more shifts alternative does not conflict with the government regulations, company policies or even union desires itself. As long as it is 8:30 hours shift and employees are informed at least one week before about their schedules, the new model offer flexibility and the improvement to the scheduling. Talking with the store managers on why they use only three shifts for the operations, most of them replied saying that it is a culture comes from the past or not enough time to do scheduling with that specifications.

The Kamelya store is open between 09:00 – 22:00 for the cashiers. Therefore, there are 10 different 8:30 hours of shift possibility starting from 09:00, 09:30 and ends with 13:30 due to closing hours of the store. The shifts later than 13:30 has the problem of working hours of 8:30 per day.

Table 13. Kamelya M Store – Cashier Scheduling Chart Done by the Algorithm

Employees	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Atay K***	*Day Off*	13:30 - 22:00	10:30 -19:00	09:00 - 17:30	12:00 - 20:30	09:30 - 18:00	13:30 - 22:00
Funda K***	13:30 - 22:00	09:00 - 17:30	*Day Off*	12:00 - 20:30	09:00 - 17:30	13:00 - 21:30	11:00 - 19:30
Recep C***	09:00 - 17:30	*Day Off*	13:30 - 22:00	11:30 - 20:00	10:00 - 18:30	13:30 - 22:00	09:00 - 17:30
Ayşe Ç***	10:30 -19:00	12:00 - 20:30	09:00 - 17:30	13:30 - 22:00	*Day Off*	09:00 - 17:30	13:00 - 21:30
Hasan S***	12:30 - 21:00	10:30 -19:00	12:00 - 20:30	*Day Off*	13:30 - 22:00	11:00 - 19:30	09:30 - 18:00

Table 13 shows the result of the scheduling by the algorithm. As in the store management schedules, the algorithm also did not give day off during weekends because of having highest demands on Saturday and Sunday. There are shifts like 10:30 – 19:00 or 12:30 - 21:00 different than the store managers shift planning habits. There are different shifts in weekdays based on the requirements. The store management scheduling model had same schedules for all weekdays.

The total periods and the total hours of both scheduling models are same because of each employee must work 8:30 hours a day. However, the scheduling done by the algorithm there are differences in the hours near to closing hours and all of days the last time periods have only one employee, where it used to be 2 in the store managements schedules. There are also different schedules in the other periods compare to store management-based schedules.

The total requirement of workforce is 439 periods, which is 246:30 hours of weekly. Comparing with the Store Management Schedules, there are 116 periods (58:00 hours) of over planning and 45 periods (22:30 hours) of under planning and The Scheduling Efficiency Rate (SER) of store management is 90%.

Comparing the algorithm-based scheduling with the employee requirement, there are 101 periods (50:30 hours) of over planning and 30 periods (15:00 hours) of under planning and The Scheduling Efficiency Rate (SER) of algorithm is store management is 93%.

Table 14. Comparison of Store Management and Algorithm Based Scheduling

	Requirement	Store Management Scheduling			Algorithm Scheduling		
Days	**Total Period of Requirement**	**Over Planning Periods**	**Under Planning Periods**	**SER of Store Management**	**Over Planning Periods**	**Under Planning Periods**	**SER of Algorithm**
Monday	61	14	-7	88,5%	14	-7	88,5%
Tuesday	57	16	-5	91,2%	14	-3	94,7%
Wednesday	61	15	-8	86,9%	11	-4	93,4%
Thursday	59	15	-6	89,8%	15	-6	89,8%
Friday	63	14	-9	85,7%	13	-8	87,3%
Saturday	68	22	-5	92,6%	18	-1	98,5%
Sunday	70	20	-5	92,9%	16	-1	98,6%
Total	**439**	**116**	**-45**	**89,7%**	**101**	**-30**	**93,2%**

The algorithm-based scheduling increases the efficiency by 3,5% in 18th -24th of November scheduling. Looking at some days it increased the efficiency by 6% almost having 99% ratio on Saturday and Sunday. Decreasing the under planning from 22:30 hours to 15:00 minutes also leveraged the company in the customer satisfaction as well (See Table 14).

The methodology given for Kamelya store is used for Kozzy MM store and Anadolu Hisarı MMM Store as well.

The results of cashier's requirement and scheduling algorithms are described in the following.

The coronavirus pandemic prevented the on store-based application for implementing and testing the algorithm. Thus, the fingerprint data of the stores are used to reach for the scheduling done by the store managements.

The algorithm-based scheduling gives alternative flexible shifts to the management with 10 different shifts rather than only using 3 shifts. In the end, of the testing the algorithm with the three stores with different sales volume, employee number and sales area gave efficiency leverage starting from 2,8% 3,4% and 3,9%. Altogether, with the algorithm scheduling methodology in three store 3,4% efficiency increased achieved.

It is expected that if the employee number and the sales volume go higher, the efficiency gain rate of the algorithm goes higher as well. The more employees give the algorithm more flexibility to use more options from 10 different flexible schedules and compare with the alternative and try to find the best solution in terms of scheduling. There is only one exception because of Kozzy MM Store. The store has more sales and employee than the Kamelya Store, however the efficiency increase is less than the Kamelya M store results. This is mainly because, Kozzy MM store is a shopping mall store, which has one less hour of working time. Therefore, when Kamelya and Anadolu Hisarı is using 10 flexible shifts, Kozzy Store uses only 8 shifts due to customer opening time is 10:00. This issue has been neglected when calculating the company potential of efficiency increase and the average of 3,4% and 3,9% (3,7%) will be used as a Kozzy Store efficiency increase rate (See Table 15).

Table 15. The Result of Cashier Store's Test

Stores	**Number of Employee (FT)**	**Daily Sales (Turkish Lira)**	**Sales Area (m2)**	**Total Period of Requirement**	**SER of Store Management**	**SER of Algorithm**	**Efficiency Increase**
Kamelya M	5	52.249	1.162	439	89,7%	93,2%	3,4%
Kozzy MM	7	83.977	1.356	705	89,4%	92,2%	2,8%
Anadolu Hisari MMM	9	117.936	1.917	982	83,0%	86,9%	3,9%
Total of 3 Stores				**2.126**	**86,5%**	**89,9%**	**3,4%**

The company operated 1118 of stores with the M, MM and MMM formats in the November 2019. 143 of the stores have 2 or less cashiers in the stores. When there are 2 or less employee in the operation there is no flexible shifts due to there must be at least one employee constantly in the department. Therefore, one employee work in the morning shifts and the other employee works in the afternoon shifts. Therefore, neglecting the stores with 2 or less employee, the company's potential of workforce increase is calculated.

Table 16. The Potential Efficiency Increase of Cashiers Operation in the Company

	Number of Stores			Number of Employees			Employee Saving Potential		
Formats	**3-4-5**	**6-7-8**	**9+**	**3-4-5**	**6-7-8**	**9+**	**3-4-5**	**6-7-8**	9+
M	381	88	5	1.299	471	42	44	17	2
MM	143	185	35	521	1.038	314	18	39	12
MMM	9	58	71	35	355	766	1	13	30
Sub Total	533	331	111	1.855	1.864	1.122	63	69	44
Total	**975**			**4.841**			**176**		

As shown in the Table 16, there are 975 of store, which have 3 or more employees working as a cashier In total there were 4841 employee in the cash operation of Migros. Three groups based on the employee number created to reach for the company view potential. The first group are the stores with 3,4,5 employees and accepted that they have efficiency rate of 3,4% as measured in the Kamelya Store. The second group has the stores with 6,7,8 employees and the accepted that they have efficiency rate of 3,7%, the average of Kamelya M and Anadolu MMM stores because of Kozzy MM had one hour less working time which affected efficiency increase rate. The last one is the store with 9 or more employee and the efficiency rate is 3,9% as in Anadolu Hisarı MMM store. Calculating the potential saving of the cashiers from these stores is 176 full time employees, which is in total 3,4% efficiency increase in the operation.

In 2019 the average employee cost to the company is nearly 3500 TL, with the bonuses and side benefits. (TC Çalışma Bakanlığı, 2021)Having a potential of saving 176 Full Time employees gives 7.392.000 Turkish lira which is almost same profitable as operating 10 of big size MMM stores in 2019.

The third paragraph's second subparagraph is establishing an algorithm-based scheduling for the stockers. In Chapter III, time studies in 20 different shifts with more than 170 hours, the mobile stockers team data with the total amount of 523 days and 203116 products replenishment and the cash register's data helped to generate a workforce requirement algorithm, therefore knowing the employee requirement per 30 minutes periods in each day facilitate to form an efficiency scheduling algorithm for the stockers.

The methodology mentioned in the cashier is used for stockers as well with comparing the results of store management and the algorithm-based scheduling compared with the indicator of Scheduling Efficiency Ratio (SER)

The test has been run in the Kosuyolu M Store, Ugur Mumcu MM and Anadolu Hisarı MMM store for 11^{th} – 17^{th} of November 2019 data.

Koşuyolu M Store has 3 full time stockers working between 11-17 of November. The daily sale is 46712 TL, has 1162 m2 of sales area and classified as M format, which is the smallest format of the Migros Company.

The algorithm establish in chapter III for stockers is used to calculate the employee requirement of the store for week of 11-17 November.

The stocker requirement algorithm calculates the need of cashiers of 11^{th} November is 49 periods. Total workforce need for Monday is 24:30 hours (49 periods X 30 minutes of an interval / 60 minutes). The total requirement of 11^{th} – 17^{th} November is 159:00 hours. The highest demand is on Friday with the need of 25:00 hours of employee and the lowest demand is on Tuesday with the 18:30 hours of employee. Compare the other stores, Kosuyolu store has the

almost same amount of workforce requirement balanced each day of the week and there is no weekend fluctuation for the store. Hence, demand is based on the sales volume, the employee requirement may can fluctuate, such as on Saturday, there is only 1 employees required for 12:00 period however because of both 11:30 and 12:30 periods requires 2 employees, it is not practical nor legal to send the employee back home and then summon again for 12:30 period. Each employee must work at least 8:30 hours a day and each employee can only work one time per day, it is not possible to establish an algorithm which fulfills the all requirement, because of the government and company policies constraints. Instead of reaching for fulfilling all the requirement our aim is to increase the Scheduling Efficiency Rate (SER) compare to the store manager. These results will be examined in terms of how much improvement has been done by the algorithm as done in the stocker scheduling part and see if there it may scientifically benefit to the store for using the new approach.

After analyzing fingerprint data of the employees, the schedules of 11^{th} -17^{th} of November made by the store management is achieved. Kosuyolu Store Management plans the stocker for two shifts because of having only three employees in the operation. First shift starts at 08:00 (morning shift) and always there must be an employee for that period and the other scheduling period starts at 13:30 (afternoon shift). Store managers planned the off the days on the Tuesday, Wednesday and Thursday, which is beneficial in terms of efficiency because these days have the lowest workforce requirements compare to other days.

As mentioned in the mathematical model, the scheduling algorithm uses different shifts rather than just morning, noon or afternoon shifts as used by the store management. Having more shifts alternative does not conflict with the government regulations, company policies or even union's desires itself, as long as it is an 8:30 hours shifts, and employees are informed at least one week before about their schedules. The new model offers flexibility and the improvement to the scheduling. The stockers come to the store before the customer opening time to refill the shelves and get the store ready for the customers. Therefore, they come one more hour before the cashiers, which gives algorithm to be more flexible in terms of having more shift alternative. The opening hour for stockers is 08:00, which give 2 more flexible shift alternative to calculation. Thus, shifts start from 08:00 to 13:30 having total 12 shift alternative to have a plan.

Koşuyolu has only 3 stockers, therefore in terms of flexibility, there are not many options to plan shifts due to minimum requirement of one employee for each period. That is the reason, Tuesday, Wednesday and Thursday algorithm-based schedules are the same as store management schedules. However, having shifts like 10:00-16:30 or 12:30-21:00 still be beneficial to the efficiency more than store management schedules able to cover more under planning periods.

The total periods and the total hours of both scheduling models are same because of each employee must work 8:30 hours a day. However, the scheduling done by the algorithm there are differences in the Friday, Saturday and Sunday to the closing hours. There are also different schedules in the other periods compare to store management-based schedules.

The total requirement of workforce is 317 periods, which is 159:00 hours of weekly. Comparing with the Store Management Schedules, there are 37 periods (18:30 hours) of over planning and 39 periods (19:30 hours) of under planning and the Scheduling Efficiency Rate (SER) of store management is 87,7%.

Comparing the algorithm-based scheduling with the employee requirement, there are 30 periods (15:00 hours) of over planning and 33 periods (16:30 hours) of under and The Scheduling Efficiency Rate (SER) of algorithm is store management is 89,6%.

The algorithm-based scheduling increases the efficiency by 1,9% in 11^{th} -17^{th} of November stocker scheduling. There is also different efficient increase rate in between days. Decreasing the under planning from 19:30 hours to 16:30 minutes also leveraged the company in the customer satisfaction as well. It should be noted that, this efficiency increase be provided

with only three employees, even where 3 days were same with the store managements. The hypothesis is that having more of employee will higher the efficiency rate due to having more room for flexible shifts. The hypothesis has tested in Uğur Mumcu MM store and Anadolu Hisarı MMM store with much more employee and the same methodology has been applied.

The results of stocker's requirement and scheduling algorithms are described in the following.

The algorithm scheduling model gives the alternative flexible shifts to the management able use 12 different shifts rather than only three shifts. It may be problematic to keep track of each employee starting and end time in the store management view, but there is a fingerprint system to check and control that side of the problem. In the end, the test with the different sales volume, employee number and sales area gave efficiency leverage starting from 1,9% to 4,5%. Altogether, with the algorithm scheduling methodology in three store 3,7% efficiency increased achieved.

As shown in the Table 17, as long as the employee number and the sales volume goes higher, the efficiency gain rate of the algorithm goes higher as well. The more employees give the algorithm more flexibility to use more options from 12 different flexible schedules and compare with the alternative and try to find the best solution in terms of scheduling. As in all of 3 stores potential saving from the operation is 3,7% as the efficiency increased by the amount.

Table 17. The Result of Stockers Store's Test

Stores	Number of Employee (FT)	Daily Sales (Turkish Lira)	Sales Area (m2)	Total Period of Requirement	SER of Store Management	SER of Algorithm	Efficiency Increase
Kosuyolu M	3	46.712	1.162	317	87,7%	89,6%	1,9%
Ugur Mumcu MM	6	77.229	1.577	601	89,5%	92,8%	3,3%
Anadolu Hisari MMM	8	117.936	1.917	889	84,0%	88,5%	4,5%
Total of 3 Stores				**1.807**	**86,5%**	**90,1%**	**3,7%**

The company operated 1118 of stores with the M, MM and MMM formats in the November 2019. 407 of the stores have 2 or less stockers in the stores. When there are 2 or less employee in the operation there is no flexible shifts due to there must be at least one employee constantly in the department. Therefore, one employee work in the morning shifts and the other employee works in the afternoon shifts. Therefore, neglecting the stores with 2 or less employee, the company's potential of workforce increase can be calculated.

Table 18. The Potential Efficiency Increase of Stockers Operation in the Company

	Number of Stores			Number of Employees			Employee Saving Potential		
Formats	3-4	5-6-7	8+	3-4	5-6-7	8+	3-4	5-6-7	8+
M	231	19	0	750	100	0	15	3	0
MM	194	111	18	680	639	155	13	21	7
MMM	12	57	69	47	336	663	1	11	30
Sub Total	437	187	87	1477	1075	818	29	36	37
Total	**711**			**3370**			**102**		

As shown in the Table 18, there are 711 of store, which have 3 or more employees working as a stocker. In total there were 3.370 employee in the operation of Migros. Three groups based on the employee number created to reach for the company view potential. The first group are the stores with 3 or 4 employees and accepted that they have efficiency rate of 1,9% as measured in the Kosuyolu Store. The second group has the stores with 5,6 or 7 employees and the accepted that they have efficiency rate of 3,3% as Ugur Mumcu store. The last one is the store with 8 or more employee and the efficiency rate is 4,7% as in Anadolu Hisarı MMM store.

Calculating the potential saving of the stockers from these stores is 102 full time employees, which is in total 3% efficiency increase in the operation (See Table 18).

In 2019 the average employee cost to the company is nearly 3.500 TL, with the bonuses and side benefits. (TC Çalışma Bakanlığı, 2021)Having a potential of saving 102 Full Time employees gives 4.284.000 Turkish lira which is almost same profitable as operating 6 of big size MMM stores in 2019.

The third paragraph's second subparagraph is establishing an algorithm-based scheduling for the butchers. In Chapter III, time studies in 12 different shifts with 102 hours, the butcher performance measurement study with 21 days of observation with 58.627 products preparation time and the cash register's data helped to generate an workforce requirement algorithm, therefore knowing the employee requirement per 30 minutes periods in each day facilitate to form an efficiency scheduling algorithm for the stockers.

The test has been run in the Dudullu M Store, Kadıköy MM Store and Ümraniye MMM store for 11^{th} – 17^{th} of November 2019 data. The results have been examined with SER indicator of store management and the algorithm-based scheduling.

Dudullu M Store has 4 full time butchers working between 4-10 of November. The daily sale of meat department is 9384 TL and has 974 m2 of sales area and classified as M format, which is the smallest format of the Migros Company.

The algorithm establish in chapter III for butchers is used to calculate the employee requirement of the store for week of 4-10 of November. The total requirement of 4th – 10th November is 184:00 hours. The highest demand is on Sunday with the need of 34:30 hours of employee and the lowest demand is on Tuesday with the 19:00 hours of employee.

After analyzing fingerprint data of the employees, the schedules of 4^{th} -10^{th} of November made by the store management for butchers is achieved. The store management uses three shift model. Morning shifts starts at 08:30, noon shifts stars at 11:30 and afternoon shifts starts at 13:30. Examining the store management schedule results, in weekdays there are mostly 1 employee per shifts because there are only 3 employees working, in the Friday and weekends the afternoon shifts has 2 employees.

Comparing with the store management schedules, the algorithm proposed shifts like 12:00 – 20:30, 10:30-19:00, which are not used by the store management currently. Although the algorithm-based scheduling has 11 flexible shift model starting from 08:00 – 17:00 to 13:30 – 22:00, the model could not use most of the alternatives due to employee number constrain. The store has 4 employees working in the store and in the off days there are only three employees. Therefore, it is necessity to plan an employee for each basic shifts to cover the needs, however the algorithm-based scheduling gave leverage to the store by changing the shift times such as in stead of having 11:30 – 20:00 shifts on Sunday the algorithm suggested 12:00 – 20:30 to cover one more under planning period.

The total hours of the days in both scheduling models are same because of number of employees and the since the requirements are high in the Friday and weekends, off days scheduling are the same in the both models as well.

The difference is in the algorithm-based scheduling, afternoon shifts may have only one employee such as on Friday, where compare to store management schedule there are 2 employees.

The total requirement of workforce is 368 periods, which is 184:00 hours of weekly. Comparing with the Store Management Schedules, there are 68 periods (34:00 hours) of over planning and 50 periods (25:00 hours) of under planning. The Scheduling Efficiency Rate (SER) of store management is 86,4%. Comparing the algorithm-based scheduling with the employee requirement, there are 63 periods (32:30 hours) of over planning and 45 periods (22:30 hours) of under planning and The Scheduling Efficiency Rate (SER) of algorithm is store management is 87,8%.

The algorithm-based scheduling increases the efficiency by 1,4% in 4th -10th of November butcher's scheduling. There is also different efficient increase rate in between days. It should be noted that, this efficiency increase be provided with only four employees, due to low number of employee and less usage off flexible shifts. The hypothesis is that having more of employee will higher the efficiency rate due to having more room for flexible shifts. The hypothesis has tested in Kadıköy MM store and Ümraniye MMM store with much more employees and same methodology is used for both stores.

The results of butcher's requirement and scheduling algorithms are described in the following.

In the butchers the algorithm scheduling model gives the alternative flexible shifts starting from 08:30 to the last shifts of 13:30 to the management usage with 11 different shifts rather than only three shifts. In the end, the test with the different sales volume, employee number and sales area gave efficiency leverage 1,4%, 1,8% and 2,1%. Altogether, with the algorithm scheduling methodology in three store 1,8% efficiency increased achieved.

As shown in the Table 19, as long as the employee number and the sales volume goes higher, the efficiency gain rate of the algorithm goes higher as well. The more employees give the algorithm more flexibility to use more options from 11 different flexible schedules and compare with the alternative and try to find the best solution in terms of scheduling.

Table 19. The Result of Butcher Store's Test

Stores	Number of Employee (FT)	Daily Sales of Meat (Turkish Lira)	Sales Area (m2)	Total Period of Requirement	SER of Store Management	SER of Algorithm	Efficiency Increase
Dudullu M	4	9.384	974	368	86,4%	87,8%	1,4%
Kadıköy MM	5	11.375	1.233	614	77,7%	79,5%	1,8%
Ümraniye MMM	6	12.282	2.123	608	87,7%	89,8%	2,1%
Total of 3 Stores				**1.590**	**83,5%**	**85,3%**	**1,8%**

The company operated meat department in 974 of stores with the M, MM and MMM formats in the November 2019. 871 of the stores almost 89% of the stores have 2 or less butchers in the stores. When there are 2 or less employee in the operation there is no flexible shifts due to there must be at least one employee constantly in the department during the day. Therefore, one employee work in the morning shifts and the other employee works in the afternoon shifts. Therefore, neglecting the stores with 2 or less employee, the company's potential of workforce increase can be calculated.

The company potential is studied with only 103 of the stores shown in the Table 20 with the total 512 employees.

Table 20. The Potential Efficiency Increase of Butchers Operation in the Company

	Number of Stores			Number of Employees			Employee Saving Potential		
Formats	3-4	5	6+	3-4	5	6+	3-4	5	6+
M	2	1	0	8	5	0	0	0	0
MM	25	7	4	100	35	25	1	1	1
MMM	25	14	25	101	70	168	1	1	4
Sub Total	52	22	29	209	110	193	3	2	4
Total	**103**			**512**			**9**		

Three groups based on the employee number created to reach for the company view potential. The first group are the stores with 3 or 4 employees and accepted that they have efficiency rate of 1,4% as measured in the Dudullu M Store. The second group has the stores with 5 employees and the accepted that they have efficiency rate of 1,8% as Kadıköy MM store.

The last one is the store with 6 or more employee and the efficiency rate is 2,1% as in Ümraniye store. Calculating the potential saving of the butchers from these stores is 9 full time employees, which is in total 1,8% efficiency increase in the operation (See Table 20).

The efficiency increase in cashiers was 3,4% and in the stockers it was 3,7%. However, in butchers it is only 1,8%. This is most because of total number of employees are less than cashiers and stockers. Most of the time during each period there are one or two employees in the operations, which limits the flexible shifts advantage as in the other departments as well.

In 2019 the average employee cost to the company is nearly 3.500 TL, with the bonuses and side benefits. (TC Çalışma Bakanlığı, 2021)Having a potential of saving 9 Full Time employees gives 378.000 Turkish lira which is almost same profitable as operating 2 of small size M stores in 2019.

In the fourth paragraph, summaries and conclusion of the chapter has written:

- For the modelling the workforce scheduling an approach is defined by using a mixed integer linear programming model by using IBM CPLEX optimization tool for the departments of cashier, stockers and the butchers. The main of the work in the chapter is defining the schedules for the departments via algorithm-based scheduling and using the demand found in the Chapter III, where for each 30 minutes requirement of workforce calculated with empirical data of time study results and the data analysis of the sales data.
- The workforce scheduling model is established according to the government regulation, union rules and the company policies with having a mathematical model with the constrains applied to each of the departments of cashier, stockers and butchers. Comparing with the schedules made by the store manager, the efficiency increase percentages is calculated with Scheduling Efficiency Rate (SER). The KPI of SER is used to measure the difference between store managements schedules and the algorithm-based schedules, basically, evaluating a period in terms of over planning, under planning and fit planning.
- Cashiers, Stockers and Butchers algorithm-based scheduling tested in three different stores with the help of fingerprint data back testing and Scheduling Efficiency Rate of each results compared with the store management results. Cashiers scheduling algorithm could give in company view of 3,2% efficiency increase and 172 full time potential saving in the 2019 operation (7,3 Million Turkish Lira). Stockers scheduling algorithm could give in company view of 3,0% efficiency increase and 102 full time potential saving in the 2019 operation. (4,2 Million Turkish Lira). Butchers scheduling algorithm could give in company view of 1,8% efficiency increase and 9 full time potential saving in the 2019 operation. (378 Thousand Turkish Lira).
- From point view of store management guessing the manpower needs, to the algorithm-based scheduling methodology with much more details and data driven perspective helped to increase workforce efficiency in the company.

CONCLUSION OF THE DISSERTATION

The retail has $24 trillion dollars all around the world. The sector is getting bigger and multinational with the increase of organizational retailer ratio in countries and technology with e-commerce and m-commerce channels. Having coronavirus pandemic in early 2020, pushed the customers to the online channels. The e-commerce retail increased 27,6% in worldwide, where used to between 7% - 12% early years. Having hard competition in the sectors, new players entrance to market each year and low revenue percentage on the online operations squeezed the ratio of the company's profitability.

Managing the costs became priority of each company in terms of sustainability. Grocery retailers focuses on each progress of the cost minimizing projects, whether it is in the last mile operation or the workforce management. Most of the expenditure comes from the employees in the grocery retailer sector, companies have mostly brick-and-mortar stores.

In the grocery retail, the management of the operation is complex by itself due to unexpected events, different requirement for different departments and dynamic life of itself. Managing employees and having the right number of employees in the right time is the key success to have better sales revenues.

In the study, one of the biggest Turkish retailer Migros stores department are examined in the concept of looking for efficiency increase in the workforce management.

Having examined literature reviews, studies and the models used in retail as well as banking, manufacturing and the health sectors inspired to work on the problem of how we can increase the workforce efficiency by changing the schedules of employees. After having couple stores visits, the main department of the operations noted as cashiers, stockers and butchers to have studies on.

Thorough the study, time study observations with data analysis linked each other to configure the workforce requirement of any given 30 minutes and the scheduling, which fits best with the requirement, to establish algorithm-based solutions for each department.

In the cashier's department, 7-time studies with 60 hours conducted observing 12 different work structures to be able to understand the nature of the daily cashier routine. Analyzing sales data of 84.867 products with Python program with 16 different variables resulted the average scanning time of 10 different categories having also average customer time based on the payment methodologies. Compiling the time study results, data analysis of the cash register data, sales department's forecasted sales has resulted to be able to calculate the cashier requirement for any given 30 minutes period.

In the stockers department, 20-time studies conducted with 170 hours with the observation of 17 different work structures. The daily routine of a stocker has been established via time studies. Having Mobile Stocker Team results, which includes 133 days of progress with 203116 number of product and 523,4 days of replenishment time, outputs an average replenishment time for 5 different categories of stockers responsibilities. Uniting the sales data with the time studies and average replenishment time has resulted of 30 minutes period stockers requirements.

In the butcher's department, 12-time studies conducted with 102 hours of observation with 19 different work structures to have an idea about butcher's daily work routine. Having butcher's performance measurement studies, which have 21 days of meat preparation time of 58627 products, outputs 3 subcategories of meat department product preparation time. Having time studies, butcher's performance measurement study results and data analysis of cash register data helped to establish an employee requirement per 30 minutes periods.

The government regulations and the company policies taken into consideration in the scheduling algorithms. The constrains are regarded with mixed integer programming with the tool of CPLEX and having employee requirements per 30 minutes periods for each department resulted an algorithm-based schedules for each department.

Algorithm-based schedules with opportunity of having 10 different flexible schedules compared in three different store with store manager three shifts choices with the scheduling efficiency rate key indicator performance resulted workforce efficiency increase potential by 3,4% and 172 Full time employee fictitious saving with around 7,3 million Turkish Lira in 2019 cashier's workforce management operation in the all stores.

In the stockers, having 12 different flexibles schedules and comparison the store management schedules in 3 different stores resulted workforce increase potential by 3,7% in the workforce management operation. Having 3370 employees in 2019 all over the country, the algorithm-based scheduling offers 102 full time fictitious saving with around 4,2 million Turkish Lira in stockers workforce management operation in Migros.

The butchers having 11 different flexible schedules with the test in 3 different stores resulted potential efficiency increase by 1,8%. Migros operating 974 stores with meat department and 871 of the stores have 2 or less butchers in the operation. Therefore, the

algorithm-based scheduling can be applicable only for 103 stores. The new approach offers 9 full time fictitious saving around 378 thousand Turkish Lira in the meat department's operation.

In the study, total of 332 hours of time study observation with data analysis of 346610 products with different methods and approaches via using modelling tools leveraged the company to have an algorithm-based scheduling structure. This will not only help to increase the workforce efficiency, it will be beneficial to store management as well, in terms of spend less time on the weekly scheduling. Having flexible shifts may also be useful for the employee in terms of taking care of personnel needs in workdays.

The study offers a complete and inclusive approach in terms of a retail store scheduling progress, having cashiers, stockers and a service section of meat. The literature enriched especially with the studies of stockers and butchers, where the literature is very limited. A product average scanning time of categories; a product replenishment time of categories; a product preparation time of meat department subcategories' values and an average daily routine of the jobs and work structure distribution percentages has been included in the literature with this study.

The approach in the study offers a complete solution to a workforce management system starting from understanding job responsibilities, daily work routines with time studies and supported with data analysis. Therefore, it can be used in the different departments of grocery retailers such as fruit&vegetable, bakery or delicatessen and it is also applicable for non-retailer sector as well in terms of applying the aspects of the workforce managements.

IV. REPORT ON THE CONTRUBITIONS IN THE DISSERTATION WORK

1. Based on the studied literature sources and models applied in the banking, manufacturing, health and retail sectors, an in-depth study of the empirical factual picture in the retail sector (at the level of: international market, national market and individual company – following the example of Migros, Turkey) has been made. Unused fields for implementing software solutions and achieving time efficiency by forecasting the workforce and optimizing the work schedules of the company's employees have been identified. The literature enriched especially with the studies of stockers and butchers.

2. By applying a mathematical approach to interrelated methodologies for monitoring and analysing data on key performance indicators on labour requirements and algorithms for planning the organization of work of a company, a methodology for research, development and subsequent improvement of an algorithm for forecasting the requirements for the workforce at the level of a company department (following the example of Migros, Turkey) has been constructed, with targets: improving the customer experience, improving strategic decisions, improving operational results, reducing costs, improving demand forecasting, successful forecasting of trends, etc. The data analysis is aimed at identifying opportunities to achieve a higher degree of customer satisfaction through efficient and better quality of service. The approach in the study offers a complete solution to a workforce management system starting from understanding job responsibilities, daily work routines with time studies and supported with data analysis

3. Based on the author's methodology for data research and analysis, development and subsequent improvement of an algorithm for forecasting the requirements for the workforce at the company level (following the example of Migros, Turkey), an algorithm for workforce planning at the department level has been developed and tested as an organizational and management tool for searching and identifying opportunities for achieving time efficiency on the basis of a key performance indicator (SER – Scheduling Efficiency Rate. The study offers a complete and inclusive approach in terms of a retail store scheduling progress, having cashiers, stockers and a service section of meat.

4. Through the development, testing and implementation of the workforce forecasting algorithm to optimize Migros work schedules, positive effects have been achieved, related to increasing the workforce potential, saving labour and significantly reducing the company's costs.

V. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

I. Articles (3):

1. **Guney, E. Zafer** (June, 2019). Forecasting workforce for store attendants in a grocery retailer. *Knowledge - International Journal*. 31.1, pp. 293-298. ISSN: 2545-4439.

2. **Guney, E**. **Zafer** (2019). Butchers scheduling model examination by time study observations. *Годишен алманах „Научни изследвания на докторанти". СА „Д. А. Ценов",* Свищов: АИ Ценов, т. XII, кн. 15, с. 398-407. ISSN 1313-6542. **[Guney, E. Zafer** (2019). Butchers scheduling model examination by time study observations. *Annual Almanac PhD students Scientific Researches. Tsenov Academy of Economics.* Svishtov: Tsenov Publishing House, vol. XII, iss. 15, pp. 398-407, ISSN 1313-6542.**]**.

3. **Guney, E**. **Zafer** (2021). Workforce efficiency increase for online sales in-store picking operation. *Годишен алманах „Научни изследвания на докторанти". СА „Д. А. Ценов",* Свищов: АИ Ценов, т. XIII, кн. 16. ISSN 1313-6542. (под печат) **[Guney, E. Zafer** (2021). Workforce efficiency increase for online sales in-store picking operation. *Annual Almanac PhD students Scientific Researches. Tsenov Academy of Economics.* Svishtov: Tsenov Publishing House, vol. XIII, iss. 16. ISSN 1313-6542 (in print)**]**

II. Scientific papers (1):

1. **Guney, E. Zafer** (2018). The efficiency increase in cashier performance. *Сборник-доклади от Международна научно-практическа конференция „Възможности за развитие на бизнеса – икономически, управленски и социални измерения".* СА „Д. А. Ценов" – Свищов, 30 Ноември 2018, Свищов: АИ Ценов, т. I, с. 550-561. ISBN: 978-954-23-1702-9. [**Guney, E. Zafer** (2018). The efficiency increase in cashier performance. *Proceedings of the International scientific-practical conference „Opportunities for business development - economic, managerial and social dimensions".* Tsenov Academy of Economics, November 30, Svishtov: Tsenov Publishing House, vol. I, pp. 550-561, ISBN: 978-954-23-1702-9.**]**

VI. DECLARATION OF ORIGINALITY AND RELIABILITY

from Emre Zafer Güney

In connection with the procedure for obtaining the educational and scientific degree “Doctor” in the scientific specialty “Economics and Management (Industry)”, I declare that:

1. The results and contributions to the dissertation on “Algorithms to Forecast Workforce” are original and are not borrowed from research and publications in which the author has no participation.

2. The information presented by the author in the form of copies of documents and publications, personally compiled reports, etc. corresponds to the objective truth.

3. The results obtained, described and / or published by other authors are duly and in detail cited in the bibliography.

14.06.2021
Svishtov

Declarant: ……
Emre Zafer Güney