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# The Potential of Self-service technologies in a Football Stadium: A Case Study at Stadion Feijenoord



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# Preface

This thesis investigates the use of self-service technologies (SSTs) in public catering systems at football stadiums, focusing on Stadion Feyenoord. This research uses Stadion Feyenoord's data to evaluate the efficiency and benefits of various SSTs.

I would like to extend my thanks to Ron Beenhakker for providing the opportunity to conduct my research at the iconic Stadion Feijenoord. I greatly enjoyed my time during the last half-season at Stadion Feijienoord and appreciate Ron's guidance, along with the support from Demi and Danny.

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Lastly, a big thanks to my family and friends for their constant support, great advice, and encouragement. You made the last six months really enjoyable!

# Abstract

**Purpose** - This research aims to explore the potential of Self-Service Technologies (SSTs) within football stadiums, with a particular focus on Stadion Feijenoord ”De Kuip” as a case study. The willingness to adopt these SSTs will be explored, along with assessing the potential added value they may bring in terms of reducing costs and enhancing customers satisfaction and strategies for their effective implementation.

**Approach** - Firstly, literature on SSTs and hospitality in general and within stadiums is reviewed. Then, with stated choice experiments, data collection and observations, the willingness to adopt and the potential added value of SSTs will be investigated.

**Value** - SSTs in hospitality are gaining traction. Although, research about the implementation of SSTs in football stadiums is scarce. This research should provide insights about whether and how to implement SSTs in football stadiums.

**Keywords** - Self-service technologies, stadiums, choice experiment, adoption, supporters experience, productivity

# Summary

In recent years, the Self-service technologies (SSTs) have been gaining traction, including in the hospitality sector. However, SSTs are still in the early stages of being adopted in the public catering systems of football stadiums. The SSTs could be an innovative solution to reduce waiting times and enhance supporter experience. Moreover, SSTs have the potential to increase cost-efficiency by reducing personnel costs.

Over the years, Stadion Feijenoord has not invested in innovative projects for its public catering system, anticipating a move to a new stadium. However, the plans for the new stadium did not go ahead. As a result, Stadion Feijenoord need to invest in their current stadium as they did not do over the last ten years.

Therefore, Stadion Feijenoord is interested in exploring the opportunities presented by SSTs in the public catering system. This research aims to evaluate the potential added value of implementing SSTs in De Kuip, considering the willingness of the crowd to adopt these technologies. The study will focus on the impact on supporter experience, cost reduction, and revenue enhancement for Stadion Feijenoord. Ultimately, an advise is provided on whether and how to effectively implement SSTs in Stadion Feijenoord.

To address the aforementioned knowledge gap, the main research question of this study is:

**What specific self-service technologies should be implemented in the public catering system at football stadiums to enhance supporter experience, reduce waiting times, lower costs, and increase revenue?**

The following sub-question are formulated in assisting getting an answer to the main research question.

*1. What SSTs are already integrated in hospitality and what SSTs are available to integrate in the future into stadiums?*

*2. What are the key determinants of success of SSTs in the public catering system?*

*3. How can a choice model be estimated in order to investigate the crowd's intention to use SSTs based on the key determinants of the public catering system?*

*4. What is the potential benefit of SSTs in public catering?*

*5. How should the SSTs be implemented and what are important factors that should be taken into account during implementation?*

To answer all these research question several methods are applied throughout the research: literature review, choice modeling, survey, data analysis, and observations.

The Self-Ordering kiosk (SOK), the snack wall, the mobile ordering platform (MOP), and the automated beer tap system are identified as SSTs through a literature review. These SSTs are thoroughly examined throughout the research. Moreover, the literature indicates that waiting time and convenience are key determinants of a successful public catering system. Later in the research, the system description reveals that walking distance to the counter is the third key determinant in the public catering system.

For the choice experiment, a survey was distributed to a group of supporters after Feyenoord matches against PEC and Excelsior. This resulted in 1,241 respondents, each of whom answered four choice sets. Consequently, a total of nearly 5,000 choices were made. In each choice set, respondents had to choose between the normal counter and the SST counter, with varying attribute levels for each alternative. The attributes were based on the key determinants: waiting time, walking distance, and convenience. A multinomial logit (MNL) model will predict the probabilities for the different options. This resulted in that when all attribute levels between the two options are the same, the probability of a supporter choosing the normal counter is 64%, while the probability of choosing the SST counter is 36%. The estimates for the each parameter are shown

in Table 1, where waiting time is in minutes, walking distance in meters, and convenience in percentages. Positive estimates increase utility, while negative estimates decrease it. Higher utility translates to a higher likelihood of choosing a specific alternative. Therefore, waiting times and walking distance negatively impact utility, whereas convenience has a positive effect. The parameter $\beta_{normalcounter}$ represents the base alternative, comparing the utilities of the "normal" current counters to the SST counter. A positive value suggests that Feyenoord supporters favor the "normal" counters over the SST counters.

| Attribute | Estimate | Std. Error | p-value |
|---|---|---|---|
| $\beta_{\text{waiting time}}$ | -0.245 | 0.014 | 0.000 |
| $\beta_{\text{walking distance}}$ | -0.005 | 0.000 | 0.000 |
| $\beta_{\text{convenience}}$ | 0.001 | 0.000 | 0.002 |
| $\beta_{\text{normal counter}}$ | 0.560 | 0.031 | 0.000 |

Table 1: MNL Model Estimates and characteristics of the attributes of all data

| Counter type | Service time (s) |
|---|---|
| *Normal counter* | 34.5 |
| *Hot food stand counter* | 32.2 |
| *Beer counter* | 19.6 |
| *SOK* | 50.4 |
| *Automated beer tap system* | 35.0 |
| *Snack wall* | 13.3 |

Table 2: Service time per transaction of different counter types

To explore the potential added value of the SSTs involving reduced waiting times and personnel costs, the services and waiting times of different counter types were obtained through data analysis and observations. Data analysis is done through analyzing of the number of pin transaction during the halftime of the Feyenoord match against Ajax. Observations were conducted at home games against FC Utrecht, Ajax, PEC, and Excelsior. Besides, observations were carried out at the Johan Cruijff Arena, the stadium of football club Ajax, to obtain the service times for the SOK, and at Rotterdam Central Station to capture service times for the snack wall.

Table 2 presents the different service times for each counter type. The normal counter can be compared to the SOK, the hot food stand counter to the snack wall, and the beer counter to the automated beer tap system. These comparisons will be considered when deciding on counter replacements. The average waiting time at the normal counter at Stadion Feijenoord, obtained through observations, is 3.46 minutes.

Based on these service times, the potential saved working hours are calculated. Using this information, the potential cost savings on personnel can be determined. Table 3 provides an overview of these numbers. The working hour savings are based on the assumption that all counters are replaced by the corresponding SST counters. Productivity increase is measured in euros revenue per employee per hour. Finally, the cost reduction is calculated as the total amount of euros that can be saved if all counters are replaced. As can be seen, significant working hours can be saved, employee productivity can be increased, and personnel costs can be reduced.

| Counter | Δ working hours | % | Δ productivity | % | Personnel cost reduction |
|---|---|---|---|---|---|
| *SOK* | 6669 | -32% | 116€ | 46% | €167,477 |
| *Automated beer* | 790.5 | -59.5% | 465€ | 146% | €19,763 |
| *Snack wall* | 872 | -14.5% | 24€ | 17% | €21,800 |

Table 3: Summary productivity and cost efficiency over the season 23/24

This last sub question is addressed in the design phase. During implementation, all SST counters and their corresponding findings are taken into consideration. The SOK and snack wall are potentially suitable for replacing or partially replacing the normal and hot food counters. The automated beer tap system shows less potential to replace the current beer counters but could complement the public catering system at Stadion Feijenoord effectively. For the implementation, it is recommended to initially focus on partially replacing different types of counters. Given that supporters prefer the normal counter over the SST counter, allowing supporters to choose their preferred type of counter ensures that the implementation of new SST counters is not at the expense of the supporters experience.

The research gap is parly solved since this research contributed to understand the potential added value of SSTs in the public catering system of Stadion Feijenoord and has estimated the preferences of the supporters

regarding SST at the stadium. These insights indicate that SSTs present opportunities to enhance the public catering system at Stadion Feijenoord. For further research, it is recommended to investigate supporter preferences across different types of SSTs. Additionally, conducting more extensive research on the service times obtained and exploring the adoption rate of new innovations at football stadiums, along with effective strategies to stimulate this adoption rate, are key aspects for successful implementation.

# List of Abbreviations

| Abbreviation | Meaning |
|---|---|
| SOKs | Self-ordering kiosks |
| SSTs | Self-service technologies |
| TAM | Technology Acceptance Model |
| F&B | Food and Beverage |
| SCE | Stated Choice Experiment |
| RUM | Random Utility Maximization |
| MNL | Multinomial logit model |
| MCDA | Multi-criteria decision analysis |
| CVM | Contingent valuation methods |
| CE | Choice experiment |
| WTP | Willingness to Pay |
| WTA | Willingness to Adopt |

| Symbol | Definition |
|---|---|
| $\lambda$ | Arrival rate |
| $\mu$ | Service rate |
| $W$ | Average waiting time |
| $P_i$ | Probability to choose alternative $i$ |
| $V_i$ | Systematic utility of alternative $i$ |

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# 1 Introduction

## 1.1. Introduction

Football clubs need their fans and fans need their football club. The supporter experience is one of the key aspects driving supporters to the stadium, a principle equally applicable to football club Feyenoord. One element that is important for the supporter experience is food and beverage offerings (Oracle, 2018). Unfortunately, due to the absence of the anticipated new Feyenoord stadium, investments in the "old" stadium, Stadion Feijenoord also known as De Kuip, have stagnated over the past decade. This lack of investment has had a negative impact on the fan experience, regarding the stadium facilities. This aligns with the fact that the stadium's physical environment is considered as one element that influences spectators' desire to stay at and revisit the stadium (Wakefield, Blodgett, & Sloan, 1996). Besides, over the past years, stadiums face increasing competition from home-viewing options (Giorgio, Deweese, Reicheld, & Ebb, 2018). Now that the plan for a new stadium has been scrapped, Feyenoord is keen and ready to invest in Stadion Feijenoord. The club is committed to exploring innovative measures to enhance the supporter experience and increase its own revenue streams. In essence, Feyenoord aspires to establish Stadion Feijenoord as an innovative stadium, particularly in terms of its food and beverage offerings.

Self-service technologies (SSTs) are rapidly gaining traction in the restaurant industry (Hanks, Line, & Mattila, 2016). Integrating SSTs into the food and beverage section of Stadion Feijenoord could serve as an innovative solution to enhance the supporter experience. Long waiting times for food and beverage orders have been shown to significantly reduces supporter satisfaction (Chen, 2019). Additionally, SSTs offer firms to reduce their labor costs (Collier & Kimes, 2013). Examples of SSTs include Self-Ordering Kiosks (SOKs) and mobile platforms for online ordering. Currently, the SSTs are becoming more popular in restaurants, however their adoption in football stadiums remains limited, though supporters report interest in them (Oracle, 2018).

Additionally, this research will dive into the acceptance of a new technology considering the unique crowd of Feyenoord. Many research theories are written about the acceptance of new technology. However, Feyenoord has a unique crowd that may not necessarily correspond with previous research on the acceptance of new technologies. Individual differences, innovation characteristics, context, and social influences seem to be important factors (Na, Yang, & Lee, 2021) (Samengon et al., 2020).

Finally, it is crucial for Feyenoord to know whether and how to implement to the SSTs. The added value, the number of kiosks, the usability, and the costs will be considered.

Summarized, two knowledge gaps were found:

1. It is unclear why SSTs are implemented less frequently within football stadiums compared to other hospitality settings.
2. There is insufficient knowledge about the potential impact of SSTs on supporter experience and revenue optimization in football stadiums.

## 1.2. Problem Definition

Due to the planned closure of Stadion Feijenoord and the construction of a new stadium for Feyenoord's first team, Stadion Feijenoord did not prioritize investing in innovative methods to enhance service quality for supporters during matches. One big culprit for derailing food and beverage sales is slow service (Oracle, 2018). Even the perception of lengthy waits at concessions will drop sales. Research indicates that minimizing waiting times is crucial for satisfying food and beverage services. Considering the USA, 42% of US supporters reported that long waiting lines deterred them from purchasing food or beverages at least once in the past 12 months (Oracle, 2018). Additionally, supporters across all countries expressed that they would consider increasing their spending by at least 30% if wait times were cut in half (Oracle, 2018). Hence, fixing issues as long waits enhances supporter experience and increases revenue. SSTs could be a solution to reduce the waiting times and improve the service quality and supporter experience. Furthermore, SSTs can be a solution for shortage of staff. SSTs has the potential to increase productivity, and consequently reduce personnel costs. Additionally, shorter service times could lead to higher revenue as more customers can be served in less time. Currently, such options are scarce in Stadion Feijenoord. A mobile ordering platform (MOP) and self-ordering kiosks (SOK) are examples of SSTs. The added value of these SSTs must be explored. Besides, it is questionable if supporters report interest in using the SSTs, this needs to be investigated.

## 1.3. Research Objective

As the plans for a new stadium for Feyenoord are shelved, Stadion Feijenoord decided that they must invest in the current stadium to improve the supporter experience. The public catering is one of the aspects intended for improvement. SSTs are being considered as a potential solution to enhance the supporter experience, while also reducing costs and increasing revenue for the club. To be clear; the research objective for this research is set as follows:

Exploring the potential benefits of implementing SSTs at Stadion Feijenoord, considering the willingness of the crowd to adopt these technologies, in terms of supporter experience, reducing waiting times, reducing costs and increasing revenues. The outcome of this research will provide an advise on whether to invest and how to effectively implement SSTs at Stadion Feijenoord.

## 1.4. Research Questions

Based on the two knowledge gaps, the main research question is set as follows:

*Main research question:*
**What specific self-service technologies should be implemented in the public catering system at football stadiums to enhance supporter experience, reduce waiting times, lower costs, and increase revenue?**

*Sub-questions:*

*1. What SSTs are already integrated in hospitality and what SSTs are available to integrate in the future into stadiums?*

*2. What are the key determinants of success of SSTs in the public catering system?*

*3. How can a choice model be estimated in order to investigate the crowd's intention to use SSTs based on the key determinants of the public catering system?*

*4. What is the potential benefit of SSTs in public catering?*

*5. How should the SSTs be implemented and what are important factors that should be taken into account during implementation?*

## 1.5. Methods

Different research methods are used to answer each sub-question and ultimately the main research question. These methods are described in detail in Chapter 2. For the first two sub-questions, literature research is executed. For the second, third, and fifth sub-questions desk research is used. Choice modeling and a survey is utilized to answer the third sub-question. Data analysis and observations are assessed to investigate the potential added value of SSTs in Stadion Feijenoord.

| **Sub-Question** | **Methods** |
|---|---|
| Q1 | Literature Research |
| Q2 | Literature Research, Desk research |
| Q3 | Literature Research, Choice modeling, Survey |
| Q4 | Survey, Data analysis, Observations |
| Q5 | Desk research, Choice modeling |

Table 1.1: Research methods per sub-question

## 1.6. Scope

This research focuses on the potential benefits of SSTs for supporters and Stadion Feijenoord, as well as the willingness of supporters to adopt these technologies. These benefits of SSTs in football stadiums are examined with a case study focusing on Stadion Feijenoord. To understand supporter preferences and answer specific sub questions, surveys will be conducted among the crowd.

Besides, the focus lies on the logistics of food and beverage within the football stadium, particularly the ordering process within the public catering system. Possible implications with the supply outside the stadium by implementing SSTs is left out of the scope.

Lastly, the observations will be conducted during six football matches across three different stadiums: four matches at Stadion Feijenoord (Feyenoord vs. FC Utrecht, Feyenoord vs. Ajax, Feyenoord vs. PEC Zwolle, and Feyenoord vs. Excelsior), one match at the Johan Cruijff Arena (Ajax vs. Excelsior), and one match at the Philips Stadion (PSV vs. Sparta).

## 1.7. Structure of the report

The structure of the report is outlined in Figure 1.1. It provides an overview of the different chapters and specifies which sub-questions will be addressed in each chapter. The report concludes with the most significant findings summarized and recommendations provided to Stadion Feijenoord.

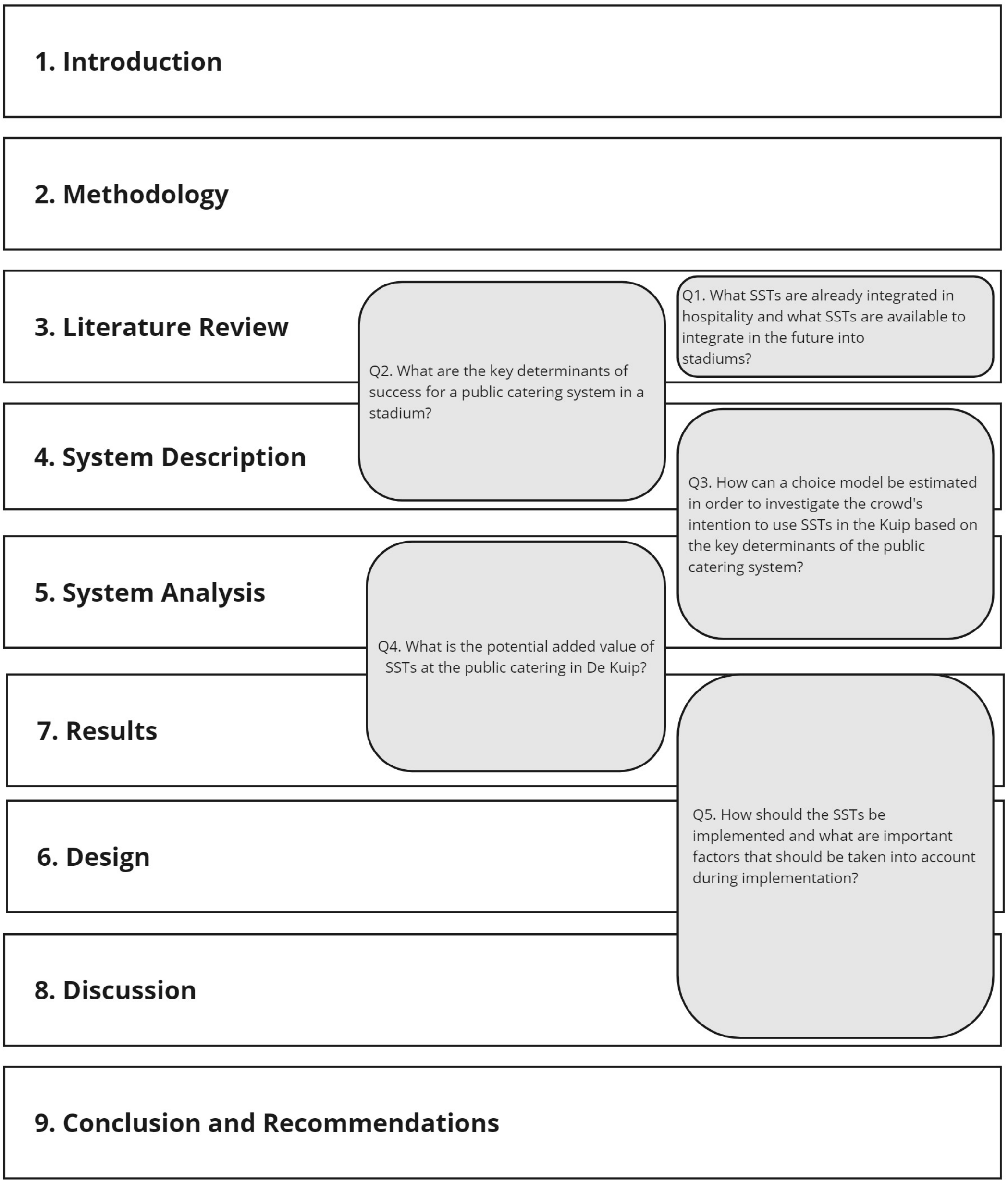


Figure 1.1: Structure of this research

# 2

# Methodology

This chapter delves into the different methods used. Following this, the research framework is considered.

## 2.1. Research Methods

Table 2.1 presents an overview of the methods used for each sub-question. Additionally, it shows the goal of each sub questions and indicates the chapter where the corresponding information can be found.

| Question | Goal | Methodology | Chapter |
|---|---|---|---|
| 1. What SSTs are already integrated in hospitality and what SSTs are available to integrate in the future into stadiums? | Understanding the current state of SSTs in hospitality and exploring the options for SSTs in stadiums | Literature review | 3 |
| 2. What are the key determinants of success for SSTs in the public catering system at Stadion Feijenoord? | Obtaining the important factors for supporters when choosing between certain service options | Literature review<br>Desk research | 3, 4 |
| 3. How can a choice model be estimated in order to investigate the crowd's intention to use SSTs at Stadion Feijenoord based on the key determinants of the public catering system? | Understanding the relative importances between the key attributes. Predicting the probabilities of the choice behaviour between counter types. | Desk research<br>Choice modeling<br>Survey | 5 |
| 4. What is the potential added value of SSTs in the public catering at Stadion Feijenoord? | Knowing the added value of implementing certain type at Stadion Feijenoord considering the KPIs | Survey<br>Data analysis<br>Observations | 7 |
| 5. How should the SSTs be implemented and what are important factors that should be taken into account during implementation? | Developing a design of how, where, and what should be implemented in Stadion Feijenoord to maximiuze the KPIs | Desk research<br>Choice modeling | 6 |

Table 2.1: Sub-questions, their goal, methods and chapter

**Literature Research**
In order to answer sub-question 1 and 2, literature research is executed. Literature research is useful to get better understanding what factors influence people's choice behavior for catering during events. Besides, the literature is usefull to know the newest development regarding the SSTs and its implementation.

**Desk research**
Desk research is needed to apply the findings of the literature research, choice modeling, observations, and data to the context of Stadion Feijenoord.

**Choice modeling**
The choice modeling is crucial to get understanding in the supporters behavior and their willingness to use SSTs at the public catering of Stadion Feijenoord.

**Survey**
Surveys are used to know the current supporter experience involving the public catering at Stadion Feijenoord.

**Data analysis**
Data analysis is executed to get insights in the current public catering system. The throughput at the cash registers and the personnel productivity can be determined by data analysis.

**Observations**
Observations during games of Feyenoord are executed to validate the supporters experience. Waiting and service times at the queue for various SSTs are explored. Additionally, the queuing process at the counters can be examined, aiming to determine the average waiting time, arrival rate, and service rate.

## 2.2. Research Framework

To provide an overview of this research, the different steps of this research are outlined in the form of a research framework. The research framework is based on the design framework of Herder and Stikkelman (2004).

#### Problem Analysis

As stated before, the goal is to explore the potential benefits of implementing SSTs at Stadion Feijenoord, considering the willingness of the crowd to adopt these technologies, in terms of supporter experience, reducing waiting times, reducing costs and increasing revenues. The outcome of this research will provide an advise on whether to invest and how to effectively implement SSTs at Stadion Feijenoord.

#### System Description

In this section all components of the public catering system at Stadion Feijenoord are identified. This entails the food & beverage preparation, sales, distribution and consumption. The preparation is about how the f&b is prepared, the time it takes, the space it occupies, prepared f&b before sellings, the personnel required and the types of equipment. The sales is about, the personnel required, the working and the number of cash registers, the queue length and the waiting and service time. The distribution includes, the location of the concession stands, the stockroom, the stock level per counter, the runners. Lastly, the consumption is about the supporters, the quality of the food, the costs, and the location where to eat or drink their consumption. This is done to all SSTs that will be discussed in Section 3.1. Finally, the evaluation criteria for all SSTs and KPI's for the public catering system as a whole are determined.

#### System Analysis

The current state of the identified components and the system as a whole is analyzed in this section. Strong points and weaknesses will arise. As illustrated in Figure 2.1, data and models help with doing the analysis.

For this system analysis, a wide range of data must be collected. This includes the number of concession stands, sales per concession, food and beverage offerings, personnel schedules, queue lengths, customer satisfaction surveys, and feedback from supporters. Additionally, choice modeling is employed to get insights in the preferences of the public catering system in Stadion Feijenoord. Lastly, findings from observations at Stadion Feijenoord, Philips Stadion and Johan Cruijf Arena are used. Based on this analysis, potential improvements to the system may already begin to emerge.

#### SST Evaluation

The possible improvements of the SSTs will be assessed in this section, focusing on time savings, increased convenience, revenue growth, and cost reduction. This assessment will be conducted using a Multi-Criteria

Decision Analysis (MCDA) and by testing the key performance indicators (KPIs). Based on the results and performance of each SST, several design will be considered.

#### Design

From the output of the evaluation and results, a new design can be formulated. This section will determine if and where new SSTs could be implemented to achieve the set goals. Each SST will be discussed and considered for its optimal placement and timing of use.

#### Implementation

In this section the implementation is discussed at a micro level. This includes the type of SSTs, the placement, the costs, and the profits. The monitoring and the marketing of the implementation falls not into the scope of this research as the SSTs will not be implemented before the end of this study.

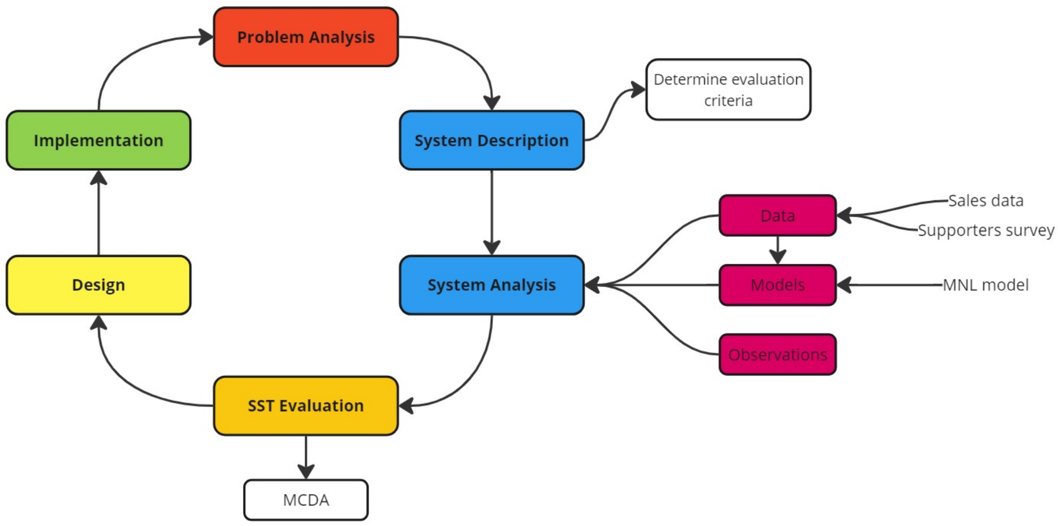


Figure 2.1: Research Framework based on Herder and Stikkelman 2004

# 3

# Literature and Background

Big events as sports games, festival, and concerts attract enormous crowds. Well-organized logistics are required to meet the food and beverage demand of the crowd. Although, these events pose unique challenges to the food and beverage logistics as these events do often not occur regularly and massive crowd come and go within a relative short time period. The peaks in consumption are high. Consequently, the challenges occur in efficient and effective procurement, distribution, consumption, inventory management and crew scheduling. Besides, factors as safety and crowd management need to be taken into account.

Each event is different, the attendance, the time of the year, the artist, the opponent, the employees. There are 6 key factors identified regarding the logistics of big events. Firstly, logistics planning and coordination, an effective planning is crucial for a smooth operation. Procurement and supply needs to be on time and crew scheduling needs to be properly arranged. Secondly, effective inventory management is essential for large events to ensure crowd satisfaction, maximize revenue, and minimize stock loss and theft. Thirdly, the distribution is a key factor. This is about the routes and vehicles or runners used. Fourthly, the quality of the f&b needs to be on point, preventing the events from safety issues. Fifthly, the sustainability is an growing important aspect. For example reducing the amount of plastic is a hot topic. Sixthly, the integrating of technology can play an important role in logistics. For instance, data analytics, SSTs and tracking system can enhance the efficiency of the supply chain. Within this research the focus lies sixth key factor on integrating technology into the logistics system. Next, self-service technology is considered as a whole and certain SSTs are discussed itself.

The following sub-question will be answered in this chapter:

*Sub question 1: What SSTs are already integrated in hospitality and what SSTs are available to integrate in the future into stadiums?*

## 3.1. Self-service technologies

Currently, in this fast-paced world technology plays a major role in the daily life of people. The technology provide services as transactions where there is no or minimal need for human interaction. The customers (partly) perform the service, which was traditionally performed by a service employee. The number of customers interacting with technology is growing (Taillon & Huhmann, 2019). Hence, SST use continues growing. SSTs refer to technological interfaces that empower customers to produce a service independent of direct involvement from service employees (Meuter, Ostrom, Roundtree, & Bitner, 2000). Companies implement these SSTs to increase the companies' productivity and simultaneously enhancing customers experience with convenient technology and reducing waiting times (Meuter, Ostrom, Bitner, & Roundtree, 2003) (Walker, Craig-Lees, Hecker, & Francis, 2002). The increased productivity leads to cost reduction. Besides, fewer service employees are needed which minimize the costs of firms. Additionally, the technological interface can be adjusted to guide customers to specific purchases which can help with the inventory management. From the customer's perspective, SSTs improve service delivery by providing a standardized transaction process. This standardized approach enhances transaction efficiency, leading to increased customer satisfaction.

Thus, SSTs have the potential to enhance customer experience, improve firm productivity, and reduce costs. Besides, it can increase the speed of transactions, and consequently reducing the waiting times. Customers can be guided to specific purchases which can help with the inventory management and provide more consistent service encounters compared to interactions with firm employees.

Nowadays, SSTs are extensively integrated into various sectors such as retail and hospitality. Supermarkets provide self-scanning and self-checkout technologies for their customers. In this case, the service employee for checkout became redundant. Considering hospitality, SSTs have been widely used in food service industry since they are perceived to enhance service quality and built new experience that can gain satisfaction from the customer (Yaacob, Abdul Aziz, Ahmad, & Ismail, 2022). Fast-food restaurants, in particular, are embracing SSTs due to their high customer throughput. The Self-Ordering Kiosk (SOK) is one of the SST that has been adopted in the food service industry. More and more people and restaurant adopt this SOKs. Moreover, SOKs show potential in reducing the waiting times, enhancing customers satisfaction and lowering firms costs. Studies show that SSTs can improve the customer loyalty, satisfaction and trust (Meuter et al., 2000). However, it is crucial to ensure that the technology functions well to realize these benefits.

On the other hand, SSTs entail some disadvantages. The implementation is costly and can be complex. Research shows that SSTs are prone to failure and that failures leads to frustrating customers (Bitner, Ostrom, & Meuter, 2002). Especially for smaller firms, the implementation costs and sensitivity to failure can be a threshold for introducing SSTs to their company. Additionally, studies have identified technology anxiety and need for interaction as influencing factors for SST usage (Walker et al., 2002) (Meuter et al., 2003). From both the customer and firm's perspectives, these factors could deter the implementation of SSTs, leading to customer dissatisfaction and potential revenue loss for the firm.

When considering the SSTs in football stadiums, smart tools have been integrated in football stadiums over the years (Yang & Cole, 2022). Smart tools that assist in crowd control, cleaning and maintenance management, energy consumption, staffing and ticketing check-in have proven their benefit. However, SSTs in stadiums are in the beginning phase. Simulations of SOKs counter show potential in reducing the total time in system (Chen, 2019). At the end 2023, the SOK is tested and implemented in the Johan Cruijff Arena. In summary, SSTs in football stadiums are in the beginning phase and there remain numerous opportunities for exploration.

#### Mobile Ordering Platform

Mobile Ordering Platform (MOP) is increasingly integrated in hospitality throughout the world. Mobile ordering involves the online ordering of f&b via your mobile device. Customers can place orders by scanning a QR code. The proposed system automates customer bills after the order, and no human mistake can be made by putting the order in the system (Wong, Chong, Chong, & Law, 2023). Besides, the provider can modify the interface of all product to steer the customer towards certain purchases (Wong et al., 2023). Lastly, the online ordering process overcomes the queuing for ordering and customers can track their order (Adithya, Singh, Pathan, & Kanade, 2017). A downside of the MOP is the technical implementation and usage. For instance, implementing a proper control system is necessary to adjust waiting times based on the volume of orders received. On the other hand, disadvantages of the system are: cost of installation and running the system and online ordering has the potential to increase rush time volume, which exceeds the capacity and will overwhelm the personnel (Kimes & Laque, 2011).

#### Self-Ordering Kiosk

SOKs are well-integrated into the fast food industry. At a SOK, customers place their orders themselves at the kiosk. Similar to the MOP, no human mistake can be made and the restaurant can modify the menu to their preferences. In fast food restaurants, the SOKs show potential to increase customers satisfaction and reduce costs (Ishak, Lah, Samengon, Mohamad, & Bakar, 2021). Human interaction disappears by the use of SOKs, which can be positively and negatively affect the customers satisfaction based on personal preferences. However, the satisfaction is mainly dependent on the ease of use, interface, and reliability of the technology (Meuter et al., 2003). The success of a SOK depends on how well the system is implemented and usability of the system.

**Snack Wall**

The snack wall is predominantly used in Netherlands. Originally, the snack wall comes from Germany, Max Sielaff invented the snack wall in 1888. He started the company AUTOMAT and obtained patent on it. The first snack wall opened in 1895 and later in 1902 in the United States (Philadelphia) (History Associates, 2020). The snack wall failed to gain traction in Germany and the United States. However, in the Netherlands, its implementation has proven successful, and it continues to be widely used by the Dutch. There is limited research conducted on the snack wall. The closest area of research is focused on automated vending machines. This research is executed to explore the key determinants of the automated vending machine that increase the sales volume. Healthy food, localization, maintenance, and payment methods seem to be important factor to increase sales volume (Mnyakin, 2021). The snacks in a snack wall are already prepared, eliminating preparation time, which is an advantage. However, a disadvantage is that the snacks might remain in the wall for too long. The context of Stadion Feijenoord differs from the broader context presented in the literature. However, maintenance, localization, and healthy food seem to be relevant factors for this research as well. When it comes to healthy food options, the variety of products offered is crucial. Furthermore, the location of the snack wall is an important aspect that needs to be considered for implementation. Besides, with proper maintenance hiccups are minimized which increased the supporters satisfaction and experience.

**Automated beer tap system**

Limited research has been conducted on the automated beer tap system. These systems allow users to pay for their beers and then dispense their own drinks. This SST is already implemented at gas stations, where customers first pay for their fuel before filling up their cars. As well as the other SSTs, this technology can increase the customers experience. Research illustrates the importance of fun during the ordering process (Collier & Barnes, 2015). Fun is one the determinants of the customers satisfaction. Automated beer tap systems leverage the concept of putting enjoyment into the ordering process. (Collier & Barnes, 2015).

Table 3.1 shows the differences among the different SSTs. This will be further elaborated upon in Section 4.2.

| **Self-service technology** | **Order and supply** | **Preparation** | **Human interaction** |
|---|---|---|---|
| *Mobile Ordering Platform* | Separate | Preparation on order | Partly |
| *Self-Ordering Kiosk* | Separate | Preparation on order | Partly |
| *Snack Wall* | Integrated | Pre-preparation on stock | None |
| *Automated beer tap system* | Integrated | Preparation on order | None |

Table 3.1: Different characteristics per self-service technology

## 3.2. Key determinants of success in SST implementation

In order to assess the potential of SSTs, it is essential to examine the key determinants the determine the success of SSTs in the public catering system. Considering the stakeholders, which include the users (supporters) and provider (Stadion Feijenoord). For the users, it is about the customer experience of the process, which is influenced by the attributes of the public catering system. These are discussed below. For the provider, Stadion Feijenoord, the focus is on enhancing the customer experience while also maintaining cost-efficiency. They aim to ensure user satisfaction and optimize costs efficiency at the same time.

When considering the users' perspective on SSTs, several key determinants emerge. Convenience is one of the driving factors in the evaluation of a SST. Convenience encompasses aspects as time-saving through increased speed, ease of use, avoidance of service personnel, and reliability. (Collier & Kimes, 2013) (Meuter et al., 2000). Meuter et al. (2000) claim saving time, reliability, and ease of use appear to be the most critical factors. This can be applied to the scenario in a football stadium during halftime, where time and ease of use are crucial factors. This aligns with the discussed benefits of SSTs, where improved efficiency, and a standardized approach for each transaction positively impact ease of use and waiting/service time. Conversely, technology and process reliability and need for interaction are other important factors that can negatively influence customers satisfaction and must be considered in evaluating SSTs. (Meuter et al., 2000) (2000) indicate that system failures or process malfunctions can lead to customer dissatisfaction. Design is an important factor, a confusion ordering process can increase customers dissatisfaction (Meuter et al., 2003). Moreover, some users want to avoid interaction with personnel, as other users need interaction. Therefore, the availability of personnel for assistance becomes an important criteria. Users should have the option to choose between technological or interpersonal encounters, or utilize SSTs where personnel is available for support (Bitner, Brown, & Meuter, 2000).

Regarding the providers perspective, as mentioned, SSTs can effectively reduce costs and enhance revenue simultaneously. The evaluation criteria center on efficiency and profitability. This should reduce the waiting and service time, and amount of personnel required and increasing the throughput. Consequently, reducing the costs and increasing the revenue. This corresponds to the KPI set in section 4.4. Additionally, the customer satisfaction can be enhanced by the use of SSTs (Meuter et al., 2003) (Lee, 2017). On the other hand, as mentioned, the implementation costs bring risk to the provider. Therefore, the involved costs of implementation and (expected) revenue increase are important aspects that needs to be considered. The revenue increase is related to the adoption of SST which in turn is dependent on all the attributes of the SST and normal ordering option.

In evaluating the potential of SSTs, stakeholders encounter positive and negative aspects. It may appear that no trade-offs are visible between customers experience and profitability. It is important to bear in mind that the success of an SST largely depends on how it is implemented. The following evaluation criteria should be taken into account for a successful implementation. The SST needs to shorten the waiting times, be convenient and ensure the absence of technical and process failures for the user. Additionally from the provider perspective, the SST should improve the efficiency and profitability involving the provider.

| | **User** | **Provider** |
|---|---|---|
| *Key determinants* | - Decreasing waiting/service time<br>- Be convenient<br>- Absence of system failures<br>- (Human interaction) | - Decreasing waiting/service time<br>- Increase productivity<br>- Absence of system failures |
| *Goal* | - Improve customer experience | - Improve customer experience<br>- Increase profit |

Table 3.2: Determinants and goal for succesfull SST from user and provider perspective

## 3.3. Self-service technologies adoption

SSTs can be regarded as an innovative technology within the context of football stadiums. In this section the TAM and Rogers' Diffusion of Innovation theory will be discussed to get familiar with the way people adopt technologies and what aspects are important in this process. The TAM model and diffusion of innovation theory from Rogers show many similarities. These theories needs to be considered during the design, implementation, and discussion of the research.

### 3.3.1. Technology Acceptance Model

The adoption of technology is an interesting aspect that needs to be considered before the SSTs can be well-implemented. The Technology Acceptance Model (TAM) is a conceptual framework that explains how users develop acceptance towards adoption of a technology for use. This framework is extended twice to TAM2 and TAM3. The framework is shown below in Figure 3.1. Following TAM1, the intention to use a technology is influenced by the perceived usefulness and perceived ease of use. The intention to use a technology directly influences the actual use of a new technology (Davis, 1989). TAM2 is an extension of TAM1 created in 2000 by Venkatesh and Davis. TAM2 includes external social factors that influence the perceived usefulness behavioural intention to use new technology. This relates to individual differences as the image of a technology and innovation characteristics as output quality and result demonstrability. Besides, the context plays a role. The context often determines the subjective norm which directly influence the intention to use a technology. Translating this to the context of supporters in a football stadium, if one or a group of supporters establish a positive or negative standard regarding a technology, then other supporters outside of this group are likely to be influenced by the subjective norm they set. TAM3 is an extension on TAM1 and TAM2 created by Venkatesh and Bala in 2008. TAM3 represents the factors that influence the perceived ease of use. This has to do with individual preferences regarding computer anxiety, computer self-efficacy and perceived enjoyment and innovation characteristics as the objective usability. For the introduction of SSTs into a company a good understanding of those factors and their influence is needed.

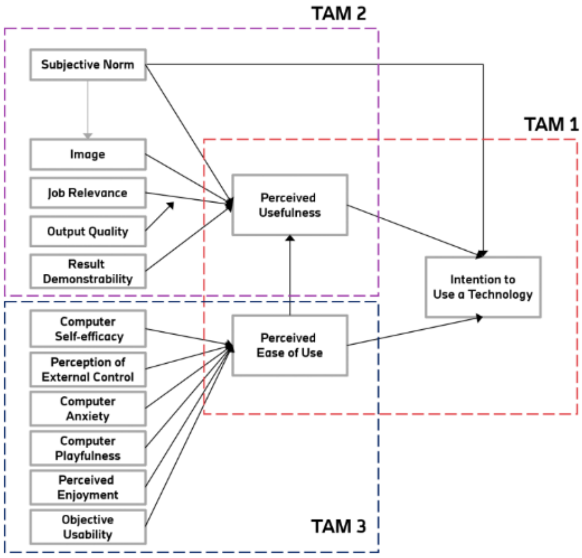


Figure 3.1: TAM 1, 2, 3 - TAM1 by Davis 1989, TAM2 by Venkatesh and Davis (2000), TAM3 by Venkatesh and Bala (2008)

As considered, the TAM shows that the intention to adopt is the factor that leads to use the technology. As mentioned, the determinants of the intention to adopt includes the characteristics of the innovation, individual differences and the context (Samengon et al., 2020). These three determinants are elaborated below.

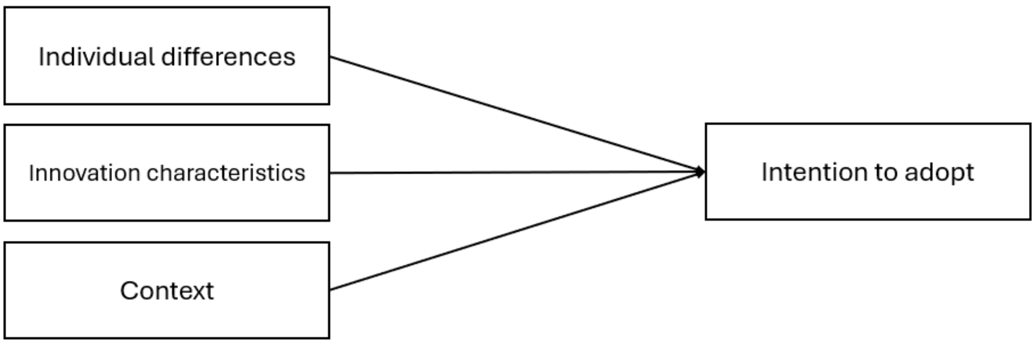


Figure 3.2: Factors influencing intention to adopt

Individual differences play a crucial role in determining the adoption level of specific SSTs. Several individual differences have been identified, including inertia, need for interaction, past experience, technology anxiety, and demographics (Lee, 2017; Samengon et al., 2020; Curran, Meuter, & Surprenant, 2003). Inertia makes it hard to quantify the requirements necessary for the implementation of SSTs. Past experiences with SSTs, whether positive or negative, significantly influence the adoption of new SSTs. Technology anxiety, refers to the fear or discomfort experienced by individuals when faced with using or interacting with technology. This makes it unlikely that they will adopt new SSTs. Lastly, demographic factors such as age, gender, education, and origin may also influence SST adoption, with age appearing to be the most significant factor (Lee & Lyu, 2019).

Innovation characteristics is a second mechanism used to influence to SST adoption. The three main attributes that determine the adoption are the relative advantage, compatibility, and the complexity of the SST (Samengon et al., 2020). The relative advantage entails the consumer empowerment, the waiting time, service heterogeneity, and service convenience (Lee, 2017) (Curran et al., 2003). Consumer empowerment refers to the process of giving individuals the knowledge and tools to make informed decisions about their purchases and consumption habits. Waiting time refers to the comparison of waiting times between SSTs and traditional counters. A SST offers a consistent service experiences since they operate in a standardized manner. Service convenience is about the technical interface. The compatibility is about the working of the system. Compatibility of SSTs can be defined as the ability to integrate with various systems without causing conflicts or issues. This is related to the reliability of the SST. Complexity is associated with the level of difficulties experienced in understanding and utilizing technology. All these factors affect the customers satisfaction.

Lastly, it is crucial to consider the context in which SSTs are established (Samengon et al., 2020). The atmosphere and environment of the location where the SSTs are installed can influence how customers perceive and interact with them. Customers expect a certain hospitality when visiting a location. If the SSTs are placed in a setting known for its excellent customer service and hospitality, customers may deter using the SST as the need for interaction is an important aspect. Conversely, if the speed of the ordering food and beverage plays great role. Customers are more likely to adopt SSTs earlier. Furthermore, the presence of human staff for assistance can also influence adoption. Customers may feel more confident in using the SSTs if they know that assistance is readily available in case they encounter any issues or have questions.

### 3.3.2. Diffusion of Innovation

In this section, the diffusion of innovations is discussed. In Everett M. Rogers' "Diffusion of Innovations," he discusses four important aspects of the diffusion process: the four elements in diffusion research, the five characteristics distinguishing innovations, the five steps in the innovation-decision process, and the stages outlined in the adoption curve (Rogers, Singhal, & Quinlan, 2014). These elements collectively form the base of understanding how new ideas spread through societies, shedding light on the complexity of adoption patterns and societal change and behavior. In this case, the new ideas correspond to SSTs that the society (supporters) may already be familiar with from other hospitality venues like restaurants and festivals. Through a concise exploration of these aspects, the fundamental principles underpinning the diffusion of innovation are uncovered, offering valuable insights into its mechanisms and implications.

Four Main Elements in the Diffusion of Innovations are the innovation, communication channels, time, and the social system. The innovation itself. Rogers offered the following description of an innovation: "An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers et al., 2014). Hence, an innovation can exist for longer, but as individuals perceive it as new, it is an innovation for them. In this research the SSTs do exist in other context, although implementing the SSTs at Stadion Feijenoord will be innovative as it will be perceived as new for the supporters. The second element is the communication channels. Mass media and interpersonal communication are two communication channels. The channels create and share information about the innovation. This information can be diffused during each step of the innovation-decision process. Time is another important aspect in diffusion research. The innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension. The final element is the social system. The social system can be regarded as the environment in which the innovation diffusion process unfolds. In this case, Stadion Feijenoord and the supporters during a game.

Rogers (2014) characterized the innovation-diffusion process as "an uncertainty reduction process". The diffusion of innovation can be seen as a process of reducing uncertainty among potential adopters. The following five attributes are identified that help to reduce this uncertainty: relative advantage, compatibility, complexity, trialability, and observability. The way individuals perceive these attributes predicts their adoption rate of the innovation (Rogers et al., 2014). The first three characteristics are discussed earlier. Trialability refers to the extent to which an innovation can be tested. Observability is described as the extent to which the outcomes of an innovation are apparent to others. In this case, fans notice that the queue for the SOK moves faster than the queue for the normal service counter. Over the time the uncertainty about SSTs in Stadion Feijenoord as the output of these five attributes becomes visible to the supporter. Besides, all discussed SSTs have already been implemented in other contexts. Hence, the uncertainty may start at a lower level, as some supporters are already familiar with the technology.

Rogers identified 5 steps into the innovation-decision process, which has similarities to the TAM. As illustrated in Figure 3.3, the communication channels influence each stage of the process, the media and personal evaluation of each can affect the process at each stage. The first stage knowledge is affected by past experience, personality variables, demographics, and the norm of the social system. The considered SSTs could be known. This corresponds to external variables of the TAM. Subsequently, the persuasion phase occurs when individuals have a certain attitude (positive or negative) towards an innovation. The innovation characteristics, as discussed before, affects the attitude at this stage. At the decision stage, the individual determine whether to adopt or reject an innovation. As demonstrated in Figure 3.3, this choice can evolve over time. If a supporter chooses to use an SST in Stadion Feijenoord and has a negative experience, it is conceivable that they may choose differently next time. Subsequently, at the implementation phase, the innovation is put into practice. Finally, at the confirmation stage the individual seeks support for his/her decision.

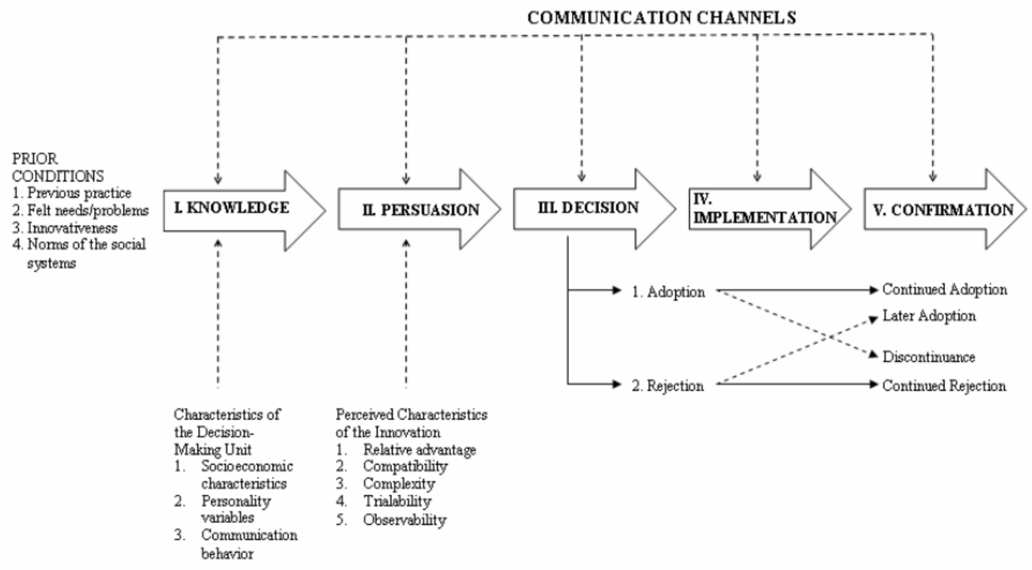


Figure 3.3: Innovation-decision process stages

Lastly, Rogers defined five categories of adopter. The innovator, early adopter, early majority, late majority, and laggards. These categories are depicted below. The categories follow a normal distribution, correspond to the adoption of innovation, which follows an S-curve pattern over time based on their respective usage percentages. As observed, the adoption rate varies over time. This is crucial to consider during the design and implementation phases, particularly in determining the number of SSTs to be implemented.

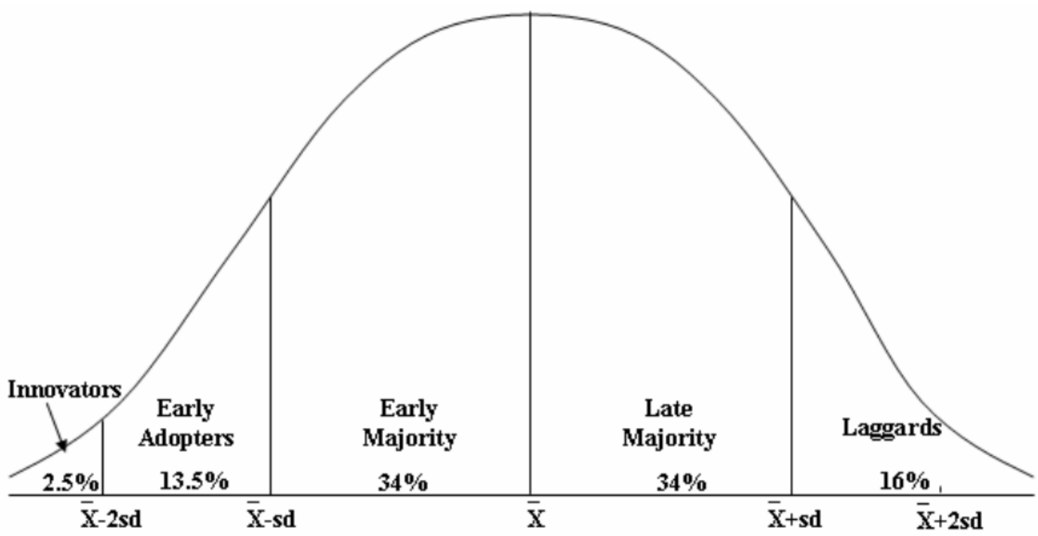


Figure 3.4: Diffusion curve of Rogers

Examining the factors influencing the intention to adopt in the previous section, the individual differences, innovation characteristics, and the context are considered. Considering this in the context of a football stadium, certain things differ compared to a restaurant. During the break the entire stadium rushes to purchase drinks or snacks, needing to be back before the match resumes. Missing game action is a main reason for not buying food and beverages (Oracle, 2018). This makes the context of a football stadium unique. Hence, the major potential benefit of SSTs in stadiums lies in the relative advantage they offer in terms of reducing service/waiting time and convenience. These are innovation characteristics that is crucial for crowd adoption of SSTs. Involving the individual preferences, the majority of fans are male (Overmars, 2010). Besides, the fans represents all ages, education levels and income (Overmars, 2010). Although, social influence can play a major role in technology adoption. With most fans attending the stadium once every two weeks and a high level of familiarity among the crowd in the stadium, social factors may either speed up or slow down the adoption of SSTs.

## 3.4. Stated Preference and Choice Modelling

Stated preference (SP) methods are survey-based techniques used to gather data on individual preferences by presenting respondents with hypothetical scenarios and asking them to make choices or express their preferences. This methods is useful when data is unavailable about peoples behavior. The main drawback of stated choice experiments is that it is not sure that people would make the same decision in real-life. In this context, the stated preference is useful to obtain the preferences of supporters about the non existing SSTs in stadion Feijenoord. There are two main approaches to SP valuation, namely choice experiments (CE) and contingent valuation methods (CVM) (Hanley & Czajkowski, 2019). Those two methods are considered to obtain these preferences.

### 3.4.1. Choice experiment

As mentioned in Chapter 2, choice modelling is used to understand to relative importance between the key attributes. Samuelson (1948) explained that choice is a signal of underlying preference. Later in 1959, Luce said that choices are partly random due to the noise within each decision. In 1966, Lancaster claimed that a choice alternative can be seen as a bundle of attributes. Concluded, choices in the public catering system are a signal of the supporters preference and are based on the attributes discussed and their corresponding level. Besides, a decision of the supporter is partly random due to the noise between the choices alternatives. A choice can be stated as the follows: "A choice for a multi-attribute alternative from a multinomial choice set can be conceptualized as a noisy multi-dimensional signal of the weights attached by a decision maker to the alternative's attributes." Based on these insights, McFadden built a mathematical discrete choice model based on the Random Utility Maximization (RUM) theory. The RUM entails that an individual choose the alternative with the highest utility. Within the research the Multinomial logit (MNL) model is a statistical tool for the analysis of the discrete choice data. Discrete choice data refers to situations where a person must select one alternative from a range of potential alternatives. The MNL model represents the coefficients denoting the relative importance of each attribute. Furthermore, the MNL is required to obtain the probability that a person choose a certain alternative. A drawback of the MNL model is its assumption that the decision probabilities of each alternative are independent of those of the other alternatives. This can play a role when predicting probabilities between several SST counters and normal service counters.

The discrete choice data within this research is gathered with a survey in the form of a stated choice experiment. Within a stated choice experiment respondents are asked what option they would select in a certain environment. In stated choice experiment alternatives can be hypothetical, in this way the behavior of supporters towards non-implemented SSTs can be tested. The main drawback of stated choice experiments is that it is not sure that people would make the same decision in real-life.

### 3.4.2. Contingent valuation methods

Contingent valuation methods (CVM) is a survey-technique where respondents can express their preferences by rating an alternative/environment/situation. As well as choice modeling, CVM can be used for to estimate people preferences and value of goods. For example, in CVM the respondent is asked their willingness to pay (WTP) or willingness to adopt (WTA) in return to something else. The survey presents the respondent a scenario describing a good being valued along with a proposed change. This is done multiple times to elicit the WTP or WTA. CVM is able to estimate services (public catering service) that do not have market prices, this can help decision-makers for the implementation of SST. Besides, CVM is flexible as a wide range of goods and services levels across different contexts can be chosen.

On the other hand, hypothetical bias may arise with this method. Hypothetical bias means that respondents may not reflect their true preferences, leading to not valid estimates. Besides, some respondents can refuse to value certain WTP or WTA and give unreasonable high value as a protest (Hanley & Czajkowski, 2019). Moreover, the respondents can not consider substitution possibilities, with can increase the bias (Boxall, Adamowicz, Swait, Williams, & Louviere, 1996). Lastly, CVM are not capable to identify the marginal rates of substitution between different attributes (Christie & Azevedo, 2009).

| **SP Approach** | **Hypothetical bias** | **Ease of Implementation** | **Multiple attributes** |
|---|---|---|---|
| Choice Experiments | + | ++ | +++ |
| Contingent Valuation | - / + | ++ | - |

Table 3.3: Overview of SP Approaches and its characteristics

**Sub question 1: What SSTs are already integrated in hospitality and what SSTs are available to integrate in the future into stadiums?**

The following SSTs are identified and discussed in this section: Self-Ordering Kiosk (SOK), Mobile ordering platform (MOP), the snack wall, and automated beer tap system. Each SST has their advantages and disadvantages which will be further examined in the upcoming chapters.

When focusing on each SST. The SOK has already been well-integrated in the fast food industry and show potential for the integration in a football stadium. The SOK is categorized as early majority according to Rogers' diffusion curve.

The mobile ordering platform is well integrated into the food industry as well, however this ordering process can cause technical implications when implementing this to other types of events with high ordering peaks. As well as the SOK, the MOP is categorized as early majority.

The snack wall is already widely used in the Netherlands. The Dutch are used to this SST. The snack wall show potential for implementations in a football stadium. Due to its widespread use, the snack wall is classified under the laggards category of Rogers' diffusion curve.

Lastly, the automated beer tap system, not many research is conducted to this process. However, similar self-serve technologies as the self-service at the pump are well-integrated. The automated beer tap system shows potential, however it have not proven itself in hospitality. Hence, this SST is classified under the innovators according to Rogers' diffusion curve.

# 4
# System Description

This chapter will perform a description of the public catering system at Stadion Feijenoord. This is the second part of the research framework as shown in Figure 2.1. The public catering system of Stadion Feijenoord will be analyzed by means of defining the different system components and their relation to each other. In the context of this research, the focus within the public catering system is on the ordering process of supporters at the counters. Also, the key performance indicators (KPIs) will be described for the public catering system.

The counters at the public catering system at Stadion Feijenoord entail the following components: forecasting, supplying, the food & beverage preparation, sales and consumption. The forecast determines the needs f&b per concession stands, the supply of the concession stand is done before the game and includes the location of the concession stands, the stockroom, the stock level per counter, the runners. The preparation is about how the f&b is prepared, the time it takes, the space it occupies, prepared f&b before sales, the personnel required and the types of equipment. The sales is about, the personnel required, the working and the number of cash registers, the queue length and the waiting and service time. Lastly, the consumption is about the supporters, the quality of the food, the costs, and the location where to eat or drink their consumption. The emphasis is placed on improving the process of the preparation and sales process to enhance the overall system.

The following sub-question will be answered in this chapter:

*Sub question 2. What are the key determinants of success for a public catering system in a stadium?*

## 4.1. Public Catering at Stadion Feijenoord

As mentioned, the goal of this research is to improve the supporters experience and increase profit regarding the public catering system at Stadion Feijenoord. In this section, some important numbers are highlighted to keep in mind. The public catering consist of 46 concession stands, including eight hot food stands, which are outsourced to the company Number One. Additionally, there are different types of counters. Table 4.1 presents the various types of counters.

Stadion Feijenoord is divided into four sections: the yellow side (Gerard Meijer Tribune or Stadion side), the blue side (Olympia side), the green side (Willem van Hanegem or Marathon side), and the orange side (Maastribune), see Figure 4.1. In this report, these sections will be referred to as the yellow, blue, green, and orange sides. The most fanatical supporters are seated at the yellow side, in particular at box S. In general the most expensive tickets and business seats are at the orange side. On the green side, the box for the supporters of the opponent is located (box GG). Each side features counters located in the outer ring, inner ring, and upper ring. Additionally, each side has a coffee counter and beer counter, which are not shown in Figure 4.1. The beer counters are equipped with a "raptap" that can pour four beers at once. Only beer and 0.0 percent beer is served at those counters. At the coffee counters only coffee and hot chocolate can be ordered. At the other counters all drinks and snacks can be ordered. Lastly, the stadium includes three rooms —de

Vereeniging, Maaszaal, and Legioenzaal— where all drinks and snacks are available. Within this research the focus lies on the outer ring, inner ring, upper ring, beer, and hot food stand counters.

Alongside, as shown in Figure 4.1, the location of the counters could be an important factor that influences sales. All boxes in the inner ring are closest to the inner ring counters and farthest from the outer ring. The same applies to the upper ring boxes and counters, which are farthest from both the outer and inner rings. Consequently, it is interesting to investigate the importance of walking distance to the counter. This attribute should be considered in the choice behavior of supporters when designing a new layout for the counters.

Considering the personnel, several service employees work at each counter work . Besides, during games, runners supply the counters from the warehouses. Furthermore, two sector coaches assist in managing the counters on each side. This research focuses primarily on the service employees who work at the counters and directly impact the ordering process.

| Counter Type | Amount | Drinks/Snacks |
|---|---|---|
| Upper ring | 12 | Both |
| Inner ring | 9 | Both |
| Outer ring | 6 | Both |
| Food counter | 8 | Hot food |
| Beer counter | 4 | Beer |
| Coffee counter | 4 | Coffee |
| De Vereeniging | 1 | Both |
| Legioenzaal | 1 | Both |
| Maaszaal | 1 | Both |

Table 4.1: All concession stands

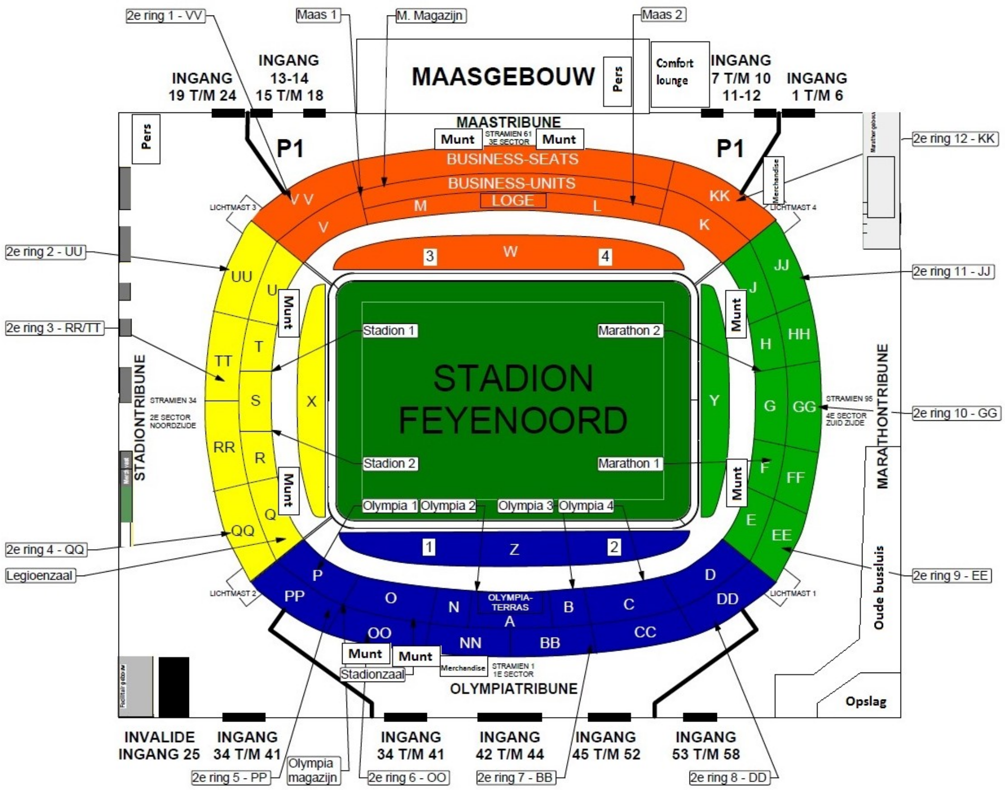


Figure 4.1: Layout Stadium

To provide an overview of the counter operations within the public catering system, Tables 4.2 and 4.3 display the number of counters used during the Feyenoord-Ajax match. This match generated the highest public catering revenue of the Eredivisie season, making it an ideal case for observing counter operations during peak hours. For less busy games, personnel deployment can be scaled down to maintain high productivity and performance. The total number of transactions during this game was 29,253, excluding transactions from the hot food stand, which is outsourced to Number One.

When analyzing the transactions of each counter, it can be seen that almost halve of the transactions are made at inner ring counters. To put this in perspective, it can be seen that apart from De Vereeniging, the most transactions per counter of a counter type are also made in an inner ring counter. This probably has to do with the size of the inner ring counters which are relatively large compared to the other counter types.

The personnel numbers represent the hours worked at each counter. For the game against Ajax, a total of 1011.25 hours were needed to run all counters, excluding the hours of runners and other supportive personnel. Focusing on the personnel deployment, it can be seen that most personnel is allocated to the inner ring counters. This corresponds to the size and numbers of this counter types. Besides, these counters handle the highest number of transactions, as discussed in previous section. Upon closer examination, the beer counters handle by far the most transactions per hour worked of an employee and the coffee stand the least, 40 and 10 transaction per hour worked of an employee, respectively. The upper ring, inner ring and outer ring counters, which handle a significant number of transactions do approximately 30 transaction per hour worked of an employee. In conclusion, it can be stated that the beer counters are highly efficient in terms of the productivity of an employee compared to the other counters. This is supported by Table 5.2, which shows the productivity per counter type.

Besides, regarding the counters per side, it is remarkable that the transaction per hour worked of an employee is significant lower at the orange side compared to the other sides. This means that the productivity of the employee at this side is relatively low.

| Counter type | Transactions | Counters | T/C | Personnel | P/C | T/P |
|---|---|---|---|---|---|---|
| *Upper ring* | 6404 | 12 | 534 | 241.25 | 20 | 27 |
| *Inner ring* | 13037 | 9 | 1449 | 419 | 47 | 31 |
| *Outer ring* | 4134 | 5 | 689 | 143 | 24 | 29 |
| *Coffee counter* | 346 | 4 | 87 | 35.5 | 9 | 10 |
| *Beer counter* | 2108 | 4 | 527 | 52.75 | 13 | **40** |
| *De Vereeniging* | 1825 | 1 | 1825 | 62.75 | 63 | 29 |
| *Legioenzaal* | 284 | 1 | 284 | 14.5 | 15 | 20 |
| *Maaszaal* | 1115 | 1 | 1115 | 42.5 | 43 | 26 |
| ***Total*** | 29253 | 38 | 770 | 1011.25 | 27 | 29 |

Table 4.2: Numbers per counter type during the game Feyenoord-Ajax

| Side | Transactions | Counters | Personnel | T/P |
|---|---|---|---|---|
| *Marathon* | 6695 | 9 | 232 | 29 |
| *Stadion* | 7280 | 9 | 243.25 | 30 |
| *Maas* | 4028 | 8 | 209 | **19** |
| *Olympia* | 9858 | 12 | 327 | 30 |

Table 4.3: Numbers per side of Stadion Feijenoord

## 4.2. Public Catering ordering process System Description

The public catering system at Stadion Feijenoord entails the process from the moment a supplier supplies the stock to the moment a supporters gets his/her order. As mentioned, for this research the focus lies on the ordering process in the system. This can be done in several ways. Currently at Stadion Feijenoord the normal counter ordering process is running. Below from Figure 4.2 until Figure 4.6 different ordering processes are illustrated. The two main actors are the stadium and the supporters. Those two actors perform according to the system.

Figure 4.2 illustrates the current ordering process at Stadion Feijenoord. Before each game, a forecast is conducted, and each concession stand is supplied based on this forecast, which relies on the consumption data from the previous season. Besides, sales orders are prepared in advance. Soft drinks, beers and coffee are prepared to enhance the service efficiency at the counter. If, the ordered drink is not ready, it is prepared directly after ordering. Afterwards it is delivered to the customer. It is important to note that only after a supporter has received their order a new order can be placed by the subsequent supporter.

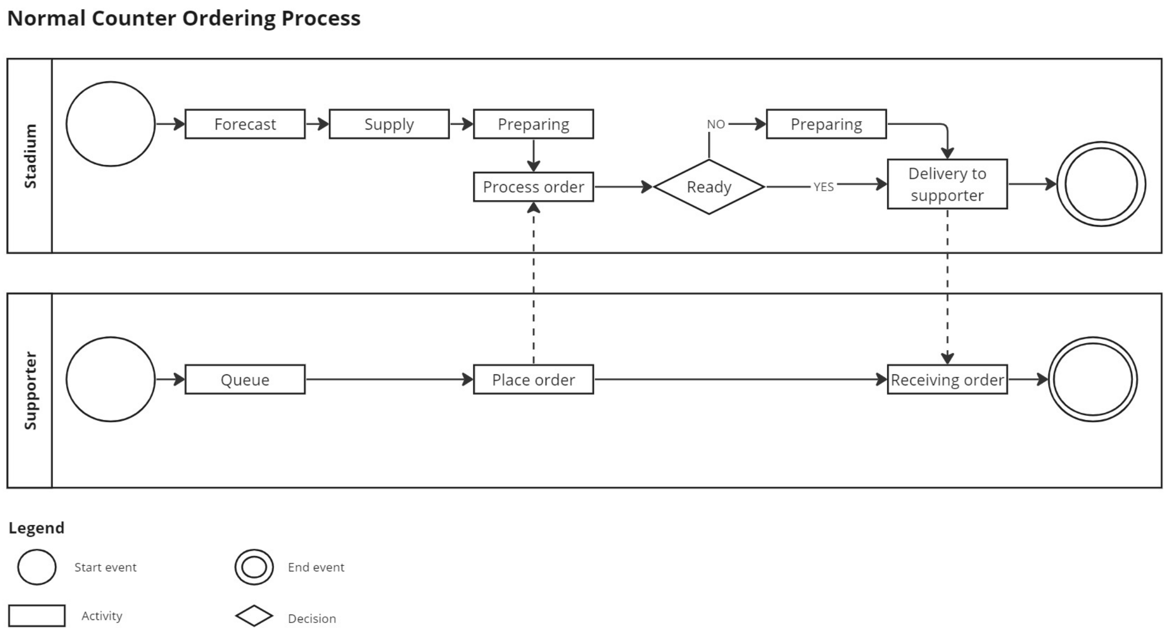


Figure 4.2: Ordering process: Normal Counter

The SOK process shares many similarities to the normal ordering process. However, the queue and counter location can be separated if desired. Dependent on the available space, it can be wise to separate the queue to the SOK from the counter. It is crucial to ensure that supporters clearly understand which counter corresponds to each SOK. The ordering process can initially be complicated for supporters, potentially increasing the service time. However, since the adoption rate will not immediately reach 100 percent, this increased service time may not significantly impact overall waiting times (Wang, Harris, & Patterson, 2012). Later, the SOK shows potential to be less heterogeneous compared to the normal service process (Yaacob et al., 2022). Unlike the normal ordering process, during the SOK process after each placed order, a new order can be placed directly. Besides, supporters need to monitor when their order is ready. This part can bring some complications when supporters do not know enough attention and do not take their order quickly. This can cause problems in space as the counters are not spacious. Besides, differences occur in the tasks of employees (Leong, 2016). During the normal process, employees should process the order. The SOK system eliminates that task. On the other hand, the dispensing process of the food have complications as supporters do not have attention and consequently the order takes space and the beer of the supporter is not fresh. Considering the productivity, it is expected that less employees are needed for the same amount of transactions as the ordering process is done by the supporter itself.

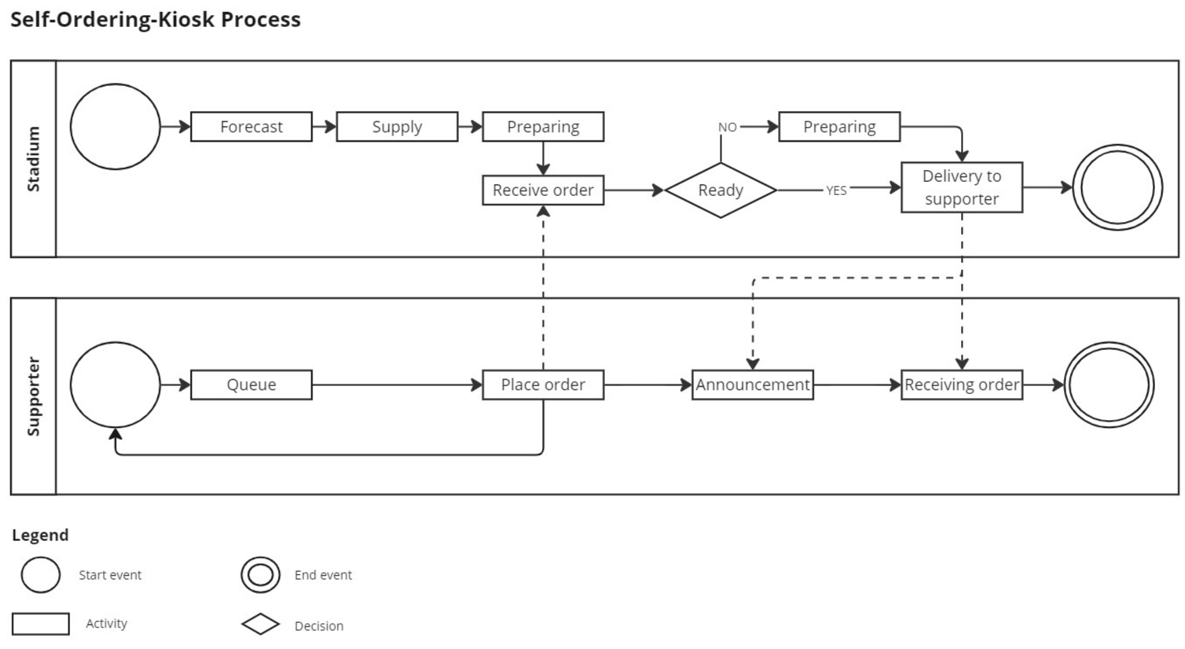


Figure 4.3: Ordering process: Self ordering kiosk

The mobile ordering platform process is almost the same as the SOK process. The main difference is that there is no queue for the customers, which is appealing to supporters who dislike queues. The supporters can order their order online with via an application. One crucial component of online-ordering is order confirmation (Sam, Leong, & Ku, 2023). Aligning with the SOK process signing and informing the supporters about the location where to pick up their order is a crucial aspect in the process. Another aspects of this process is that is takes no additional space, which is a good thing as space is scarce. Considering the personnel, the MOP system eliminates the need for an employee to take an order, which aligns with the SOK system (Leong, 2016). Again, the ordering process is done by the supporter, therefore it is expected that the productivity of the services employees increase. Lastly, the MOP process possibly cause technical implications. The platform needs to be convenient; it should clearly display the expected waiting time before ordering and implement an order stop when too many orders come in. Moreover, there might be problems with wireless signal coverage at such a busy places as a stadium (Leong, 2016).

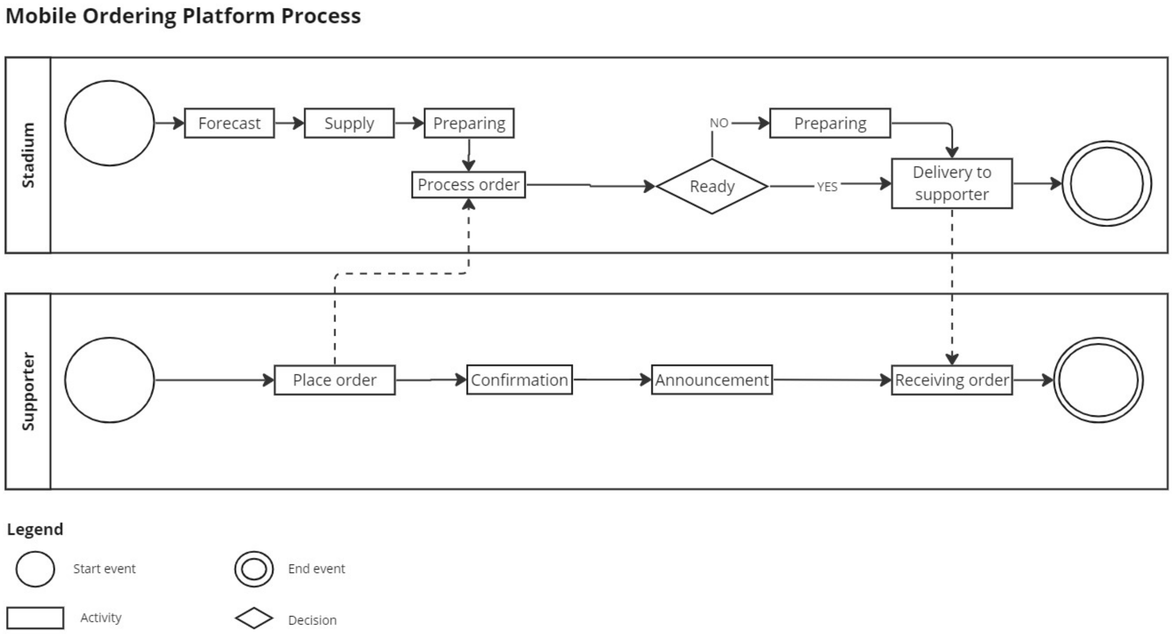


Figure 4.4: Ordering process: Mobile ordering platform

Figure 4.5 represents the system description involving the snack wall process. As compared to previous Figures this system is less complicated. The supporter has to wait in the queue, although the ordering process and receiving process is done by the supporters individually. Therefore, the service employee does not deliver the order to the supporter; instead, the supporter collects it themselves. Therefore, the personnel's only task is to replenish the wall based on the orders of the supporters, with the service employee refilling the empty boxes in the wall. This can make the work really efficient, however the employee can perceive it as boring. Based on observations in April and May 2024 at the Johan Cruijff Arena and Philips Stadion, it can be noted that the process was smooth and efficient. The snack wall was busy and popular among supporters. Additionally, at the Philips Stadion, the head of public catering mentioned that they now use only two employees instead of five to achieve at least the same amount of sales at their hot food stand, which was switched from a normal counter to a snack wall. These observations will be further elaborated on in Section 5.3.

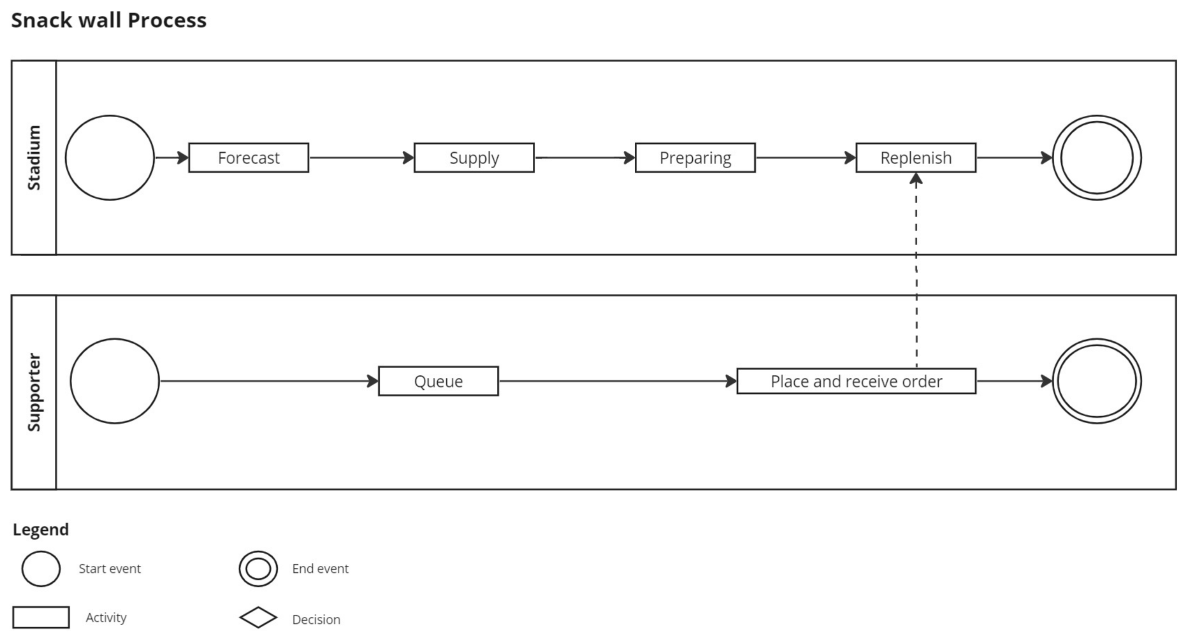


Figure 4.5: Ordering process: snack wall

Figure 4.6 illustrates the system description of the beer tap system. For the beer tap system, only personnel is required for supply. There is a queue, but supporters prepare and receive their own beer. This is highly efficient considering the deployment of personnel, as no personnel is needed during the game. Besides, supporters who prefer no human interaction are satisfied with this ordering process. Throughout the entire process, there is no interaction between the supporter and the stadium, as the supporter's ordering behavior does not influence any actions taken by the stadium.

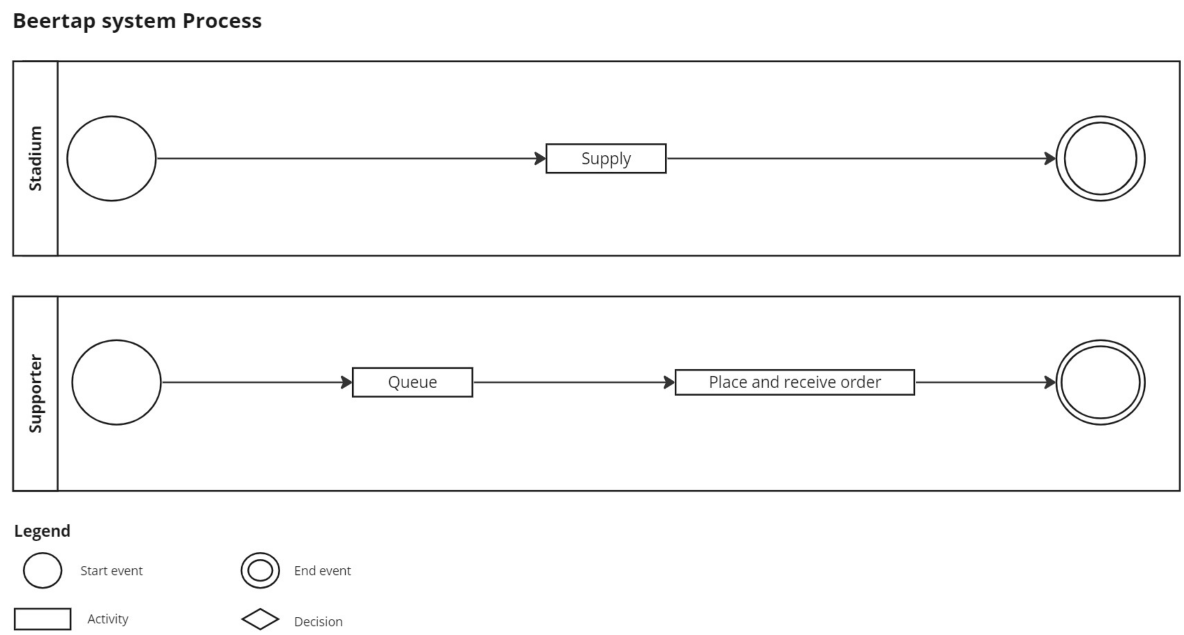


Figure 4.6: Ordering process: automated beer tap system

## 4.3. Public Catering Components

**Supporter**

The decisions made by the supporters significantly influence the performance of the public catering. The supporter starts and ends the ordering process. Stadion Feijenoord can steer the supporters towards specific choices through marketing and signaling, however this might affect the supporters satisfaction (Yaacob et al., 2022). Consequently, understanding supporters' preferences and wishes regarding public catering is crucial. This is further elaborated in Section 5.2. In doing so, Stadion Feijenoord can guide supporters towards the most efficient ordering process while also designing the counters to their preferences as much as possible. Moreover, given that the supporters group is divers, it is important to serve all supporters' wishes rather than solely focusing on one type of counter.

**Forecast**

The forecast entails predicting both inventory levels and personnel deployment. Stock levels at each counter remain consistent for all matches. There are a few exceptions as the cup final and matches of the national team. Stadion Feijenoord is responsible for the supply of all drinks and snacks except beer, which is managed by Heineken. The personnel deployment is determined based on the supply needs and the type of the upcoming match.

**Supply**

Before each match, the counters are replenished to a specified level based on forecasts. These forecasts, along with the consumption of f&b from the previous match, determine the required supplies for each concession stand. All drinks and snacks must be manually transported to the upper levels, except for beer, which is transported through pipes. Consequently, the supply process encounters extra personnel deployment as there is no elevator to the upper ring of the stadium. Additionally, during the match, the counter chefs at each counter may request additional supplies through runners. Due to limited space at each counter, the supply process must be both efficient and secure. Overall, it is expected that the type of ordering process will have minimal effect on the supply chain.

**Sales**

Within the light of this research, the most important component of the system is the sale to the supporter. The sales component of the system encompasses various factors crucial for efficiency and customer satisfaction. The productivity of each aspect in the sales process is key for a smooth operations and to minimize bottlenecks. Adequate personnel is required, ensuring supporters get proper and prompt service. Sufficient cash register are needed to get the throughput at sufficient level and prevent bottlenecks during payment. Besides, the preparation strategy for handling orders during peak periods, such as halftime breaks, is crucial for meeting demand effectively. Proactive stocking and readiness to serve increases the throughput, however it is essential to remain fresh beer to prevent a supporters experience decrease. In summary, an optimized sales system ensures seamless transactions, enhances customers experiences, maximizes revenue potential. When considering the different ordering process, each ordering process effectively satisfies a particular demand. Each type of counter is best suited for handling a specific type of order.

**Counter type**

As indicated in Table 4.1, Stadion Feijenoord features various counter types. Currently, each counter operates under the standard ordering process. Ideally, it should be assessed which ordering process is most suitable for each counter. Moreover, it should be wondered whether a counter type with a specific ordering process can be added, removed, or relocated to the public catering system of Stadion Feijenoord. These aspects will be explored further in Chapters 6 and 7.

## 4.4. Key Performance Indicators

To assess the performance of the public catering system, key performance indicators (KPIs) have been established. The KPIs involving the public catering are supporters experience, profitability, and throughput. In the 2021/2022 season, the public catering received a rating of 5.7 out of 10.0, which improved to 6.1 out of 10.0 in the 2022/2023 season. The current season maintains a rating of 6.1 out of 10.0, based on feedback from 7639 respondents. Within public catering, factors such as service speed, variety of food and drinks, price/quality ratio, professionalism, and assortment are taken into consideration. By investigating the opportunities of implementing SSTs, the primary focus of this research lies in service speed and professionalism part to increase the supporters experience.

The second KPI is profitability, which is determined by revenue and costs. Revenue and costs, in turn, are influenced by various factors such as purchase and sales prices, personnel deployment, maintenance, and other expenses. When considering the profitability, it must be kept in mind that this is also dependent on match types, the amount of matches, the result of the match, number of visitors. Therefore, this KPI should be evaluated over a season rather than for each individual match. Within the scope of this research, the main focus is on reducing personnel costs rather than increasing revenue. Additionally, assessing productivity per employee provides valuable insights into the efficiency of the system.

In summary, both supporters' experience and profit are influenced by the throughput at a concession stand, making it a crucial indicator. Therefore, this KPI will be included as it is essential within the scope of this research.

| **KPI** | **Method / Formula** | **Unit** |
|---|---|---|
| Supporter Experience | Survey | 1-10 scale |
| Profit | Revenue - Costs | € |
| Throughput | Time / # served | seconds |

Table 4.4: KPIs with regard to the public catering

Sub question 2: What are the key determinants for success of SSTs in the public catering system at Stadion Feijenoord?

From Chapter 3 it became clear that waiting time, convenience and human interaction are important determinants for success of SSTs in hospitality. According to Meuter et al. (2000) are saving time, reliability, and ease of use the most critical factors that determine people's intention to use self-service technologies. Besides, the avoidance of personnel or the need for interaction is an important factor that determine the use of SST (Collier & Kimes, 2013) (Meuter et al., 2000). Hence, it is important to estimate whether the supporters of Feyenoord prefer interaction or avoidance with personnel.

The last found important determinants comes from the system description and is relevant within this context. Walking distance to the counter is identified as the last important factor that influence the intention to use SSTs. As Figure 4.1 shows there are many counters at different walking distances. It is interesting to investigate whether, the supporters choose always the closest counter or they do not care about the distance.

# 5 System Analysis

This chapter entails the system analysis of the public catering of Stadion Feijenoord. With the help of data analysis (Section 5.1), a choice experiment (Section 5.2, and observations (Section 5.3), the system is outlined. The data analysis helps to investigate the service time of the different counter types, the current cost/revenue and deployment of personnel. Additionally, the stated choice experiment is conducted to obtain a better understanding of peoples choice behaviour in the public catering system. Besides, observations are executed to reveal the current situation involving service times of different counter types, in Stadion Feijenoord and other stadiums. Afterwards, all factors that might influence the revenue are considered in Section 5.4. Finally, each SST is evaluated to develop a MCDA in Section 5.5. Within this chapter the following sub-questions will be answered:

*Sub-question 3: How can a choice model be estimated in order to investigate the crowd's intention to use SSTs in the Kuip based on the key determinants of the public catering system?*

## 5.1. Data Analysis

In the data analysis, the focus lies on the service time. Service time directly affects the waiting time, which is considered as a key determinant for the supporters experience. Besides, for the normal counter the productivity is taking into account as this directly influences the profit. A higher productivity generally leads to greater profits.

#### Service-time

To obtain the service time of a cash register of a counter, a data analysis is executed. All transactions of each cash register during the match Feyenoord-Ajax on 7 april 2024 are merged into one data file. For each transaction it is visible at what specific time (HH:MM:SS) a payment of a supporter is done. For each cash register the payments on time period 15:18:00 - 15:38:59 and 15:21:00 to 15:38:59 are considered. These time periods correspond to 3 minutes before start break to end break and start break to end break, respectively. For each counter listed in Table 4.1, the most frequently used cash register of that counter—meaning the one with the highest number of transactions throughout the day—is analyzed. Hence, this counter is not necessarily the fastest during halftime. The outcome of the whole data analysis per cash register at each counter is shown in the Appendix A.6.

From the overall data analysis on the cash registers, a few things stand out. Firstly, apart form the coffee counters at each counter during the break there is a queue. This is deducted from the (average) time between transaction. This means that almost all personnel is well-used during the peak moments and the profits is maximized this way as no more supporters could be served within the same time. Besides, it means that supporters could find their way to the counter in the outer ring. Although, this data say nothing about the average queue time, from observations it can be stated that queues at the inner ring counter are longer. Secondly, it is noticeable that the average spending during the break is approximately one euro higher, compared to the spending outside the break. The reason for this could be that this spending is in general the last spend a supporter does and if they stay in a queue they better order directly all. The average spending lies between €8.46, a counter a the upper ring, and €16.65 a beer counter at the inner ring where the most passionate supporters are seated.

When considering this data, it is important to bear in mind that this is data during one football match. When seeing the bigger picture, the sales in the public catering are dependent on multiple factors as time of the day, weather, and opponent. Besides, the time between transaction is dependent on the experience and attitude of the employee behind the cash register and the decision-making and acting of the ordering supporter. Despite of this consideration, it provides useful information about how each counter operate during peak moments.

**Transaction time**

When focusing on the transaction time, certain things arise. The average time of all most used cash registers at each between each transaction during the break is 29.6 seconds. The average time between each transaction at the cash registers in the coffee counters are not taken into account as there was no queue here. When considering the beer counters only, the average transaction time is 19.6 seconds. This is exactly 10 seconds per transaction quicker. This has mainly to do with uniformity of the orders, at these counters only beer and 0.0 percent beer can be ordered. At the other counter, beer, soft-drinks and snacks are available Besides, the employee do not has to wait for the beer most of the time. In general, this should be the same at the normal counters, however the beer is not always ready at these type of counters.

Table 5.1 represents the top 10 quickest counters. All four beer counters are in the top 10 quickest counter and three out of four counters are cover the full top three. The average service time at the inner, outer, and upper ring are 34.5, 28.2 and 30,1 respectively. This are significant difference, while the average spending stays the same and the product range is the same too. Hence, the difference could be assigned to personnel, supporters, and/or queue formation. The average transaction time for the hot food stands is 32.2 seconds, which is similar to the normal counter. Although the average spend euro per transaction is significant lower, see Appendix A.6. The standard deviation of the transaction times is also included. All transaction times are considered, including outliers such as instances where the system malfunctions or when supporters are doubting during the ordering process, which affects transaction times. The standard deviation ranges from 10.0 to 17.8 seconds, indicating variability that is relatively high compared to the average transaction times.

| Counter name | Counter type | Transactions during break | Av. transaction time (s) | Standard deviation |
|---|---|---|---|---|
| Beer counter Blue | Beer counter | 65 | 16.6 | 11.6 |
| Beer counter Yellow | Beer counter | 55 | 19.6 | 10.0 |
| Beer counter Orange | Beer counter | 53 | 20.4 | 11.2 |
| 2e ring 4 | Upper ring | 52 | 20.8 | 15.3 |
| 2e ring 1 | Upper ring | 51 | 21.2 | 14.8 |
| Beer counter Green | Beer counter | 50 | 21.6 | 14.3 |
| 2e ring 9 | Upper ring | 48 | 22.5 | 11.6 |
| Lichtmast J | Outer ring | 47 | 23.0 | 17.8 |
| 2e ring 10 | Upper ring | 46 | 23.5 | 12.9 |
| Marathon 2 | Inner ring | 46 | 23.5 | 13.1 |

Table 5.1: Top 10 counters with lowest average time per transaction during the break of Feyenoord-Ajax

**Productivity**

When considering the productivity per employee per hour the beer counters perform well too as they cover the top three again. The productivity per hour is measured over all employees hours worked that day for a specific counter. Hence, this is not the productivity during the break but the productivity during the whole day. In general, each counter opens and closes at the same time. However, not every employee works from the time that the bar opens till the closes, some of them are scheduled to leave earlier. This applies to each type of bar. The high productivity at the beer counter is primarily attributed to its operational efficiency in preparing the beers. Here, one person can handle the preparation because four beers can be tapped simultaneously. In contrast, at a normal counter, four individuals are typically required to achieve comparable effectiveness in drink preparation.

| Counter | Counter type | Productivity employee |
|---|---|---|
| Biercounter Orange | Beer counter | 671.26 €/h |
| Biercounter Blue | Beer counter | 578.55 €/h |
| Biercounter Yellow | Beer counter | 576.78 €/h |
| Olympia 1 | Normal | 515.84 €/h |
| Containerbar Vereeniging | Normal | 472.18 €/h |
| Stadion 2 | Normal | 452.59 €/h |
| 2e ring 3 | Normal | 446.45 €/h |
| Lichtmast Q | Normal | 442.49 €/h |
| Marathon 2 | Normal | 435.71 €/h |
| Marathon 1 | Normal | 413.43 €/h |

Table 5.2: Top 10 counters with highest productivity of the employees in a counter

To conclude, the analysis of all current counters. It can be stated that innovations as "raptaps" could improve the public catering system. The service is improved as the service time and so the waiting time in the queue is lowered. Although, it should be noted that the lowered service time could also lead that more supporters are using the public catering system. Hence, it is plausible the waiting time in queue will decrease however it is not necessary the truth. Besides, the profits are increased as the efficiency is increased by implementing the "raptap".

## 5.2. Stated Choice Experiment and Choice modelling

A stated choice experiment (SCE) was conducted among Feyenoord supporters, with the survey sent via email to approximately 5,000 supporters who attended the matches against PEC and Excelsior, reaching a total of 10,000 supporters. The survey received 1,241 responses, meaning roughly 1 in 8 supporters participated. In Section 3.4, a SCE is further explained. The MNL is utilized to estimate the importance of each attribute and obtaining an utility function to predict the probabilities of the choice behaviour between counter types.

With the help of this SCE and a MNL model sub-question 3 will be answered.

### 5.2.1. SCE Design

For the setup of this experiment, first the attributes and its levels need to be determined. Afterwards, the choice sets are constructed. And before the survey is distributed, it is tested to a couple of target audience.

In Section 3.2, convenience and time savings arose as important attributes that influences customers experiences. In Chapter 4, from the ground plan, it seemed that the distance to the counter could be an important attribute as the space to construct (new) counters is limited. In summary, the following attributes are chosen:

- Convenience (werking),
- Waiting time (wachttijd),
- Walking distance (loopafstand)

The choice sets are constructed with the help of the software Ngene. The full code is shown in Appendix A.3. Because it is a labeled experiment, a simultaneous choice set construction is required. Furthermore, there is chosen for an orthogonal design as the priors are very uncertain. Additionally, for each choice situation dominance is checked. However, strictly dominance is not possible because the experiment is labeled, which means that external factors of SST or normal counter could influence the choice of the respondent. Moreover, as the experiment is labeled and so the external factors of SST and the normal counter is measured. From the literature section 3, it is known that human interaction could be an important external factor that might influence the respondent's choice. Thus, the supporters' preferences between a traditional counter and an

SST counter become evident. To prevent the respondents for fatigue blocking is used to decrease the choice sets from 12 to 4. This holds that three different versions are made with each four questions. Hence, the supporters has only to choose four times between two alternatives.

Table 5.3 represents the choice with all possible attribute levels. Each respondents gets four of these choice sets. All constructed choice with the help of Ngene can be found in Figure A.7 of Appendix A.3.

| | **Self-Service** | **Normal counter** |
|---|---|---|
| *Waiting time (minutes)* | 2 / 4 / 6 | 2 / 4 / 6 |
| *Walking distance (meters)* | 20 / 60 / 100 | 20 / 60 / 100 |
| *Convenience (%)* | 90, 99, 99.9 | 90, 99, 99.9 |
| **Your choice** | O | O |

Table 5.3: Choice set with all attribute levels

Figure 5.1 below depicts one question of one of the three versions. In total each respondents receives four of those question.

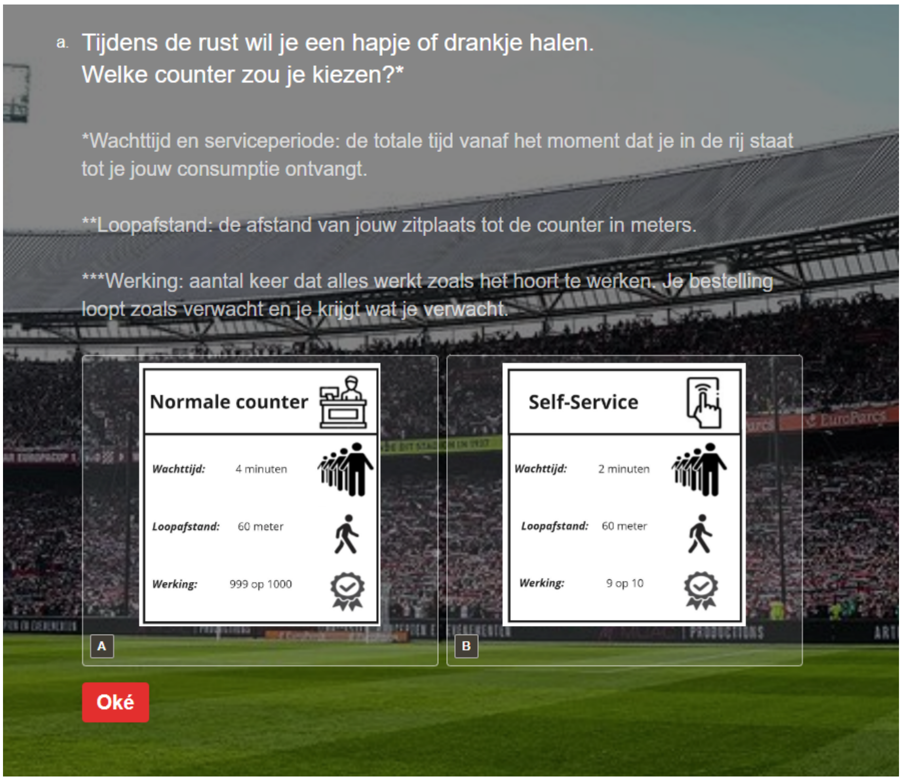


Figure 5.1: One question to supporters at the stated choice experiment

### 5.2.2. MNL design

From Chapter 3, the choice experiment came as the best stated preference method for this research. As mentioned in the choice experiment section, MNL is suitable for this research. With the MNL model the parameters for the utility function can be estimated.

#### Goal

The model can predict the option most likely to be chosen without having to perform experiments in real life. Moreover, it can estimate the relative importance between all attributes. In this case, it can be measured to what extent supporters be willing to use a certain counter with specific attribute levels compared to another counter with specific attribute levels. As mentioned, the base parameter of the normal counter is measured as well, because it is a labeled experiment. This base parameter contains all external factors that the normal counter differ from a SST counter.

**Input**

For the estimation of the model input is needed. After the game against PEC, data is gathered from 624 respondents, which corresponds to 2492 choice sets. Additionally, a post-game survey gathered responses from 617 individuals, resulting in 2468 choice sets. This brings the total to 1241 respondents and approximately 5000 choice sets. The validity of the output is enhanced by the fact that the survey was conducted exclusively among Feyenoord supporters. Moreover, the large sample size ensures the reliability of the results.

| | **# of respondents** | **# of choices** |
|---|---|---|
| *PEC* | 624 | 2492 |
| *Excelsior* | 617 | 2468 |
| **Total** | 1241 | 4964 |

Table 5.4: Input data

**Output**

The steps taken to produce the output are detailed in Appendix A.4. This MNL model estimate the beta for the waiting time, walking distance, convenience, and the base parameter of the normal counter. Besides, the p-value, standard error, and t-ratio are provided.

### 5.2.3. MNL output

The utility function is based and affected by the three obtained attributes. The utility function of the two alternatives, namely the normal and SST counter, are shown in the R code and Ngene code (Appendix A.3 and A.4).

The utility functions are as follows:

$$V_{normalcounter} = \beta_{normalcounter} + A_{normal,wt} \cdot \beta_{wt} + A_{normal,wd} \cdot \beta_{wd} + A_{normal,c} \cdot \beta_c \tag{5.1}$$

$$V_{SST} = A_{SST,wt} \cdot \beta_{wt} + A_{SST,wd} \cdot \beta_{wd} + A_{SST,c} \cdot \beta_c \tag{5.2}$$

$$U_{normalcounter} = \beta_{normalcounter} + A_{normal,wt} \cdot \beta_{wt} + A_{normal,wd} \cdot \beta_{wd} + A_{normal,c} \cdot \beta_c + \epsilon \tag{5.3}$$

$$U_{SST} = A_{SST,wt} \cdot \beta_{wt} + A_{SST,wd} \cdot \beta_{wd} + A_{SST,c} \cdot \beta_c + \epsilon \tag{5.4}$$

where,

- $V$ is the systematic utility
- $U$ is the total utility
- $wt$ is waiting time in minutes
- $wd$ is walking distance in meters
- $c$ is convenience in percentages
- $\epsilon$ is the error term

The parameters will be estimate for all input data, the input data per side of the stadium, and per age group. The results are shown below.

### 5.2.4. MNL estimation all data

Table 5.13 shows all estimates and their corresponding standard error, t-ratio, and p-value. The $\beta_{waitingtime}$ is -0.245, which means that waiting time has a negative impact on the utility. For each extra minute waiting time the utility decreases with 0.245. The $\beta_{walkingdistance}$ is -0.005. Hence, the walking distance has a negative influence on the utility, where with every extra meter the utility decreases with 0.005. From those two betas it can be stated that 1 additional minute waiting time is equal to 52 meter extra walking distance to the counter (-0.245/-0.005). This sounds quite reasonable as with a walking speed of 4 km/h a person walks 67 meters per minute. From this, it can be concluded that a person prefers to walk 1 minute over waiting 1 minute. Considering the convenience attribute, this has a positive impact on the utility. This is logical as a higher convenience should lead to a higher utility. The $\beta_{convenience}$ has a value of 0.001, meaning that if the convenience increases with a factor 10 from 90% to 99% the utility increases 0.01. This is relatively low compared to the other two attributes. Lastly, the p-value of 0.002 which is below the 0.05 and therefore statistical significant. The $\beta_{normalcounter}$ has a value of 0.560. This means that the supporters reveal preference of normal counter above SST counters. To put this into perspective, the supporter prefers to stay 2 minutes longer in the queue to get helped by a service employee than choosing a queue 2 minutes shorter but ordering at a self-service counter.

| **Attribute** | **Estimate** | **Std. Error** | **t-ratio** | **p-value** |
|---|---|---|---|---|
| $\beta_{waitingtime}$ | -0.245 | 0.014 | -17.258 | 0.000 |
| $\beta_{walkingdistance}$ | -0.005 | 0.000 | -7.394 | 0.000 |
| $\beta_{convenience}$ | 0.001 | 0.000 | 2.943 | 0.002 |
| $\beta_{normalcounter}$ | 0.560 | 0.031 | 18.101 | 0.000 |

Table 5.5: MNL Model Estimates and characteristics of the attributes of all data

Now the values of the different attributes are known, the probabilities that a certain (hypothetical) counter is selected can be calculated with the following formula:

$$P_i = \frac{e^{V_i}}{\sum_{j=1}^{j} e^{V_j}} \tag{5.5}$$

where,

- $P_i$ is the probability of alternative $i$,
- $V_i$ is the systematic utility of alternative $i$

By filling in this Equation 5.5, it arise that when counter have the same attribute levels, the probability to choose a normal counter is 64%, consequently the probability to choose the SST counter is 36%. The choice probabilities between certain counter will be further used in Chapter 6 and 7.

### 5.2.5. MNL estimation data per side of Stadion Feijenoord

This section analyzes the different estimates per group. The specific output and estimate for each group can be found in Appendix A.5. The blue group had 435 respondents, the yellow group had 272 respondents, the orange group had 202 respondents, and the green group had 72 respondents. Table 5.6 presents all the estimates along with their corresponding p-values. No significant differences were found between the groups, indicating that different types of supporters do not differ in their preferences. One notable finding is the low parameter estimate for waiting time in the green group, for which no explanation could be determined. Moreover, the p-value of the $\beta_{walkingdistance}$ and $\beta_{convenience}$ is relatively high, likely due to the smaller sample size in this group.

In summary, no significant difference were found based on the seat of the supporter. Therefore, during the possible implementation phase of the counter it does not matter on what side the implementation starts, as the results indicate that the side has no impact on the preferences.

| Attribute | Estimate | Std. Error | t-ratio | p-value |
|---|---|---|---|---|
| *Blue* | | | | |
| $\beta_{waitingtime}$ | -0.244 | 0.024 | -10.201 | 0.000 |
| $\beta_{walkingdistance}$ | -0.006 | 0.001 | -4.946 | 0.000 |
| $\beta_{convenience}$ | 0.001 | 0.000 | 1.708 | 0.043 |
| $\beta_{normalcounter}$ | 0.530 | 0.052 | 10.166 | 0.000 |
| *Orange* | | | | |
| $\beta_{waitingtime}$ | -0.293 | 0.037 | -7.929 | 0.000 |
| $\beta_{walkingdistance}$ | -0.006 | 0.002 | -3.410 | 0.000 |
| $\beta_{convenience}$ | 0.002 | 0.001 | 1.337 | 0.090 |
| $\beta_{normalcounter}$ | 0.581 | 0.078 | 7.460 | 0.000 |
| *Yellow* | | | | |
| $\beta_{waitingtime}$ | -0.258 | 0.030 | -8.603 | 0.000 |
| $\beta_{walkingdistance}$ | -0.003 | 0.001 | -2.133 | 0.016 |
| $\beta_{convenience}$ | 0.001 | 0.001 | 1.219 | 0.111 |
| $\beta_{normalcounter}$ | 0.500 | 0.066 | 7.629 | 0.000 |
| *Green* | | | | |
| $\beta_{waitingtime}$ | -0.121 | 0.052 | -2.334 | 0.009 |
| $\beta_{walkingdistance}$ | -0.002 | 0.003 | -0.808 | 0.210 |
| $\beta_{convenience}$ | 0.000 | 0.002 | 0.3283 | 0.371 |
| $\beta_{normalcounter}$ | 0.405 | 0.122 | 3.323 | 0.000 |

Table 5.6: MNL Model Estimates and characteristics of the attributes of data per side

### 5.2.6. MNL estimation data age group

This section analyzes the preferences among different age groups of respondents. The age groups 15-30, 31-50, and 51+ consist of 157, 362, and 722 respondents, respectively. This indicates that the majority of respondents are aged 51 or older, with only 13% being 30 years or younger. Table 5.8 presents all estimates found. From these estimates it is noticable that the younger people are, the less they care about whether the counter is a SST counter or a normal counter. However, each age group prefers the normal counter over the SST counter when the attribute levels are the same. Additionally, for the 51+ age group, convenience does not affect the choice between a normal counter and an SST counter.

In the case the characteristics of the normal and SST counter are equal, the following probabilities per age group arise from Equation 5.5.

| Age group | P(normal counter) | P(SST counter) |
|---|---|---|
| *15-30* | 57% | 43% |
| *31-50* | 63% | 37% |
| *51+* | 65% | 35% |
| *All ages* | 64% | 36% |

Table 5.7: MNL choice probabilities per age group

To conclude, regarding the potential implementation of SST counters, it is important to note that normal counters are generally preferred. However, younger people are more likely to choose SST counters compared to older groups. If SST counters offer slightly better characteristics, such as a shorter walking distance or waiting time, the younger group would prefer them over normal counters.

| Attribute | Estimate | Std. Error | t-ratio | p-value |
|---|---|---|---|---|
| Age 15-30 | | | | |
| $\beta_{waitingtime}$ | -0.293 | 0.039 | -7.392 | 0.000 |
| $\beta_{walkingdistance}$ | -0.006 | 0.002 | -3.108 | 0.000 |
| $\beta_{convenience}$ | 0.003 | 0.002 | 2.274 | 0.011 |
| $\beta_{normalcounter}$ | 0.287 | 0.086 | 3.327 | 0.000 |
| Age 31-50 | | | | |
| $\beta_{waitingtime}$ | -0.278 | 0.027 | -10.374 | 0.000 |
| $\beta_{walkingdistance}$ | -0.007 | 0.001 | -5.570 | 0.000 |
| $\beta_{convenience}$ | 0.002 | 0.000 | 1.989 | 0.023 |
| $\beta_{normalcounter}$ | 0.528 | 0.058 | 9.093 | 0.000 |
| Age 51+ | | | | |
| $\beta_{waitingtime}$ | -0.218 | 0.019 | -11.730 | 0.000 |
| $\beta_{walkingdistance}$ | -0.004 | 0.000 | -4.303 | 0.000 |
| $\beta_{convenience}$ | 0.000 | 0.000 | 1.541 | 0.062 |
| $\beta_{normalcounter}$ | 0.637 | 0.041 | 15.709 | 0.000 |

Table 5.8: MNL Model Estimates and characteristics of the attributes of data per age group

## 5.3. Observations

In this section, the focus lies on the waiting time and queuing at the counters during the break of a match. Understanding the waiting time is crucial for assessing the current state of queues and supporter wait times. Besides, the arrival rate, a critical indicator in designing the new counters for the public catering system, can be calculated using the average waiting time and service rate.

This is measured by observations during six football matches across three different stadiums: four matches at Stadion Feijenoord (Feyenoord vs. FC Utrecht, Feyenoord vs. Ajax, Feyenoord vs. PEC Zwolle, and Feyenoord vs. Excelsior), one match at the Johan Cruijff Arena (Ajax vs. Excelsior), and one match at the Philips Stadion (PSV vs. Sparta).

On beforehand, it need to be stated that the observations give a good indication of the waiting time during specific matches, although it is too less to use for predictions of coming matches. Besides, the waiting time is measured at only one counter and consequently it can differ per counter and per match.

### 5.3.1. Stadion Feijenoord

Figure 5.2 represents the waiting times of the supporters over time during the break of the matches against FC Utrecht, Ajax, PEC, and Excelsior. The observations are executed at the same counter for every match. In total the waiting time of 104 supporters is measured, so $N = 104$. As mentioned earlier, each match differ from opponent, importance of the result, weather, time of the day. The red dot indicates the start of the break. For all the waiting time increase whenever the break starts. The peak of the longest waiting time differ per match. From all four matches the maximum waiting time is 390 seconds (6.5 minutes). Hence, independent to at what moment a supporter starts queuing. The supporter has enough time to get a drink or a snack. Moreover, Figure 5.2 illustrates that the longest waiting times occur between the fifth and twelfth minute minute of the break. Lastly, it is remarkable that the waiting times during the match against FC Utrecht are significant lower compared to the other matches. No reason could be found for this difference.

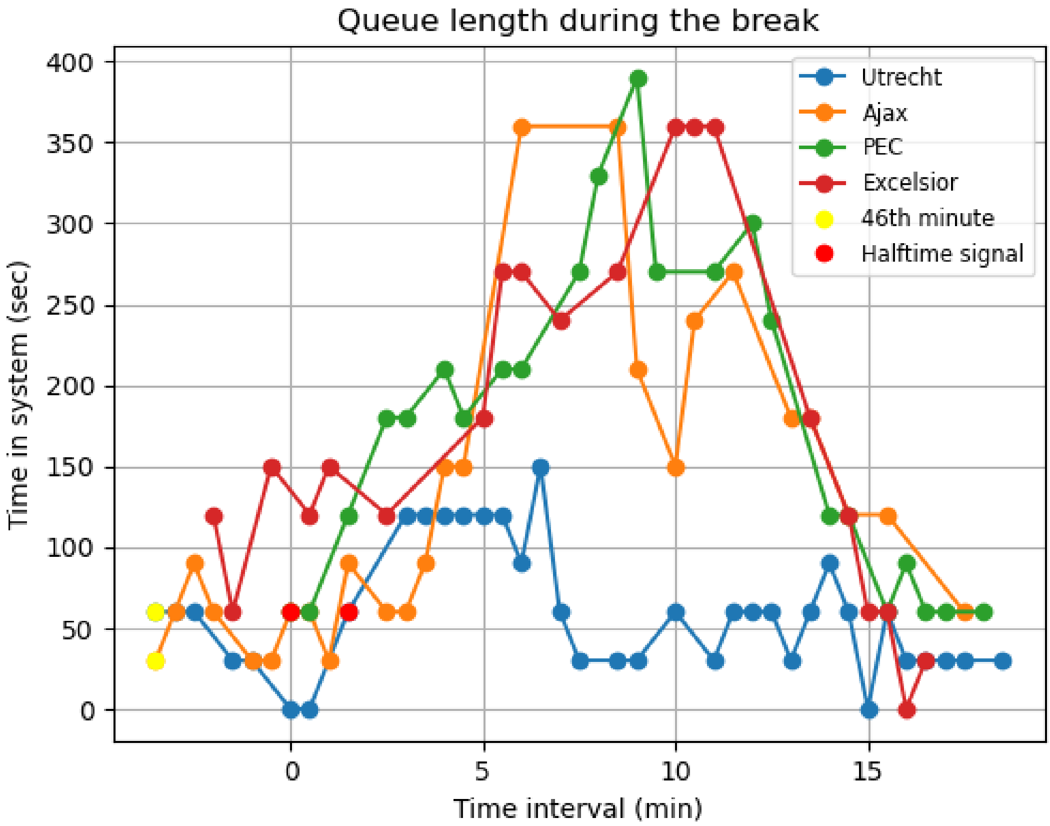


Figure 5.2: Time in system over time during the break of the Feyenoord matches

From Figure 5.2 and the corresponding data, the average waiting time per match is calculated. Table 5.9 represents these waiting times. Apart from the match against FC Utrecht, the average waiting time differs from 198-218 seconds.

With these data the arrival rate can be calculated according the following formula:

$$W = \frac{1}{\mu - \lambda} \tag{5.6}$$

where,

- $W$ is the average waiting time in minutes
- $\lambda$ is the arrival rate in supporters per minute
- $\mu$ is the service rate in supporters per minute

This queuing theory problem is a M/M/1 queue with Poisson arrivals and exponential service times.

For the average waiting time $W$, the average $W$ of the matches against Ajax, PEC, and Excelsior is taken ((198+209+218)/3=208 seconds). For the service rate $\mu$, the average service time at the inner ring is taken, i.e. 34.5 seconds per supporter, which corresponds to 1.74 supporters per minute. It needs to be said that this 34.5 seconds is based on the most used cash register per counter. Hence, the actual average service time could be slightly higher. Reflecting on the standard deviation, which is 71 seconds, means that, following the normal distribution, the average waiting time during the break of a match falls 68.2% between 102 and 244 seconds.

By filling in the formula. The arrival rate $\lambda$ is equal to 1.45 supporter per minute, which corresponds to an arrival of a supporter each 41 seconds per cash register. In the designing phase this arrival rate is taken as the overall arrival rate per cash register. With the help of Equation 5.5 and this arrival rate as constant the new waiting times can be calculated.

| **Opponent** | **Average waiting time (seconds)** | **Average waiting time (minutes)** |
|---|---|---|
| *FC Utrecht* | 67 | 1.1 |
| *Ajax* | 198 | 3.3 |
| *PEC* | 209 | 3.5 |
| *Excelsior* | 218 | 3.6 |
| **Total** | 172 | 2.9 |
| **Standard deviation** | 71 | 1 |

Table 5.9: Average waiting times during the break

### 5.3.2. Johan Cruijff Arena and Philips Stadion

During the Ajax-Excelsior (24-4-2024) and PSV-Sparta (5-5-2024) games, observations were conducted on the public catering systems at Johan Cruijff Arena and Philips Stadion.

To start of, at the Johan Cruijff Arena the SOK is implemented at one side of the stadium. These observations took place after the SOK system had been in use for more than half a season. During the break, the throughput is observed as represented in Table 5.10. As can be seen, the average throughput is 40,41 seconds, which is over 10 seconds longer than the throughput at Stadion Feijenoord. This statement is also inconsistent with what was discussed in Chapter 3, where it was mentioned that SOKs have a high throughput. It is important to note that within this 40.41 seconds only the order is placed, afterwards, the supporter has to walk to the counter and wait there for their order. It is important to note that these observations were conducted at only one SOK, which reduces the reliability. The standard deviation of 15.05 seconds is relatively high, indicating that 68.2% of the orders fall between 25.36 and 55.46 seconds. This variability is largely due to the differing sizes of orders and customer behavior.

At the normal counter at the Philips stadion the average throughput was 43.18 seconds per order. This is significantly higher than the the average throughput at Stadion Feijenoord. One observation made was that the intake and distribution of cups to the supporters took extra time at Philips Stadion due to the recycling process of the cups. This was particularly evident with larger orders, where the distribution took relatively more time. This is reflected in the standard deviation of 20.96 seconds, indicating that 68.2% of the orders fall between 22.22 and 64.14 seconds.

Overall, it is important to note that the two observations were conducted at only one counter and at a specific time. Factors such as the individual employee, the orders, and the type of match can significantly impact the results of these observations.

| Transaction | Time (s) |
|---|---|
| 1 | 64.52 |
| 2 | 50.31 |
| 3 | 47.11 |
| 4 | 19.21 |
| 5 | 26.06 |
| 6 | 30.68 |
| 7 | 75.08 |
| 8 | 26.03 |
| 9 | 43.88 |
| 10 | 30.66 |
| 11 | 34.1 |
| 12 | 34.36 |
| 13 | 52.21 |
| 14 | 70.63 |
| 15 | 28.13 |
| 16 | 32.73 |
| 17 | 48.86 |
| 18 | 48.26 |
| 19 | 52.03 |
| 20 | 37.66 |
| 21 | 22.1 |
| 22 | 35.36 |
| 23 | 27.25 |
| 24 | 32.53 |
| *Total seconds* | 969.75 |
| *Total minutes* | 16.16 |
| ***Average seconds*** | **40.41** |
| ***Standard deviation (s)*** | **15.05** |

Table 5.10: Throughput SOK Johan Cruijff Arena (April, 2024)

| Transaction | Time (s) |
|---|---|
| 1 | 46.18 |
| 2 | 66.3 |
| 3 | 50.02 |
| 4 | 36.46 |
| 5 | 9.01 |
| 6 | 88.3 |
| 7 | 34.91 |
| 8 | 35.35 |
| 9 | 30.1 |
| 10 | 25.6 |
| 11 | 32.81 |
| 12 | 42.7 |
| 13 | 78.52 |
| 14 | 28.25 |
| 15 | 59.36 |
| 16 | 20.66 |
| 17 | 21.11 |
| 18 | 24.9 |
| 19 | 50.78 |
| 20 | 81.22 |
| 21 | 34.36 |
| 22 | 53.15 |
| *Total seconds* | 950.05 |
| *Totaal minutes* | 15.83 |
| *Average seconds* | **43.18** |
| *Standard deviation* | **20.96** |

Table 5.11: Throughput normal counter Philips Stadion (May, 2024)

## 5.4. Factor influencing public catering

In Figure 5.3 below, the factors influencing the KPIs are illustrated. These factors are variable and can change throughout the season.

Considering the waiting times at the counter, which are within the control of Stadion Feijenoord. These waiting times are influenced by various factors such as the product offerings at the counters, the technical functionality of the equipment, the number of personnel deployed, and the experience of the personnel. A plus sign indicates that an increase in the first variable leads to an increase in the second variable as well. Conversely, a minus sign means that an increase in the first variable leads to a decrease in the second variable.

Focusing on the match characteristics that influence the revenue. The match characteristics and its corresponding revenue will not necessary influence the waiting times because of the personnel deployment strategy for that particular match. In the next section, each match characteristics is valued to predict the revenue for each match. It is expected that the higher the match is valued, the higher the revenue. These match characteristics are based on my own findings.

In the centre the three KPI's are considered. Higher waiting times lower the supporters experience. Besides, higher waiting times lower the revenue assumed that the service time and service desks are kept constant. Lastly, when the revenue increases, more innovative investments could be executed to the public catering system, which ultimately lowers the waiting times and enhance supporter experience. To conclude, accurate revenue prediction for each match enables optimized personnel deployment, ultimately enhancing supporter experience and increasing profits.

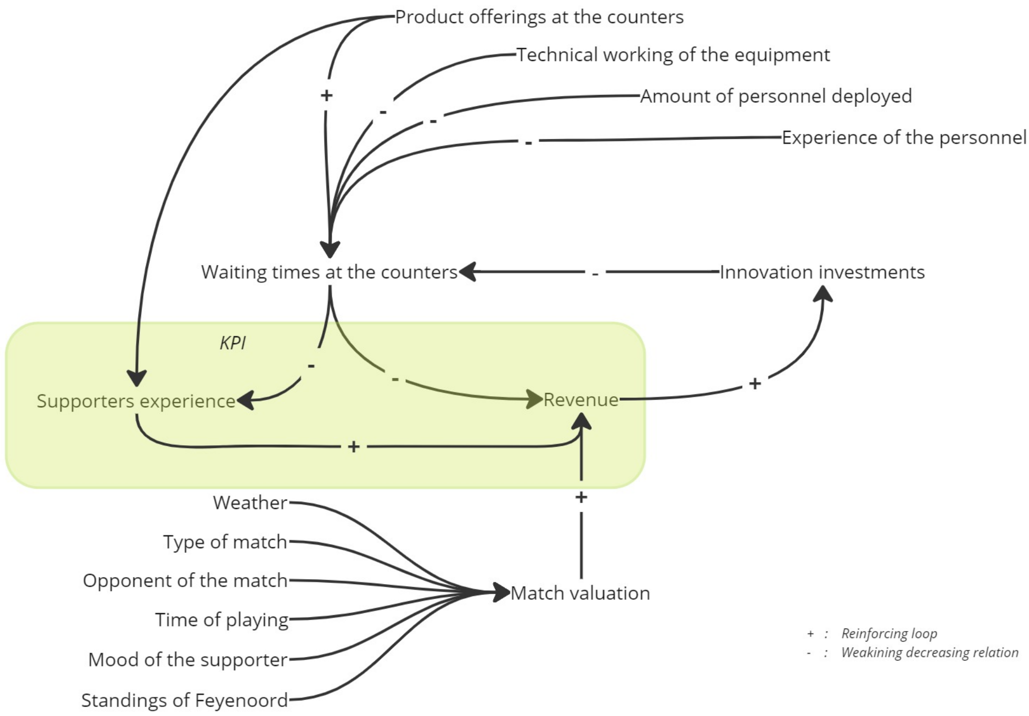


Figure 5.3: System Dynamics of Factors that influence the KPI's based on own findings

#### Predicting the revenue

Based on the match characteristics, the revenue per match can be predicted with the help of a linear regression. The code for this linear is shown in Appendix A.7.

Each characteristic is valued, the higher valued the more revenue expected. For example, considering the opponent as characteristic, the value for a match against biggest rival Ajax is valued with a score 10, conversely a match against an opponent that is at the bottom of league is valued with a score 5. The mood of the supporter and standing of Feijenoord is left out as data analysis showed that these characteristics had minimal impact on the revenue. Besides, the weather is set as constant for the linear regression, because this can no longer be determined. The valuation strategy of each characteristic is shown in Appendix A.8.

With this valuation and actual revenue of each match a linear regression can be applied. Consequently, the revenue per match or season can be predicted on beforehand. From the linear regression, the following formula can be used to predict the revenue:

$$Revenue = 8946 \cdot Valuation - 73496 \tag{5.7}$$

When applying this formula, the difference between the total actual revenue and total predicted revenue is 2900€. Hence, this method can be useful to predict the revenue per match and over the full season. Besides, these revenue predictions can be used to determine the personnel deployment per match. The result of the first five matches is shown the Table 5.12 below. The results of all matches are presented in the Appendix A.9.

| **Opponent** | **Time** | **Type** | **Actual Revenue** | **Predicted Revenue** | **Difference** |
|---|---|---|---|---|---|
| *PSV* | Sat 8PM | Super Cup final | €334.000 | €329.250 | €4.750 |
| *Fortuna* | Sun 2:30PM | National league | €202.000 | €221.850 | €-19.850 |
| *Almere* | Sun 2:30PM | National league | €252.000 | €212.900 | €39.100 |
| *Heerenveen* | Sat 4:30PM | National league | €241.000 | €239.750 | €1.250 |
| *Celtic* | Tue 9:00PM | Champions League | €305.000 | 293.450 | €11.550 |

Table 5.12: Actual and predicted revenue of the first 5 matches of the season of Feyenoord based on the match characteristics

## 5.5. Evaluating Self-Service Technologies System Analysis

Using Multi-Criteria Decision Analysis (MCDA), the various ordering processes can be compared effectively. The weights per attribute can differ depending on the location of the (new) counter. Furthermore, it is essential to recognize that the public catering system should not be viewed merely as a collection of separate counters. Instead, it is crucial to consider the broader context and understand how all counters function collectively as one system. However, the MCDA can serve as a tool in decision making for what counter type is required at a specific location, regardless of the all other counters around. All ordering-processes and their features are examined to come up with a valuation per attribute. These valuation is based on the literature review, system description, and previous Sections of the system analysis. The attributes considered are as follows: throughput time, productivity, supporters experience, space occupation, and implementation.

### 5.5.1. Normal counter

The average throughput at Stadion Feijenoord is 29.6 seconds, with the beer counters being the fastest on average at 19.6 seconds. The beer counter uses the innovative "raptap," which quickens the tapping process.

Regarding productivity, as discussed in Section 4.2, the normal counter requires employees for each step of the ordering process. Productivity could be improved by using technology to eliminate some of these tasks. Table 5.2 outlines the productivity per counter, showing that the beer counter has the highest productivity. This is due to fewer employees being needed for the preparation process, as four beers are tapped simultaneously.

According to the supporter experience elaborated in Section 5.2, supporters prefer the normal counter over the SST counter. For instance, supporters are willing to wait two minutes longer at the normal counter compared to the SST counter.

Considering the space occupation, the space is scarce for the employees in the counter. A normal counter occupies the most space among other counter types because it requires the highest number of employees, each of whom needs their own space. For implementation, the current counters can be recreated with slight improvements, requiring minimal attention for implementation.

### 5.5.2. Self Ordering Kiosk

For the SOK, from Section 5.3, it became clear that the throughput of the SOK is lower than the throughput of the normal counter. However, after each order, the next order can be placed immediately without waiting for distribution, which smoothens the process. Section 4.2 showed that the SOK eliminates the need for an employee in the ordering process, thereby enhancing the overall productivity of the system.

As mentioned, on supporters experience the SST scores lower than the normal counters. Concerning the space occupation, a SOK and a normal cash register require the same amount of space. However, the placement of the SOK is more flexible compared to the placement of the normal cash register as this is connected to a service employee. This flexibility allows SOKs to be placed in unused spaces, potentially increasing the number of SOKs compared to normal cash registers. As a result, the average waiting time can be reduced, which favors the SOK over the normal counter.

Finally, regarding the implementation, the success of the SOK is partly dependent on the implementation. Considering other stadiums, at the Johan Cruijff Arena, it is implemented well and they face little problems. This suggests that effective implementation can mitigate potential problems and provide a good SOK performance. Regarding implementation expenses, the cost of implementing one SOK is approximately €1,899 (*Foodticket*, 2024).

### 5.5.3. Mobile ordering platform

The MOP shows significant potential regarding the throughput as there is no queue for ordering. The productivity and supporter experience ratings of the MOP are similar to that of the SOK. Considering the space occupation, the MOP saves considerable space as there is only a queue for collecting the order. However, as mentioned in Section 4.2, the main challenge for the MOP is the implementation. Since every supporter can order simultaneously, the risk of system failures increases, and there is a possibility of unfair queues at the collection points during breaks.

The MOP has demonstrated its value in less crowded hospitality spots. However, in a stadium setting, ensuring proper wireless signal coverage can be challenging due to the high density of users. Overcoming these technical and logistical challenges is crucial for the successful implementation of the MOP in busy environments like a stadium. Hence, the MOP will not be considered in Chapter 6 and Chapter 7 due to technical implications and implementation feasibility.

### 5.5.4. Snack wall

Considering the throughput of a snack wall, this shows potential. The average service time for the customer is about 8.5 seconds, which is quicker than other options. On the other hand, the snack wall typically serves only one or two products per order. Hence, it might be possible that one supporter needs to place multiple orders at the snack wall, which negatively influence the throughput obviously.

Regarding the productivity, the snack wall performs well. Damian van Bakel, chef of public catering at the Philips Stadium, stated that they reduced the number of service employees from five to two while maintaining the same sales volume, corresponding to a 60% reduction of personnel. However, as discussed in Chapter 3, the variety of products is crucial for the success of a vending machine. This could potentially decrease productivity.

The supporter experience is in line with the other SSTs. At the other stadium, the same amount of space was used for the same amount of sales volume. Concerning the implementation, the snack wall have proven their success at multiple hospitality spots, including the Johan Cruijff Arena and Philips stadium.

### 5.5.5. Automated beer tap system

The throughput of the beer tapping system is about 35 seconds according to data of the company Beermate (*Beermate*, 2024), similar to normal counters. However, the beer counter at stadion Feijenoord with a throughput of approximately 20 seconds per order performs better than the beer tap system.

Regarding productivity, no personnel are needed to run the automated beer tapping system during the ordering process. Initially, one employee may be deployed to assist new users in understanding the system. This setup has the potential for excellent productivity.

Supporters experience is the same as other SSTs. Concerning the space occupation, the beer tap system has potential. The system can be placed everywhere and does not need any service employees. Therefore, this type of ordering can be a valuable addition to the current public catering system. The automated beer tap system has been successfully implemented at many festivals, where visitors frequently use it and enjoy the convenience of ordering beer through the system. This suggests it could be equally effective in a stadium environment.

Lastly, it is important to mention the implementation cost of one automated beer tap system. According to Beermate, the implementation costs per system are €50,000 (*Beermate*, 2024). The maintenance costs are excluded and would cost around a couple of hundred euros each month (*Beermate*, 2024).

**Sub question 3: How can a choice model be estimated in order to investigate the crowd's intention to use SSTs in the Kuip based on the key determinants of the public catering system?**

The MNL estimated the different parameters considered in sub question 2. All three attributes behave as expected. The waiting time and walking distance had a negative impact on the utility and convenience positive. The Table below presents that walking distance and waiting time has equal negative influence on utility, when both parameters are converted to the unit time (i.e -0.005 per meter and -0.260 per minute). Moreover, the preference for a normal counter is remarkable. The Feyenoord supporter prefers the normal counter above the SST counter. For instance, a supporter prefers to walk 100 meter extra to go to a normal counter. Or, a supporter prefers to wait two more minutes as long as he/she is served at the normal counter. This is important to consider, when Stadion Feijenoord is going to implement a SST.

| Attribute | Estimate | Std. Error | t-ratio | p-value |
|---|---|---|---|---|
| $\beta_{waitingtime}$ | -0.260 | 0.020 | -12.853 | 0.000 |
| $\beta_{walkingdistance}$ | -0.005 | 0.001 | -5.117 | 0.000 |
| $\beta_{convenience}$ | 0.001 | 0.001 | 1.477 | 0.070 |
| $\beta_{normalcounter}$ | 0.589 | 0.044 | 13.369 | 0.000 |

Table 5.13: MNL Model Estimates and characteristics of the attributes of all data

# 6 Results

In this chapter, the results derived from Chapters 4 and 5 are presented and analyzed. This analysis is conducted for each KPI: waiting time, supporter experience, and cost efficiency. In this chapter, the SOK, snack wall, and automated beer tap system are considered. As mentioned, the MOP is not further considered due to technical feasibility and the current stage of development of this innovation. Ultimately, sub-question 4 will be answered in this chapter:

*Sub-question 4: What is the potential added value of SSTs at the public catering at Stadion Feijenoord?*

## 6.1. Waiting time

In this section, the waiting times for each counter type are compared. Based on these results, an analysis is conducted for each counter type. Drawing from Section 5.3, the average waiting time, queue length, service time, and arrival rate are observed and calculated for a standard counter at Stadion Feijenoord. It is important to note that for these calculations, the observed average waiting time is set as constant for each type of counter. Using the average waiting time and service rate, the corresponding arrival rate for each traditional counter —namely, the normal counter, beer counter, and hot food counter— can be calculated. This arrival rate is assumed to remain constant for the SOK, automated beer tap, and snack wall, as shown in Table 6.1.3. Ultimately, the ratios between the traditional and SST counters can be determined and visualized.

The characteristics of the SOK and the normal counter are compared, as both serve the same purpose: the sale of all drinks and snacks. Similarly, the characteristics of the automated beer tap system are compared with those of the beer counter. Lastly, the hot food counter and snack wall are compared.

### 6.1.1. SOK versus normal counter

The service rate for the SOK is determined through observations made during the halftime of an Ajax match at the Johan Cruijff Arena. The service rate of the normal counter is derived from the data analysis presented in Section 5.1. When considering the normal counter characteristics, Section 5.3 shows that the average waiting time is equal to 208 seconds, varying on when an individual joins the queue. The service time is set at 34.5 seconds, as determined in Section 5.1. Using equation 5.6, the arrival rate is calculated to be 1.45 supporters per minute, equating to one supporter every 41 seconds.

When considering the characteristics of the SOK counter. The service time observed is 40.4 seconds, which includes only the ordering process. To account for the distribution of food and beverages, an additional 10 seconds is added to the service time, based on estimates and consultations with service employees. Consequently, the total service time is set to 50.4 seconds. It is assumed that the arrival rate of the normal counter and SOK counter is equal, with one customer arriving every 41 seconds. Thus, the arrival rate ($\lambda$) is 1.45 supporter per minute, while the service rate ($\mu$) is 1.19 supporters per minute. In this case, since $\lambda > \mu$, the system is unstable and the queue will grow over time.

To maintain the same time in the system with a constant arrival rate, additional SOKs must be implemented. To achieve this, the average waiting time is constant and observed to be 3.46 minutes (Section 5.3) and the service rate ($\mu$) remains at 1.19 supporters per minute. Hence, the ratio between the service rates is 1:1.5, meaning that for each cash register in the normal counter scenario, 1.5 SOKs are needed to maintain the same average time in the system with a constant arrival rate of 1.45 supporters per minute. This is visualized in Figure 6.4. Therefore, if SOKs are implemented to replace the normal counters, 1.5 SOKs are needed for each cash register. Currently, there are 138 cash registers in operation within the public catering system, excluding the hot food and beer counters. To replace all these cash registers, 207 SOKs would be required.

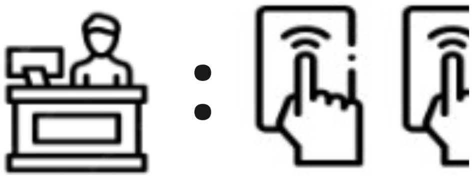

Figure 6.1: Ratio of normal counters to SOK pay points needed to maintain the current system time: 1:1.5.

### 6.1.2. Beer counter versus automated beer tap system

To ensure a consistent average waiting time when replacing the current beer counters with an automated beer tap system, the service rates of both counter type are calculated as follows. The average transaction times for the beer counters were determined to be 19.55 seconds (5.1), resulting in a service rate of 3.07 supporters per minute (60 seconds divided by 19.55 seconds). For the automated beer tap system with an average transaction time of 35 seconds (*Beermate*, 2024), the service rate calculates to 1.71 supporters per minute (60 seconds divided by 35 seconds). This ultimately results in a possible arrival rate of 1.42 supporter per minute, when the current beer counters are 1 on 1 replaced by the automated beer tap system. This is significant lower than the current arrival rate of 2.78 supporter per minute.

To maintain the same arrival rate and average time in system extra service points are required. The ratio between the service rates of the beer counter and automated beer counter is 1:1.8. Consequently, for each beer counter replaced by an automated beer tap, approximately 1.8 new service points are required to sustain the current arrival rate and average time in the system. This adjustment ensures that despite changing to automated systems, the service capacity aligns with supporter demand, thereby maintaining the same waiting experience. Each beer counter currently has 2 cash registers, amounting to a total of 8 cash registers in operation. Therefore, approximately 14 automated beer tap systems would be needed to replace the existing beer counters.

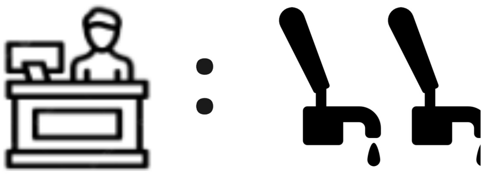

Figure 6.2: Ratio beer counter versus automated beer tap pay points needed to maintain the current time in system: 1:1.8

### 6.1.3. Snack wall

Similar to the other SST, the service time for the snack wall and the hot food stands are calculated and compared. Observations at Rotterdam central station show that the average service time for the snack wall is 8.5 seconds, see Appendix A.10. The standard deviation of the transaction time is only 2.48 seconds, indicating that the ordering process is homogeneous. Data analysis reveals that the average order size is 1.56 product per order. It is assumed that at the snack wall the order size is always equal to one.

Setting the current average order size as a constant, the average service time is calculated as the average order size multiplied by the average service time. Therefore, the new average service time for the snack wall is 1.56 multiplied by 8.5 seconds, equaling 13.26 seconds. Hence, the service rate ($\mu$) is 4.52 supporters per minute. In comparison, the average service time of the hot food counter is 32.2 seconds, which corresponds to a service rate of 1.86 supporters per minute. Thus, each service point of the snack wall can replace 2.4 cash registers, giving a ratio of 1:2.4, as shown in Figure 6.5.

Figure 6.3: Ratio snack wall versus normal counter needed to maintain the current time in system: 1:2.4

| **Counter type** | **Average time in system (W)** | **Arrival rate ($\lambda$)** | **Service rate ($\mu$)** | **System** |
|---|---|---|---|---|
| *Normal counter* | 3.46 *min* | 1.45 | 1.74 | Stable |
| *SOK* | 3.46 *min* | 1.45 | 1.19 | Unstable |
| *Beer counter* | 3.46 *min* | 2.78 | 3.07 | Stable |
| *Automated beer tap system* | 3.46 *min* | 2.78 | 1.71 | Unstable |
| *Hot food counter* | 3.46 *min* | 1.57 | 1.86 | Stable |
| *Snack wall* | 3.46 *min* | 1.57 | 4.52 | Stable |

Table 6.1: Characteristics per counter type

| **Counter type** | **Average time in system (min)** | **Arrival rate (sup/min)** | **Service time (s)** | **Service rate (sup/** |
|---|---|---|---|---|
| *Normal counter* | 3.46 | 1.45 | 34.5 | 1.74 |
| *SOK* | 3.46 | 1.45 | 50.4 | 1.19 |
| *Beer counter* | 3.46 | 2.78 | 19.5 | 3.07 |
| *Automated beer tap system* | 3.46 | 2.78 | 35.0 | 1.71 |
| *Hot food counter* | 3.46 | 1.57 | 32.2 | 1.86 |
| *Snack wall* | 3.46 | 1.57 | 13.3 | 4.52 |

## 6.2. Supporters experience

The choice experiment revealed a clear preference among supporters for normal counters over SST counters. Table 6.2 displays the estimates for each age group, highlighting significant differences. Across all age groups, waiting time and walking distance were consistently perceived negatively in the ordering process. Moreover, respondents in every age category showed a preference for the normal counter over the SST counter. It is interesting to see that older respondents tended to exhibit a stronger preference for the normal counter. Lastly, it is important to note that only 13% of the respondents fell within the 15-30 age group, while the majority (58%) were 51 years old or older.

| **Attribute** | **All** | **15-30** | **31-50** | **51+** |
|---|---|---|---|---|
| $\beta_{waitingtime}$ | -0.245 | -0.293 | -0.278 | -0.218 |
| $\beta_{walkingdistance}$ | -0.005 | -0.006 | -0.007 | -0.004 |
| $\beta_{convenience}$ | 0.001 | 0.003 | 0.002 | 0.000 |
| $\beta_{normalcounter}$ | 0.560 | 0.287 | 0.528 | 0.637 |

Table 6.2: MNL Model Estimates per age group

Upon closer examination of the results, it appears that for the age group 15-30, an additional minute of waiting time carries roughly the same weight as opting for a SST counter instead of a normal counter. This suggests that if an SST counter offers more than a one-minute waiting time advantage, supporters in this age group would prefer it over the normal counter. For a supporter aged 51 years and older, a SST should almost have a 3 minute waiting time advantage to favor an SST counter over a normal one.

In short:

- Age 15-30: be willing to wait 1 additional minute to join the queue for the normal counter
- Age 31-50: be willing to wait 2 additional minute to join the queue for the normal counter
- Age 51+: be willing to wait 3 additional minute to join the queue for the normal counter

It is crucial to consider that people, especially younger supporters, are becoming increasingly familiar to SST in their daily lives. Thus, when considering innovations to ensure Stadion Feijenoord remains a stadium that serves the supporters well in the future, larger weight should be placed on the preferences of younger supporters, as they represent the future. However, as highlighted in the previous Section 6.1, replacing a normal counter directly with an SST counter results in increased waiting times. Therefore, to serve the supporters with at least the same utility, the normal counters can not be replaced one-for- one for SST counters. Consequently, integrating SST counters as an additional option rather than a direct replacement seems more feasible.

Moreover, it needs to be stated that there exist a preference for normal counter, however the parameter estimate values of the alternative specific constant $\beta_{normalcounter}$ is relatively low. Therefore, when the attribute levels are equal to each other 64% chooses the normal counter and 36% chooses the SST counter. This percentages are even coming closer to each other, the younger the supporter gets as mentioned in Section 5.2.6 and stated in Table 5.7.

Moreover, it should be noted that there is a preference for the normal counter; however, the parameter estimate value for the alternative specific constant $\beta_{normalcounter}$ is relatively low. Consequently, when the attribute levels are equal, 64% of supporters choose the normal counter, while 36% choose the SST counter. These percentages converge even more among younger supporters, as mentioned in Section 5.2.6 and shown in Table 5.7.

## 6.3. Costs efficiency

In this section, the cost efficiency of the ordering process in the public catering system is discussed, specifically examining personnel costs. It evaluates the cost reductions associated with implementing various SSTs and their impact on employee productivity. The comparison includes the SOK versus the normal counter, the beer counter versus the automated beer tap as well as the snack wall versus the hot food counter.

### 6.3.1. SOK versus normal counter

To compare the SOK with normal counter, the focus is on the time saved when supporters handle their own ordering, as depicted in Figure 4.3. Hence, the reduction in personnel costs is based on the time saved by supporters managing the ordering process themselves. It is assumed that no assistance is required during the ordering process at the SOK.

According to Table 4.1, the following counter types are qualified for implementation of a SOK: the upper ring, the outer ring, and inner ring counters. Through data analysis, the total amount of transaction for the season of these counters has been determined. The Table 6.3 below represents the data required to derive the average transaction time. The transaction times per counter are taken from Section 5.1.

| Counter type | Average Transaction time (s) | # of transaction | Total time (s) | Total time (h) |
|---|---|---|---|---|
| *Inner* | 34.5 | 586,847 | 20,246,221 | 5,624 |
| *Outer* | 28.2 | 196,976 | 5,554,723 | 1,543 |
| *Upper* | 30.1 | 307,432 | 9,253,703 | 2,570 |
| **Total** | 32.1 | 1,091,255 | 35,054,647 | 9,737 |

Table 6.3: Number of transaction and time it takes per counter over the Feyenoord season 23/24

From this data, the average transaction time is calculated by dividing the total time in seconds (35,054,647) by the number of transactions (1,091,255), resulting in an average transaction time of 32.1 seconds. As mentioned in Section 6.1, the preparation and distribution per transaction take approximately 10 seconds per order. Therefore, the ordering process alone accounts for 32.1 - 10.0 = 22.1 seconds per order. Hence, the average time spent on ordering is 22.1 seconds, and this time could be saved per order by implementing the SOK.

The personnel costs saving can be calculated according to following formula:

$$\text{Cost savings (€)} = \frac{\text{Total number of transactions} \times \text{Average ordering time (s)}}{3600} \times \text{Work rate (€)} \tag{6.1}$$

Table 6.4 outlines the potential cost reduction in personnel by replacing the normal counters with SOK counters. The hourly work rate is set at €25, which represents the average cost per employee per hour at a counter, accounting for various employee levels. Removing 6699 working hours dedicated to the ordering process results in a total cost reduction of **€167,477.32** per season. As said, no personnel costs are included for assisting supporters during the ordering process of the SOK. If Stadion Feijenoord decides to deploy personnel for this assistance, the cost reduction would be slightly less.

| Counter type | # of transaction | Average order time (s) | Work rate (€) | Cost reduction (€) |
|---|---|---|---|---|
| *All (season)* | 1,091,255 | 22.1 | 25 | **€167,477.32** |
| *All (match)* | 40,417 | 22.1 | 25 | €6,202.86 |
| *Olympia 1 (season)* | 63,051 | 24.5 | 25 | €10,727.43 |
| *Olympia 1 (match)* | 2,335 | 24.5 | 25 | €397.30 |

Table 6.4: Overview of possible personnel cost reduction over the season

When considering the productivity of the employees by this potential time saving. The total potential time saving is calculated by multiplying the average ordering time by the total number of transactions.

$$\text{Personnel hours saved (h)} = \frac{\text{Total number of transactions} \times \text{Average ordering time (s)}}{3600} = \frac{1,091,255 \times 22.1}{3600} = 6699h \tag{6.2}$$

Over last season, the total number of hours worked is 21,154.5. In the optimal scenario where all 6699 hour work is saved by replacing the normal counter with SOK counter, only 14,455.5 hours of work would remain. This represents a reduction of 32%. From data analysis the current average productivity is measured in terms of revenue per worked hour. The average productivity is calculated by dividing the total revenue by the total number of worked hours. This results in a productivity of **250€** and **366€** revenue per worked hour for the normal counter and SOK counter scenarios, respectively.

To begin with the replacement of the normal counters with SOK counters, according to Section 6.1, 207 SOKs are required to replace all current cash registers. Section 5.5 states that implementing a SOK costs €1.899 each (Foodticket, 2024). Therefore, replacing all current cash registers with SOKs will cost €393.093 With savings of €167,477.32 per season. Assumed that the revenue stays stable, the implementation costs will be earned back in approximately 2.5 seasons. Regarding the maintenance costs, 2 percent of the revenue can be paid, approximately €100.000 per year or a fixed price per SOK can be paid dependent on how many SOKs are taken, ranging from €50-200 per SOK per month. Based on these numbers, the maintenance costs are approximately

€100,000 per year. By purchasing a significant number of SOKs and strong negotiations, it is estimated that these costs could be reduced. Taking the maintenance costs into account, the implementation costs of the SOK will be earned back in six seasons.

### 6.3.2. Beer counter versus automated beer tap system

When considering, the replacement of the beer counters with an automated beer tap system, no personnel action is necessary during the entire ordering process, as the preparation and distribution are handled by the machine itself. This eliminates the need for personnel.

Based on the data from last season, the four beer counters together require 1330.5 hours of work, equating to approximately 50 hours per match and 12.5 hours per stand per match. The potential cost savings over the season can be calculated as follows:

$$\text{Cost savings} = \text{Total number of worked hour} \times \text{Work rate (€)} = 1330.5 \times 25€ = \textbf{€33,265} \tag{6.3}$$

However, it is recommended that one service employee per selling point is deployed to assist supporters (Beermate, 2024). Besides, this person can help to verify whether no supporters below the age of 18 are ordering beer. Although the automated beer tap system can check identity cards, this may increase service time and consequently affect queue lengths, supporter experience, and revenue. When deploying one person per selling point, the required hours per stand per match reduce from 12.5 hours to 5 hours. This corresponds to a total of 540 hours per season. The potential cost savings over the season can be calculated as follows:

$$\text{Cost savings} = \Delta\text{Total number of worked hour} \times \text{Work rate (€)} = (1330.5 - 540) \times 25€ = \textbf{€19,762.50} \tag{6.4}$$

Putting this into perspective regarding the reduction in worked hours, changing to 540 worked hours represents a decrease of 59.5% in total worked hours. Regarding the productivity, replacing beer counters with automated beer taps results in an increase in productivity per worked hour from **€317.75** to **€782.96**.

Considering the replacement, 14 automated beer tap systems are required to maintain the same waiting times. Implementing one beer tap system costs €50,000 (Section 5.5). Consequently, it will cost €700,000 to replace all beer counters with automated beer tap systems. With an annual savings of approximately €20,000 from replacing the beer counters, it will take 35 seasons to recover the implementation costs. These calculations exclude maintenance costs and the possibility to rent out the system during the off-season.

### 6.3.3. Hot food stand versus snack wall

In this section the potential cost savings considering the snack wall are examined. The sales of fries are excluded within this calculation as fries are not suitable for the snack wall. Similar to the calculations for the SOK the difference in service time is needed to calculate the possible time savings. The total service time includes both preparation and service time. For the snack wall, the service time is zero seconds since supporters serve themselves. The total service times for can be calculated as follows:

$$\text{Total service time (s)} = \text{Number of transactions} \times \text{Service time (s)} \tag{6.5}$$

The number of transactions for the hot food stand and snack wall are 128,719 and 200,803, respectively. The total service times are 32.2 and 5.0 seconds, respectively. This 5.0 seconds is an estimate based on the 10.0 is takes to serve the supporter on specific orders, in the case of a snack wall orders do not have to be prepared order specific. The total service time for the snack wall is 5.0 seconds. This differs from the 8.5 seconds mentioned in Section 6.1, which refers to the supporter's service time. Hence, the employee's service time is 5.0 seconds, while the supporter's service time is 8.5 seconds.

Hence, the shutters can be filled quicker. These service times correspond to 1151 and 279 hours in total. Hence, 872 hour of working hours can be saved by replacing the current hot food stand with snack walls. Ultimately, this results in **€21,800.00** savings each year. Last season, 5,983 hours were worked at the hot food counter, excluding the worked hour at the fries counte. Therefore, a saving of 872 working hours corresponds to a reduction of 14.5% in working hours. This is significant lower than the stated reduction in working hours achieved at the Philips Stadion of 60%. The productivity increase from 140€ to 164€, which is an increase of 17%.

Regarding the implementation costs, one unit with eight shutters costs approximately 4,000€. The maintenance costs can be regarded as negligible (*Loketautomaten*, 2024). Although one snack wall can theoretically replace 2.43 cash registers based on service times, it should be noted that one unit with eight shutters might be insufficient to serve supporters effectively. The queuing process for a snack wall differs from that of a normal cash register, making this ratio unrealistic. In total there are 30 cash registers for snacks, this corresponds to 12.34 snack wall units. In this case, the implementation costs will be approximately 50,000€, consequently these will be earned back within 2.5 seasons. This will be further elaborated in Chapter 7 and 8.

**Sub question 4: What is the potential added value of SSTs at the public catering at Stadion Feijenoord?**

All three KPI's are considered in terms of the implementation of SSTs. Regarding the first KPI, throughput, it is determined that replacing normal counters with SOKs or automated beer taps requires additional units to maintain the same waiting times. This is due to the longer expected service times associated with SOK and automated beer tap. Therefore, for every cash register replaced by an SOK or automated beer tap, approximately 1.5 and 1.8 units of SOKs or automated beer taps need to be implemented (see Figure 6.4 and 6.2). Therefore, to effectively reduce waiting times and enhance system value, more than 1.5 units of SOKs and 1.8 units of automated beer taps should replace each current cash register. On the other hand, the snack wall's service time is faster than the current hot food counter's service time. Based purely on service times, each snack wall could replace 2.4 cash registers at the hot food stand.

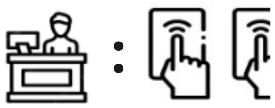

Figure 6.4: Ratio normal counter versus SOK of pay points needed to maintain the current time in system

Figure 6.5: Ratio snack wall versus normal counter needed to maintain the current time in system

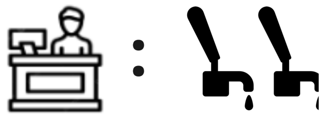

Figure 6.6: Ratio beer counter versus automated beer tap pay points needed to maintain the current time in system

Regarding the supporters experience, Table 6.2 shows that the supporters slightly prefer the normal counter over the SST counter. When having the same attribute levels between alternatives, the probability to choose the normal counter over the SST counter is 64%. The SST counter should have clear advantages over the normal counter to be in favor. Thus, implementing SSTs can only enhance value in terms of the supporter experience if the SST counter have better conditions than current ones are achieved.

Considering the cost efficiency, significant personnel cost reductions can be achieved by implementing SSTs. Over a season, the SOK can potentially save 6699 working, which corresponds to a **€167,477.32** personnel costs reduction. This results in approximately 248 hours saved and €6,202.86 in cost savings per match. This translates to a 32% reduction in working hours and an increase in productivity from €250 to €366 of revenue gained per worked hour for service employees.

The potential personnel cost savings regarding automated beer tap implies **€19,762.50** per season. This is due to the potential reduction in working hours from 1330.5 to 540. This potential reduction in working hours increases the productivity from €317.75 to €782.96.
Regarding the snack wall €21,800 of personnel costs can be saved. This corresponds to 872 working hours and a reduction 14.5% in working hours. This does not align with the stated reduction at the Philips Stadion of 60%. Lastly, an increase of 17% in productivity is expected.

| **Counter** | **Δ working hours** | **%** | **Δ productivity** | **%** | **Cost Reduction** |
|---|---|---|---|---|---|
| *SOK* | 6669 | -32% | 116€ | 46% | €167,477 |
| *Automated beer* | 790.5 | -59.5% | 465€ | 146% | €19,763 |
| *Snack wall* | 872 | -14.5% | 24€ | 17% | €21,800 |

Table 6.5: Summary cost efficiency

In summary, SST can add value in terms of waiting times if additional counters are implemented. For supporters' experience, SSTs can add value when the attributes of SST counters significantly exceed those of normal counters. Moreover, SSTs can add value through substantial reductions in the working hours currently handled by service employees.

# 7
# Design

This chapter presents several designs for the future public catering system at Stadion Feijenoord, drawing on insights from previous chapters. Different scenarios will be explored. The current counters in the public catering system, as listed in Table 4.1, will be taken into consideration. To streamline the analysis, the Maaszaal, Legioenzaal, and the Vereeniging will be excluded from scope as they each have only one counter that requires explicit consideration. Besides, as mentioned before, the MOP is not being considered for implementation because the SST is in a premature phase and involves too many implications.

The first design focuses on the replacement of counters, the second on adding counters, and the third on integrating the best elements of both approaches. By the end of this chapter, the final sub-question of this research will be addressed:

*5. How should the SSTs be implemented and what are important factors that should be taken into account during implementation?*

## 7.1. Design 1: replacing current counters with SST counter

This section explores potential designs where the current counters are replaced by SST counters. As discussed in Chapter 6, it appears that replacing the beer counters with automated beer tap systems is not feasible due to costs. Moreover, supporters tend to prefer normal counters over SST counters. Therefore, the automated beer tap system will not be implemented in this design. The following sections will focus on the implementation of the SOK and snack wall counters.

### 7.1.1. SOK

Next, the SOK. The SOK shows potential in replacing the normal counter. Assuming revenue remains constant, the SOK will pay for itself in 6 seasons, including maintenance costs, as detailed in Section 6.3. As discussed in Chapter 3, revenue could increase with the implementation of SOKs due to a potential rise in average transaction amounts. It is not feasible to replace all normal counters with SOKs simultaneously, so the focus will be on replacing specific counters. The initial implementation will begin on one side of the stadium, with the yellow side being chosen as the optimal starting point. Most supporters on this side hold season tickets, ensuring they will become familiar to the SSTs over time. In the conclusion of Chapter 3, the SOK is categorized as early majority. Therefore, the adoption of SOKs at Stadion Feijenoord is expected to gain traction steadily among supporters, especially as familiarity and acceptance grow over time.

It was chosen to replace normal counters at the inner ring, outer ring, and upper ring. This to see the potential of the SOK at each different position of a side. For the initial design the SOKs are implemented at spots where the most space is available.

For the upper ring, 6 SOKs are needed to replace the 4 cash registers in the current situation and maintain the same waiting time. As the space is scarce at the upper ring the SOKs needs to be placed precise. Based on observations at the Johan Cruijff Arena it is estimate that at least 70 centimetres between two SOKs is needed to ensure a proper crowd management. The SOK itself is approximately 40 centimetres wide (*Foodticket*, 2024). Hence, the 6 SOKs can be placed in this dead space at the upper ring. This require 70x5+40x6=590 centimetres. This space is not available at the upper ring. Therefore, initiating the replacement of cash registers at the upper ring is not advisable.

In the outer ring, all cash registers at the Lichtmast Q counter will be replaced by SOKs. Lichtmast Q currently has 4 cash registers, necessitating the implementations of 6 SOKs to maintain current waiting times. In this case, since there is enough available space at the outer ring, it can be considered to implement more than six SOKs. Figure 7.1 illustrates the outer ring counter at the yellow side where the cash registers can be replaced with SOKs, showing sufficient space for their placement.


Figure 7.1: Outer ring counter at the yellow side

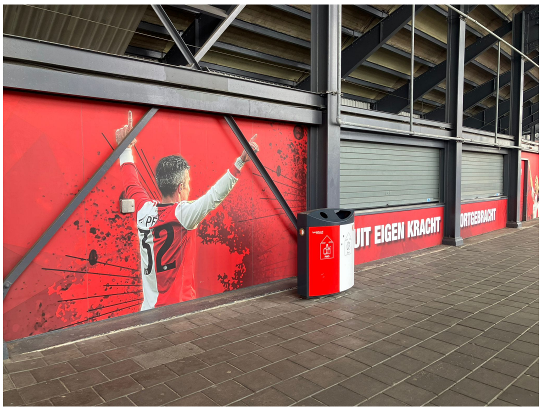


Figure 7.2: Inner ring counter at the yellow side

Figure 7.3: Outer and inner ring counters

For the inner ring, it has been decided to partially replace the cash registers at counter Stadion 1. This decision takes into account available space and crowd control during the halftime break of matches. The inner ring counters are structured with some connected to the outer ring and others to the inner ring. The counters connected to the outer ring are suitable for replacing the cash registers. In this instance, 2 cash registers need to be replaced, requiring 3 SOKs. Figure 7.3 illustrates the counter's location, showing the potential placement of the three SOKs on the left side.

In summary, this design involves (partly) replacing two normal counters at the yellow side with SOKs. The number of SOKs implemented is primarily determined by the available space. Considering the adoption rate, it is recommended to operate these SOKs for at least half a season to thoroughly test and validate their potential added value to the yellow side of the stadium initially, and subsequently to the entire stadium.

### 7.1.2. Snack wall

For the replacement of the current food counters with snack wall, the food counters at the yellow side are considered as well. Initially, only one of the two food counters will be targeted for replacement. This ensures that supporters still have the option to choose between a normal counter and an SST counter. These counters include sections for fries, snacks, and burgers, each with two cash registers. The cash registers for fries will not be replaced, as fries are not suitable for the snack wall concept. Therefore, four cash registers in total need replacement.

According to the ratio's obtained in Section 6.1, only two snack walls are required to replace the four cash registers. However, this is only based on the service times. However, queue formation for a normal cash register differs significantly from that for a snack wall. A normal cash register typically forms a straight line queue, whereas observations show that queues for snack walls tend to be more spread out and disorganized.

From Figure 7.4 and 7.5, it seems there is enough available space to implement to a snack wall with eight shutters and one pay point. As mentioned in Section 6.3, these snack wall should have earned itself back within 2.5 season.

Lastly, the snack wall is classified under the "laggards" category of Rogers' diffusion curve, as discussed in the conclusion of Chapter 3. Hence, it is expected that this innovation will gain traction quickly when implemented in new locations since most people are already familiar with the technology.


Figure 7.4: Current hot food stand


Figure 7.5: Snacks part of hot food stand

## 7.2. Design 2: adding SST counter to public catering system

This section explores potential designs for integrating additional SST counters into the current public catering system. Again, the focus for implementation lies on the yellow side of the stadium.

### 7.2.1. SOK

When considering the addition of SOKs to the current public catering system, the most practical location for this implementation is the outer ring. As previously mentioned, implementing SOKs in the upper ring is complicated due to space limitations, and the inner ring can only accommodate SOKs at counters connected to the outer ring. Therefore, for the initial phase of implementing SSTs at the public catering system, it is chosen to add SOKs to existing outer ring counters.

As discussed in the previous section, six SOKs are required to maintain the current average time in the system. In this scenario, it is proposed to reduce the observed arrival rate (1.45 supporters per minute) by doubling the number of service points. Consequently, the arrival rate decreases to 0.725 supporters per minute, while the service rate remains unchanged at 1.19 supporters per minute. By using equation 5.6, the corresponding average time in system reduces from 3.46 minute to 2.12 minute, which is a significant improvement.

However, based on the results of the supporters experience, see Section 6.2, with a waiting time reduction of 1.3 minute only the age group of 15-30 would prefer this SST counter over the normal counter. Nonetheless, supporters now have the option to select between different types of counters, enhancing their overall experience.

When applying Equation 5.5 with the new waiting times, it becomes apparent that the probability of choosing the normal counter versus the SST counter is nearly equal, at 56% and 44% respectively. It shows that even with the reduced waiting times, the normal counter remains the preferred choice. Despite of this small preferences for the normal counter, it is still recommended to implemented and add these SOK counters. The supporters experience will not be lowered as they still have the option to choose the normal counter. Meanwhile, supporters who are indifferent initially or who initially preferred the SST can benefit from the reduced waiting times.

It is important to note that for these calculations, it is assumed the arrival rate and therefore the revenue remain unchanged. Although, it is conceivable that the arrival rate will increase if the waiting time is shortened.

### 7.2.2. Automated beer tap system

The automated beer tap system did not show potential to replace the beer counters due to the costs, additional service time, and space limitations. Although, the automated beer tap system could be a valuable addition to the public catering system of Stadion Feijenoord.

Considering the available space in the outer ring, there is sufficient room to install the automated beer tap system. A suitable location could be the dead space under the stairs, as shown in Figure 7.6. Moreover, incorporating this beer tap system adds variety to the public catering options and could enhance the overall supporter experience. The new automated beer tap system would be a completely new counter, whereas the extra SOKs would be an addition to a current counter. Lastly, in the conclusion of Chapter 3, the automated beer tap system is classified as an "innovator" according to Rogers' diffusion curve. Therefore, its adoption would initially be limited to a small group of supporters who are open to new technologies. Thus, it is expected that this innovation takes longer to gain traction compared to the SOK and snack wall.

Considering the costs, as mentioned in Section 6.3, the implementation costs are €50,000. Beermate states the system lasts for 10 years. This amounts to €5,000 per year, which translates to approximately €185 per match, assuming a season comprises 27 home games. Including the personnel and maintenance costs per match, each estimated at €100, the total cost per match is €385. Therefore, by installing one automated beer tap system in the outer ring on the yellow side, the system would need to generate at least €385 in profit per match to break even, assuming its presence does not negatively impact other counters.

The profit margin per unit of beer is €3.66, corresponding to 74%. This implies that approximately 106 beers must be sold per match over a span of ten years to breakeven. To put this in perspective, during the previous season, the beer counter on the yellow side recorded an average sale of 687 beers per match. Assuming the average waiting time and demand is kept consistent for each counter, it is expected that the automated beer tap system can sell 382 beers per match. This translates to a profit of €1197 per match after the personnel and maintenance costs. Under these conditions, it is estimated that the investment will be recovered within 42 matches, which is nearly two seasons. Again, it is crucial to note that this analysis assumes the introduction of the new counter will not impact sales at existing counters.

Figure 7.6: Location of automated beer tap system

### 7.2.3. Snack wall

As said in Section 7.1, the snack wall is a good alternative for the current hot food counters. In this section, it is also stated that there is enough space for replacement of the current counter and the addition of extra service points. Besides, it is mentioned that because of the different type of counter, a normal straight queue is not expected for the snack wall. Similar to the SOKs, the introduction of extra snack walls has the potential to reduce waiting times and increase revenue.

In this case, six more snack wall are added to come to a total of eight snack wall service points. It is expected that these additional units significantly reduce the waiting times and increase the revenue.

In Section 6.3, it is stated that implementing the snack wall could lead to a saving of €21,800.00 in personnel costs. Assuming equal distribution of hot food counters on each side of the stadium, this results in an annual savings of €5,450.00 per side, which ultimately results in a €2,750 savings per counter. Therefore, the investment of €16,000 for eight snack walls would take approximately six seasons to earn this investment back. This calculation does not consider potential revenue increases resulting from the additional snack walls. Hence, it can be expected that six seasons is the maximum time to earn the investment back.

Currently four cash register are running at the counter considered for the new design. Eight snack walls correspond to 9.72 cash register, see figure 6.5. This represents a 2.43 times increase in service points (9.72 divided by 4). In this case the arrival rate is 0.65 supporter per minute and the service rate remains the same, see Table 6.1.3. The new average waiting time can be calculated using Equation 5.6, which results in a average waiting time of 0.82 minute or 49 seconds. In contrast, the current average waiting time stands at 3.46 minutes, indicating a reduction of nearly three minutes in waiting time. Based on the findings of the supporters experience, see Section 6.2, all individuals up to the age of 50 would prefer the SST over the traditional counter due to these improved waiting times.

Applying Equation 5.5 provides the following outcomes: 53% of supporters would select the snack wall, while 47% would opt for the normal counter. Consequently, there is a slight preference for the snack wall.

## 7.3. Recommended design

In the recommended design, elements from the first two designs are integrated.

The SOK and snack wall will each replace one counter on the yellow side. This setup provides supporters with the option to choose between the SST and traditional counters, easing their transition to SSTs. Additionally, the snack wall will replace one of the two existing hot food counters. The SOK will partially replace the cash registers at Stadion 1 on the inner ring and entirely replace those at Lichtmast Q on the outer ring. Due to limited space, it is advised against replacing the cash registers at the upper ring. Furthermore, it is recommended to install additional SOKs at counter Lichtmast Q and extra snack walls at Foodcounter Q to reduce waiting times and improve the supporter experience. The column "Number" for the replacement of the counters in Table 7.1 is based on the ratio mentioned in Section 6.1.

Considering the automated beer tap system, it is not recommended to replace the existing beer counters due to costs and space limitations. Although, the automated beer tap can be added to the public catering system. Due to its high implementation costs, it is recommended to do a one-season trial of this SST and install one of these systems underneath the stairs.

| SST | Location | Counter | Application | Number | Investments costs | Earned back |
|---|---|---|---|---|---|---|
| *SOK* | Inner ring | Stadion 1 | Replace | 6 | €12,000 | 2.5 season |
| *SOK* | Outer ring | Lichtmast Q | Replace and add | 6+6 | €24,000 | 5 season |
| *Beertap* | Outer ring | Under stairs RR | Add | 1 | €50,000 | 2-10 season |
| *Snack wall* | Outer ring | Foodcounter Q | Replace and add | 2+2 | €16,000 | 6 season |

Table 7.1: Overview of recommended implementations

**Sub question 5. How should the SSTs be implemented and what are important factors that should be taken into account during implementation?**

It is recommended to gradually implement the various types of SSTs. In the design for Stadion Feijenoord, the implementation will start exclusively on the yellow side. Calculations from Chapters 6 and 7 showed the benefits involving reduced waiting times, improved supporter experience, and cost efficiencies.

The SOK can not replace the cash registers at the upper ring. However, the SOK can (partly) replace the cash registers at the inner ring and outer ring. At the outer ring, additional SOKs can be implemented to reduce the waiting time and enhance the supporters experience.

The automated beer tap system is not suitable for replacing the beer counters at the inner ring due to cost constraints and limited space. However, it can be implemented at the outer ring. It is important to note that the initial investment costs are relatively high compared to other SSTs, and the potential cost savings are relatively low.

The snack wall presents significant opportunities in the design by replacing current cash registers and adding additional units to reduce waiting times and improve the supporter experience.

Considerations include the pace of implementation and replacement. Initially, supporters should have the option to choose between different types of counters, which means that all counters should not be replaced simultaneously. As stated in the literature Chapter 3, the adoption of innovations takes time. Therefore, it is recommended to introduce SSTs slowly to allow supporters to become familiar to them.

Moreover, literature indicates that the convenience of SSTs significantly influences their success. Hence, it is crucial that the functionality of the system is robust. Extra attention should be given to the beer tap and SOK systems in this regard, as these technologies may be less familiar to people compared to the snack wall.

# 8 Discussion

This chapter will discuss the methods used, the results concerning the KPI´s, and the implementation of each SST. It will also reflect on the scientific and societal contribution, as well as the limitations of the study and potential future research that can be done.

## 8.1. Methods

### 8.1.1. Choice Modeling

The primary consideration in choice modeling is that it is based on stated preferences. The main drawback of stated preference is the potential hypothetical bias. Would people really choose the option in real life? The consequences of their choices in the survey are not experienced, which affects the validity. For instance, when the halftime break during a match is almost over, would the supporters still prefer the normal counter over the SST if the queue of the SST is significant shorter? Would the supporter accept the risk of missing part of the match? Moreover, respondents can make strategic choices with the aim to influence the policy.

Another important aspect to consider is the respondent demographics. With 1,241 respondents making nearly 5,000 choices, a substantial amount of data has been gathered, enhancing reliability. Although, over half of the respondents were aged 51 and older, while only 13% were under 31. Hence, it is possible that older individuals were more likely to participate in the survey. Thus, the respondents might not represent the population at a match, which could also decrease the validity.

### 8.1.2. Data analysis and observations

For the data analysis and observations, it is important to examine the services times obtained through these methods. Regarding the data analysis, the service times are based on the pin transaction data during the match against Ajax. For each counter, the most used cash register during that day is used to determine the service times during the peak, namely during halftime. It could be possible that the most used cash register is also operated by the most experienced service employee. Hence, the real service times could be slightly higher than the obtained service times by data analysis.

Regarding the observations, the waiting times and arrival rates were determined by conducting observations at a single counter during four Feyenoord matches. Given that Stadion Feijenoord has multiple counters, each varying from the others, the actual average waiting times and arrival rates may differ from those observed. However, with these observations the best possible estimate for these values is determined. The same approach was applied to determining the service times for the SOKs at the Johan Cruijff Arena and snack wall at Rotterdam Central Station. It is important to note that these observations were conducted only once, which may affect their reliability. Lastly, regarding the observation of service times for the snack wall at Rotterdam Central Station, it is important to note that no queues were present during these observations. Consequently, individuals had time to think about their choices, and there were no delays due to doubting. This positively affected the service time.

## 8.2. Results

When reflecting on the results, it is important to discuss several aspect. Firstly, the ratios per counter type and the resulting personnel savings are derived from the obtained service times. Although the service time estimates are generally close, even a difference of a few seconds faster or slower can significantly impact more than 1 million transactions each season.

Secondly, considering the costs savings, the personnel reduction assumes the most optimistic scenario where no additional personnel is allocated to assist supporters with the SOK ordering process. In theory, no extra personnel is necessary, however, especially in the beginning, assisting personnel may be beneficial. On the contrary, the current assumption is that only waiting times will decrease through the replacement and addition of counters, with revenue expected to remain constant. However, it is plausible that revenue may actually increase as a result of implementing additional counters. Research needs to be conducted to investigate whether supporters of Feyenoord would be willing to increase their spending if improvements are made to the public catering system of Stadion Feijenoord.

Thirdly, concerning the supporters' experience, as mentioned, the respondents of the survey were relatively older. The supporters slightly favor the traditional counters. However, it is important to note that the introduction of additional SST counters will not necessary influence the supporters experience negatively, since the supporters devoted to their normal do not have to adjust their behavior. As people in general get more familiar with SSTs and because the younger supporters are less concerned about choosing between SSTs and traditional counters, innovations within the public catering for the future can make the Stadium more attractive, future-proof and less outdated.

## 8.3. Implementation

In Chapter 7, certain implementations are proposed. When reflecting on the three different SST, the KPI's are considered.

It is assumed that each SST affect the supporters´ experience equally. No distinction was made between different SST and their influence on supporter experiences.

According to the data in Table 8.1, the snack wall performs the best involving the service time. Moreover, the snack wall is well-known and favored among the Dutch population.

The SOK shows also potential, especially in the saving of personnel costs and hours. This is because the SOK can replace more counters compared to the snack wall and automated beer tap, which are limited to replacing only the beer and hot food counter. Finding competent personnel gets increasingly challenging, the SOK present to be a good solution to this.

Lastly, the automated beer tap, this SST is expensive and the current beer counter are operating efficiently and effectively. Therefore, the automated beer tap should be viewed as an enhancement to the customer experience, particularly adding enjoyment to the ordering process. This SST is the most innovative of the three, with supporters being less familiar with it. According Figure 3.4, this innovation is at the early adopters phase rather than the early majority and laggards phase, which better fits to the SOK and snack wall.

| **SST** | **Implementation Costs** | **Potential Cost Savings** | **Δ Service Time** |
|---|---|---|---|
| *SOK* | €1,899 | €167,477 | - 16 s |
| *Automated beer tap* | €50,000 | €19,763 | - 15 s |
| *Snack wall* | €4,000 | €21,800 | 19 s |

Table 8.1: Overview of KPI scores per SST

## 8.4. Contribution

This study contributes to the understanding of current ordering processes and the potential SST ordering processes in public catering systems at football stadium and extends its relevance to large events like sports matches, concerts, and festivals. The research was conducted using Stadion Feijenoord as a case study. The contribution is divided in scientific and societal contribution.

**Scientific:**

- **Operating efficiency and effectiveness of SST and traditional counters**: This report built on the existing knowledge about the efficiency and effectiveness of various counter types. The report thoroughly investigates the operating processes of various types of counters through empirical research and data analysis. The efficiency and effectiveness of these counters have been assessed, with a particular focus on service times and employee productivity. The snack wall and beer counter demonstrate exceptional service times of 13.3 seconds and 19.5 seconds, respectively, while the traditional counter averages 34.5 seconds, and the SOK has the longest service time at 50.4 seconds. In terms of productivity, the automated beer tap system shows the greatest potential, increasing productivity by 146%, compared to increases of 46% for the SOK and 17% for the snack wall. As a result, each SST counter shows significant savings in personnel costs. Overall, on a broader scale, these insights could be valuable for organizers of large events with high peak hours or challenges related to high personnel costs and staffing difficulties. Counters with faster service times are particularly beneficial for managing peak hours efficiently, while SST counters provide an effective solution to reduce personnel costs and staffing problems.
- **The Importance of Human Interaction**: The literature presents varying perspectives on the absence of human interaction with SSTs. Through a stated preference survey involving over 1,200 respondents and nearly 5,000 choices, this report highlights the significance of human interaction in the ordering process at football stadiums. The findings indicate that customers experience human interaction during the ordering process as pleasant. Customers are willing to wait an additional two minutes to be served at a traditional counter rather than a SST counter. Additionally, the survey revealed that younger respondents care less about choosing between SST and traditional counters. These insights are important for designing public catering systems at football stadiums.

**Societal:**

- **Implementation of SST Counters:** This report provides valuable insights for designing the public catering system in football stadiums, with a focus on Stadion Feijenoord. As demonstrated, SSTs have the potential to reduce both personnel costs and waiting times. For Stadion Feijenoord, it is recommended to begin implementing SST counters on the yellow side while continuing to offer supporters the choice between SST and traditional counters, given the observed importance of human interaction in the stated preference survey. In the broader context of a football stadium, this research highlights the potential benefits of each SST counter. It indicates that the snack wall and SOK should be prioritized over the automated beer tap system. This recommendation is based on the faster return on investment for the snack wall and SOK, which have lower implementation costs compared to the higher costs corresponding to the automated beer tap system.

## 8.5. Limitations

The following points highlight several limitations encountered in the study.

- **Stated preference and sample representativeness**: As mentioned, the choice experiment relies on stated preference. Therefore, it is important to acknowledge that respondents' choices may not always reflect their actual behavior in real-world situations. The survey sample may not accurately represent the actual population during a match, as more than half of the respondents were 51 years old or older, with only 13% under the ahe of 31. Hence, the results might not fully match to the real preferences. In the future, this could affect the estimation of parameters, potentially leading to a lower value for $\beta_{normalcounter}$ than currently estimated.

- **Service time accuracy**: The service times obtained from data analysis and observations might not fully capture the variability in real-world conditions. The most frequently used cash register might be operated by the most experienced employee, potentially resulting in slightly faster service times than average. This suggests that traditional counters may be evaluated more favorably compared to SST counters, as service times at traditional counters can be more variable due to human interaction. Consequently, the productivity gains associated with SST counters might be even greater than those currently observed.
- **Single counter observations**: Observations were conducted at one counter during four matches, which may not be representative of all counters. Different counters might have varying waiting times and arrival rates, thereby impacting the accuracy of general estimates. The same considerations apply to observations for the SOK and snack wall.
- **Adoption process**: The adoption process of innovation in the public catering system at Stadion Feijenoord has not been considered. For the new situation with implemented SST counters, the calculations assume the same arrival rate as the current situation. This could result in less favorable outcomes regarding cost savings and employee productivity after the implementation of SST counter, as the arrival rate is assumed to be constant.

## 8.6. Future work

In this section, several possibilities for future research are proposed.

- **Survey different counter type**: In the conducted survey, traditional counters are compared to SST counters. However, the survey does not provide insights into the differences in preference between the various SST counters. This generalization assumes that supporters view all SST counters similarly, which may not be accurate. From a scientific perspective, understanding the nuances in supporter preferences among different SST types could contribute significantly to the literature on consumer behavior and technology adoption. Future research should focus on these differences to provide a more detailed understanding of customers' preferences and how they might influence the success of different SST implementations.
- **Adoption process**: Investigating the adoption process of SSTs in the public catering system is essential. Research should be conducted at locations where SSTs are already implemented to assess the speed and effectiveness of their adoption by supporters. This research could contribute to theories on technology acceptance and diffusion of innovation within a public catering system setting. This understanding would enable more accurate calculations of the potential revenue increase resulting from the implementation of SSTs.
- **Understanding supporters' willingness to spend**: Future studies can explore whether supporters in football stadiums of visitors of large events are likely to spend more with improvements to the public catering system. From a scientific perspective, this research could contribute to economic and consumer behavior studies by examining the relationship between service quality enhancements and consumer spending.
- **Services times**: More extensive research could be executed to the service times of the SSTs. In this research the service times of the SST are based on a couple of observations, which may not fully capture the variability in service times. From a scientific perspective, future studies with more data would deepen the understanding of service times for SSTs by offering a more accurate evaluation of their efficiency across different settings.

# 9 Conclusion and Recommendations

Alongside the report, the five sub-questions are answered. In this section the key findings and answer to the main research question are summarized. Lastly, recommendations to Stadion Feijenoord are provided.

## 9.1. Conclusion

In this research, a comprehensive analysis of several SSTs is conducted, including the snack wall, SOK, and automated beer tap, and MOP to determine their potential impact on the public catering system at football stadiums and large events as festivals and concerts in a broader context. By evaluating these SSTs based on criteria such as supporter experience, service efficiency, cost-effectiveness, and revenue potential, the most suitable options for implementation are identified and designed. In summary, the research aims to answer the following main research question:

*What specific self-service technologies should be implemented in the public catering system at football stadiums to enhance supporter experience, reduce waiting times, lower costs, and increase revenue?*

It is identified that the MOP as SST in the public catering system of a football stadium is not suitable for implementation, mainly due to technical issues, and remaining control over the order. Hence, in this research the MOP is not considered for implementation.

On the other hand, the SOK, snack wall, and automated beer tap system show potential for implementation in football stadiums are large events. The snack wall excels regarding the service time, where the SOK and automated beer tap has higher services times than the current traditional counter. Hence, the snack wall reduces the waiting times and the SOK and automated beer tap system increases the waiting times when replaced one by one. Thus, the snack wall is well-suited for events with peak hours.

Regarding cost efficiency, all SSTs enable supporters to handle the ordering process themselves. Consequently, by implementing SST counters at public catering systems significant personnel costs savings can be realized. The number of working hours can be reduced by 15 to 60%, and the productivity per employee can be increased by 17% to 146%, varying per SST.

Regarding the supporters experience, the choice experiment indicates that Feyenoord supporters prefer the traditional counter over the SST counter. When the attribute levels of both types of counters are identical, 64% would opt for the traditional counter. On average, supporters are willing to wait slightly over two additional minutes to use the traditional counter rather than the SST counter. Lastly, the older the supporter, the more value is attached to the normal counter. This finding suggest that human interaction remains a critical factor in consumer decision-making, particularly among older people. Therefore, when designing public catering systems at football stadiums or large events, it is essential to consider these preferences and tailor the system accordingly. Additionally, these insights could be relevant for the integration of SSTs into public catering systems.

Finally, the proposed design involves implementing the SOK, snack wall, and automated beer tap systems. All three SSTs show potential to add value to the public catering system in terms of supporters experience and cost-efficiency. Initially, it is important to implement these SSTs on one side of the stadium as a test phase, allowing for adjustments and improvements before rolling out to the entire stadium. Additionally, partial replacement of specific counters ensures supporters retain the option to choose their preferred type of counter.

## 9.2. Recommendations Stadion Feijenoord

The results of this research offer several recommendations for Stadion Feijenoord. The main recommendation is to start investing in SSTs and use the opportunities that the SSTs offer.

Among the SSTs evaluated, the snack wall shows the highest potential in terms of reducing waiting times. It can be relatively easily been implemented and it earns itself back within 2.5 seasons.

The SOK can have the largest impact on the public catering system as of the number of normal counters that can be replaced to SOK counters, thus offering the highest potential for saving personnel costs. The SOK will earn itself back within six seasons.

Besides, the automated beer tap system currently shows the least potential among the SSTs evaluated. However, being the most innovative of all, it is still in the initial phase. The automated beer tap has the potential to enhance the variety of the public catering system and create joy in the ordering of drinks. This can enhance the supporter experience.

In summary, the SOK and snack wall should have priority when considering the implemtentation of innovative SSTs. Afterwards, the automated beer tap system could be a good addition to the public catering system of Stadion Feijenoord.

Lastly, after implementing these SSTs, conduct follow-up research to check if their actual performance matches the predictions from the stated preference survey. This will help confirm whether the SSTs effectively reduce waiting times and save costs, and ensure that the expected benefits are achieved. Additionally, it is recommended to evaluate the supporter satisfaction and service efficiency with the new SSTs.

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# A
# Appendix

## A.1. Scientific Paper

(Scientific paper starts from next page)

# The Potential of Self-service technologies in a Football Stadium: A Case Study at Stadion Feijenoord

Titus Kraanen[1]

*Abstract*— **This research aims to explore the potential of self-service technologies (SSTs) within football stadiums, focusing on Stadion Feijenoord "De Kuip". The potential benefits of these SSTs includes reducing waiting times, lowering costs, and enhancing the supporters experience. The approach begins with a review of existing literature on SSTs in the hospitality industry. Following this review, the study will employ stated choice experiments, alongside data analysis and observations, to explore the potential benefits and impacts of these SSTs. This research provides insights about operating efficiency and effectiveness of SST and traditional counters in football stadiums. Besides, the importance of human interaction at these different types of counters is assessed.** ***Keywords* - Self-service technologies, stadiums, human interaction, supporters experience, services times, productivity**

## I. INTRODUCTION

Self-service technologies (SSTs) are rapidly gaining traction in the restaurant industry [1]. Integrating SSTs into the food and beverage section of football stadiums could serve as an innovative solution to enhance the supporter experience, reducing waiting times and lowering costs. Long waiting times for food and beverage orders have been shown to significantly reduces supporter satisfaction [2]. Additionally, SSTs offer firms to reduce their labor costs [3]. Examples of SSTs include Self-Ordering Kiosks (SOKs), snack walls, automated beer tap systems and mobile platforms for online ordering. Currently, the SSTs are becoming more popular in restaurants, however their adoption in football stadiums remains limited, though supporters report interest in them [4].

Stadiums are facing growing competition from home-viewing options, a challenge that particularly affects aging stadiums [5]. Slow service at food and beverage concessions remains a significant barrier to enhancing the supporter experience. Research indicates that even the perception of lengthy wait times can deter fans from purchasing food and drinks, impacting overall sales. For example, 42% of supporters in the USA have reported that long waiting lines at concessions prevented them from making purchases at least once in the past year [4]. Additionally, fans globally have expressed that they would be willing to increase their spending by at least 30% if wait times were significantly reduced [4]. Addressing these issues is essential for improving both supporter satisfaction and revenue. Self-service technologies, such as mobile ordering platforms (MOPs) and self-ordering kiosks (SOKs), offer promising solutions by reducing wait times and improving service efficiency [1]. SSTs can also help mitigate staffing challenges, enhance productivity, and lower labor costs. However, the effectiveness and appeal of SSTs in stadium environments require further investigation.

In summary, football stadiums, including Stadion Feijenoord, face the challenge of keeping pace with the evolving expectations of their supporters. Staffing is another significant challenge in hospitality, particularly for Stadion Feijenoord. However, there is a lack of knowledge about the potential impact of SSTs on supporters experience, waiting times, labor costs and personnel deployment in football stadiums. Given these challenges, there is a need to investigate the potential of SSTs in football stadiums.

Hence, the objective of this research is to investigate the potential of SSTs in football stadiums. The main research question that this study aims to address is:

**What specific self-service technologies should be implemented in the public catering system at football stadiums to enhance supporter experience, reduce waiting times, lower costs?**

The paper is organized as follows: Section 2 outlines the literature review. Section 3 describes the methodology, including data analysis, choice modeling, and observations. Section 4 presents the results, highlighting supporter experience, service times, and productivity. Section 5 discusses the key findings and futere research directions, while Section 6 provides the conclusions.

## II. LITERATURE REVIEW

This section will explore the various existing SSTs in hospitality and their differences. Additionally, it will discuss the key determinats that determine the success of SSTs in a public catering system.

### A. *Existing self-service technologies*

The current SSTs used in the hospitality industry are analyzed. The Mobile Ordering Platform (MOP) enables customers to place food and beverage orders through their mobile devices. By scanning a QR code, customers can avoid errors and streamline the ordering process, which also allows providers to guide purchases and manage orders effectively. Despite its advantages, such as no queues and order that can be tracked, MOPs face challenges like high implementation costs and potential capacity issues during peak hours [13][12][14]. Due to these technical and operational difficulties, the current state of MOP innovation is not yet advanced enough for successful implementation at

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Stadion Feijenoord particularly and football stadiums in a broader context, leading to the decision to exclude MOPs from further consideration.

Self-Ordering Kiosks (SOKs) are widely adopted in the fast-food industry, allowing customers to place orders directly at kiosks. SOKs reduce human error and provide flexibility in menu customization. They can enhance customer satisfaction and reduce costs but may affect satisfaction depending on ease of use and system reliability. The success of SOKs is closely dependend to their implementation and the user experience [10][15].

The snack wall, originally from Germany, has gained significant popularity in the Netherlands over the years and is now widely recognized and accepted. The snack wall offers pre-prepared snacks, which reduces preparation time. Although it eliminates some operational delays, the snacks may stay too long in the wall. Factors such as product variety, location, and maintenance are crucial for effective implementation and user satisfaction [16][17].

The auomated beer tap systems allow users to pay for their beers and then dispense their own drinks. It is similar to the gas station where users can fill up their car with gas after payment. The automated beer tap system is slowly gaining traction in the hospitality industry. Fun is one the determinants of the customers satisfaction. Automated beer tap systems leverage the concept of putting enjoyment into the ordering process [18]. Table I shows the differences among the different SSTs.

### B. Key determinants of self-service technologies

In today's fast-paced world, technology increasingly impacts daily life by offering services that minimize human interaction. SSTs enable customers to complete transactions independently, enhancing efficiency and convenience while reducing reliance on service employees [6]. Besides, companies implement SSTs to enhance customers experience by reducing waiting times [10]. The adoption of SSTs, such as SOKs, is growing in sectors like retail and hospitality due to their benefits in improving service quality, increasing productivity, and reducing costs [7][8]. Lastly, SSTs streamline transactions can enhance customer satisfaction through standardized service delivery.

Despite these advantages, SSTs also present challenges. Implementation can be costly and complex, with potential technical failures leading to customer frustration [9]. Additionally, technology anxiety and a preference for human interaction can deter some users [8][10]. In football stadiums, SSTs are in the early stages of adoption, with emerging technologies like SOKs showing promise in reducing waiting times and improving service. Ongoing exploration and development are needed to fully realize the benefits of SSTs in this context [2][11].

From the literature review, several key determinants of SSTs emerge. Convenience is a critical factor, as SSTs must ensure minimal technical failures and provide a standardized process to enhance user experience. Additionally, reducing waiting times is a significant advantage of SSTs and increase user experience. Human interaction also plays a crucial role; while some users may experience technology anxiety or prefer personal contact, others may prefer not to have to interact with service personnel. Optimizing these factors is essential for the successful implementation and adoption of SSTs in various contexts, including football stadiums. Lastly, the literature indicates that SSTs reduce reliance on service employees, which addresses staffing challenges.

| **SST** | **Order & supply** | **Preparation** | **Human interaction** |
|---|---|---|---|
| *MOP* | Separate | Preparation on order | Partly |
| *SOK* | Separate | Preparation on order | Partly |
| *Snack Wall* | Integrated | Pre-preparation | None |
| *Beer tap system* | Integrated | Preparation on order | None |

TABLE I

DIFFERENT CHARACTERISTICS PER SELF-SERVICE TECHNOLOGY

## III. METHODS

To assess the potential of the discussed SSTs in terms of supporter experience, reducing waiting times, increasing productivity, and lowering labor costs, several methods are employed, including a stated choice experiment, data analysis, and observations.

### A. Stated Choice Experiment

A stated choice experiment (SCE) is conducted to evaluate the importance of each key determinant discussed in Section II-B. Using a Multinomial Logit (MNL) model, the magnitude of each attribute can be estimated. Particularly interesting is the human interaction factor, as both literature and logical reasoning do not provide a definitive answer regarding whether human interaction positively or negatively influences decision-making in the ordering process.

The SCE was conducted among Feyenoord supporters, with the survey sent via email to approximately 5,000 supporters who attended the matches against PEC and Excelsior, reaching a total of about 10,000 supporters. The survey received 1,241 responses, meaning roughly 1 in 8 supporters participated. Each respondent made four choices, resulting in a total of approximately 5,000 choices.

| | **# of respondents** | **# of choices** |
|---|---|---|
| *PEC* | 624 | 2492 |
| *Excelsior* | 617 | 2468 |
| **Total** | 1241 | 4964 |

TABLE II

INPUT DATA

As mentioned, the attributes of the choice experiment are based on the key determinants. The attribute levels are defined and shown in Table III. The human interaction determinant is evaluated through the choice between self-service options (with no human interaction) and traditional counters (with human interaction).

| | Self-Service | Normal counter |
|---|---|---|
| *Waiting time (minutes)* | 2 / 4 / 6 | 2 / 4 / 6 |
| *Walking distance (meters)* | 20 / 60 / 100 | 20 / 60 / 100 |
| *Convenience (%)* | 90, 99, 99.9 | 90, 99, 99.9 |
| **Your choice** | O | O |

TABLE III

CHOICE SET WITH ALL ATTRIBUTE LEVELS

Appendix VI-A shows an example question from the survey, where the respondent can choose between the normal counter with certain attribute levels and the self-service counter with certain attribute levels.

Table IV shows all estimates and their corresponding standard error, t-ratio, and p-value. The $\beta_{waiting\ time}$ is -0.245, indicating that waiting time has a negative impact on utility. For each additional minute of waiting time, the utility decreases by 0.245. The $\beta_{walkingdistance}$ is -0.005. Hence, the walking distance has a negative influence on the utility, where with every extra meter the utility decreases with 0.005. From those two betas it can be stated that 1 additional minute of waiting time is equivalent to approximately 52 meters of extra walking distance to the counter (-0.245 / -0.005). This sounds quite reasonable as with a walking speed of 4 km/h a person walks 67 meters per minute. From this, it can be concluded that a person prefers to walk 1 minute over waiting 1 minute. Considering the convenience attribute, this has a positive impact on the utility. This is logical as a higher convenience should lead to a higher utility. The $\beta_{convenience}$ has a value of 0.001, meaning that if the convenience increases with a factor 10 from 90% to 99% the utility increases 0.01. This is relatively low compared to the other two attributes. Lastly, the p-value is 0.002 which is below the 0.05 and therefore statistical significant. The $\beta_{normalcounter}$ has a value of 0.560, indicating that supporters prefer a normal counter over SST counters. To put this into perspective, supporters would rather wait 2 minutes longer to be served by a service employee than choose a queue that is two minutes shorter but involves using a self-service counter.

| Attribute | Estimate | Std. Error | t-ratio | p-value |
|---|---|---|---|---|
| $\beta_{waitingtime}$ | -0.245 | 0.014 | -17.258 | 0.000 |
| $\beta_{walkingdistance}$ | -0.005 | 0.000 | -7.394 | 0.000 |
| $\beta_{convenience}$ | 0.001 | 0.000 | 2.943 | 0.002 |
| $\beta_{normalcounter}$ | 0.560 | 0.031 | 18.101 | 0.000 |

TABLE IV

MNL MODEL ESTIMATES AND CHARACTERISTICS OF THE ATTRIBUTES OF ALL DATA

By filling in these estimates into the utility function and Logit model, the probability of an individual choosing either the normal counter or the SST counter can be predicted. The utility function is specified as follows:

$$V_{normalcounter} = \beta_{normalcounter} + A_{normal,wt} \cdot \beta_{wt} + A_{normal,wd} \cdot \beta_{wd} + A_{normal,c} \cdot \beta_c \quad (1)$$

$$V_{SST} = A_{SST,wt} \cdot \beta_{wt} + A_{SST,wd} \cdot \beta_{wd} + A_{SST,c} \cdot \beta_c \quad (2)$$

The logit model is specified as follows:

$$P_i = \frac{e^{V_i}}{\sum_{j=1}^{j} e^{V_j}} \quad (3)$$

Additionally, preferences among different age groups are analyzed. The age groups 15-30, 31-50, and 51+ consist of 157, 362, and 722 respondents, respectively. This distribution indicates that the majority of respondents are aged 51 or older, with only 13% being 30 years old or younger. Using the utility function and Logit model, the probabilities of choosing either an SST counter or a normal counter can be estimated. Table V presents the probabilities for each age group when the attribute levels of both alternatives are equal. When the characteristics of the normal and SST counters are the same, the probabilities per age group derived from Equation 3 are as follows:

| Age group | P(normal counter) | P(SST counter) |
|---|---|---|
| *15-30* | 57% | 43% |
| *31-50* | 63% | 37% |
| *51+* | 65% | 35% |
| *All ages* | 64% | 36% |

TABLE V

MNL CHOICE PROBABILITIES PER AGE GROUP

From these probabilities, it is noticeable that younger individuals care less about whether the counter is an SST counter or a normal counter. However, each age group prefers the normal counter over the SST counter when the attribute levels are the same.

In conclusion, regarding the potential implementation of SST counters, it is important to note that normal counters are generally preferred.

### *B. Data analysis*

The data analysis was conducted to determine the service times for various types of counters at Stadion Feijenoord. These include a normal counter where snacks and drinks can be ordered, a beer counter where only beer is served with a "raptap" system that dispenses four beers simultaneously, and a hot food counter for hot snacks.

Service time impacts waiting time, which is a key determinant of the supporter experience. Additionally, the productivity of the normal counters was assessed through the data analysis. Higher productivity typically results in greater profits or a reduced need for service employees to handle the same level of demand.

To analyze service times at each counter, transactions from the most frequently used cash register at each counter during the halftime break of the Feyenoord-Ajax match on April 7, 2024, were compiled into a single data file. During the halftime period, there was a queue at each counter. The service time for each counter was calculated by dividing the total duration of the specified period (in seconds) by the number of transactions. Based on this analysis, the average service times are 32.1 seconds for the normal counter, 32.2 seconds for the food counter, and 19.5 seconds for the beer counter. These service times are displayed in Table VII.

The productivity per counter type is extracted from the data as well. The productivity is expressed in revenue per hour worked per employee in a specific counter. Considering this productivity per counter, it seems that the beer counters scores good compared to the normal counters. Table VI displays the top 5 counters with the highest productivity. This indicates that beer counters are notably more efficient in generating revenue per employee and innovations such as the "raptap" system enhance productivity and efficiency.

| Counter | Counter type | Productivity employee |
|---|---|---|
| Biercounter Orange | Beer counter | 671.26 €/h |
| Biercounter Blue | Beer counter | 578.55 €/h |
| Biercounter Yellow | Beer counter | 576.78 €/h |
| Olympia 1 | Normal | 515.84 €/h |
| Containerbar Vereeniging | Normal | 472.18 €/h |

TABLE VI

TOP 5 COUNTERS WITH THE HIGHEST PRODUCTIVITY OF THE EMPLOYEES

### C. Observations

Observations are utilized as a final method to assess the service times of the SST counters, specifically the SOK and the snack wall.

During the Ajax-Excelsior match on April 24, 2024, observations were conducted on the public catering systems at the Johan Cruijff Arena. At the Johan Cruijff Arena, the SOK is installed on one side of the stadium. These observations occurred after the SOK system had been in use for more than half a season. During the halftime break, 24 transactions were observed over a period of 969.75 seconds, resulting in an average transaction time of 40.4 seconds. It is important to note that this 40.41 seconds only accounts for the time taken to place the order; supporters must also walk to the counter and wait for their order. To account for the additional time required for the distribution of food and beverages, an extra 10 seconds is added to the service time, based on estimates and consultations with service employees. Thus, the total service time for the SOK is 50.4 seconds.

Observations conducted at 'Smullers' at Rotterdam Central Station on June 24th from 3:45 PM to 4:15 PM indicate that the average service time for the snack wall is 8.5 seconds. Data from Stadion Feijenoord reveals that the average order size is 1.56 products per order. It is assumed that at the snack wall, each order is equivalent to one product. Therefore, the adjusted average service time for the snack wall is 1.56 multiplied by 8.5 seconds, resulting in a total of 13.3 seconds.

All service times per different counter type are presented in Table VII. The average service time for the automated beer tap system is derived from data provided by Beermate, a company that sells and leases these systems.

| Counter type | Average service time (s) |
|---|---|
| Normal counter | 32.1 |
| Food counter | 32.2 |
| Beer counter | 19.5 |
| SOK | 50.4 |
| Snack wall | 13.3 |
| Automated beer tap system | 30.1 |

TABLE VII

AVERAGE SERVICE TIME PER COUNTER TYPE

Lastly, observations at Stadion Feijenoord were conducted during the halftime breaks of four national league matches. Figure 1 depicts the waiting times of supporters over time during the breaks of the matches against FC Utrecht, Ajax, PEC Zwolle, and Excelsior. The observations were made at the same counter for each match. In total, the waiting times for 104 supporters were recorded, so $N = 104$. The red dot marks the beginning of the break. Waiting times increase as soon as the break starts. The peak waiting times vary by match, with a maximum waiting time of 390 seconds (6.5 minutes) recorded for all four matches. Additionally, Figure 5.2 shows that the longest waiting times occur between the fifth and twelfth minutes of the break. Lastly, it is remarkable that the waiting times during the match against FC Utrecht are significant lower compared to the other matches. No reason could be found for this difference.

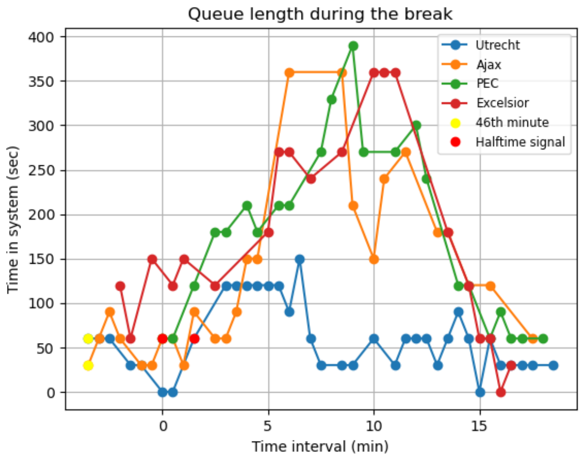


Fig. 1. Time in system over time during the break of the Feyenoord matches

From Figure 1 and the corresponding data, the average waiting time per match is calculated. Excluding the match against FC Utrecht, the average waiting time ranges from 198 to 218 seconds, with an overall average of 208 seconds, which is equivalent to 3.46 minutes.

Giving the average waiting time (in minutes) $W$ and service rate (customers per minute) $\mu$, the arrival rate (customers per minute) $\lambda$ can be calculated using the following formula:

$$W = \frac{1}{\mu - \lambda} \tag{4}$$

By applying the formula, the arrival rate $\lambda$ is equal to 1.45 supporter per minute, which corresponds to an arrival of a supporter each 41 seconds per cash register.

## IV. RESULTS

The results section is divided into three sections: a comparison of waiting times, supporter experience, and cost efficiency between SST and traditional counters.

### A. Waiting times

In this section, the waiting times for each counter type are compared. The arrival rate $\lambda$ is assumed to remain constant for the SOK, automated beer tap, and snack wall. The ratios between the traditional and SST counters while maintaining the same average waiting, can be determined and visualized based on the service times. Considering the normal counter and the SOK, their service rates $\mu$ are 1.87 and 1.19 supporter per minute, respectively. With an arrival rate of 1.45 supporter per minute, $\lambda > \mu$, indicating the system is unstable the queue will continue to grow. Hence, the SOK can not replace the normal counter on a 1:1 basis. The ratio between the service rates is 1:1.6. They is visualized in Figure 2. The same principle applies when comparing the beer counter to the automated beer tap. Maintaining the same average waiting time requires 1.8 times as many pay points when implementing the automated beer tap instead of the beer counter, as shown in Figure 3. The situation is reversed for the snack wall, where its service rate surpasses that of the hot food counter. This is illustrated in Figure 4.

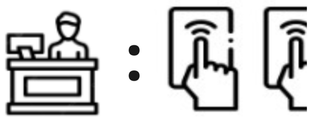

Fig. 2. Ratio of normal counters to SOK pay points needed to maintain the current system time: 1 : 1.6.

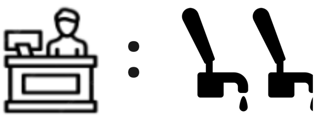

Fig. 3. Ratio beer counter versus automated beer tap pay points needed to maintain the current time in system: 1 : 1.8

Fig. 4. Ratio snack wall versus normal counter needed to maintain the current time in system: 1 : 2.4

### B. Supporters experience

Table VIII presents the estimates for each attribute by age group. As expected, both waiting time and walking distance negatively impact the utility. The $\beta_{normalcounter}$ has a positive impact on the utility. The primary difference between the normal counter and SST counter lies in the presence or absence of interaction during the ordering process. Literature presents both positive and negative views on the role of human interaction during ordering. However, the SCE clearly shows a preference for normal counter over SST counters. This preference weakens as the respondent gets younger. In short:

- Age 15-30: be willing to wait 1 additional minute to join the queue for the normal counter
- Age 31-50: be willing to wait 2 additional minute to join the queue for the normal counter
- Age 51+: be willing to wait 3 additional minute to join the queue for the normal counter

| **Attribute** | **All** | **15-30** | **31-50** | **51+** |
|---|---|---|---|---|
| $\beta_{waitingtime}$ | -0.245 | -0.293 | -0.278 | -0.218 |
| $\beta_{walkingdistance}$ | -0.005 | -0.006 | -0.007 | -0.004 |
| $\beta_{convenience}$ | 0.001 | 0.003 | 0.002 | 0.000 |
| $\beta_{normalcounter}$ | 0.560 | 0.287 | 0.528 | 0.637 |

TABLE VIII
MNL MODEL ESTIMATES PER AGE GROUP

Moreover, it should be noted that although there is a preference for the normal counter, the parameter estimate values of the alternative specific constant $\beta_{normalcounter}$ is relatively low. When the attribute levels are equal for both alternatives, 64% chooses the normal counter and 36% chooses the SST counter.

### C. Cost Efficiency

In this section, the cost efficiency of the ordering process in the public catering system is examined, with a specific focus on personnel costs. It evaluates the cost reductions associated with implementing various SSTs and their impact on employee productivity. Less working hours not only lower costs, but also address staffing problems, which are increasingly significant due to personnel shortages. The comparison includes the SOK versus the normal counter, the beer counter versus the automated beer tap, and the snack wall versus the hot food counter. To compare the SST counter with traditional counter, the focus is on the time saved when supporters handle their own ordering. Hence, the reduction in personnel costs is based on the time saved by supporters managing the ordering process themselves.

It is assumed that no assistance is required during the ordering process at the SOK. For these calculations, transaction data from Stadion Feijenoord for season 23/24 is used. Given that distribution and preparation still need to be handled by service employees, 22.1 seconds can be saved per transaction. With a total of 1,091,255 transactions, the total time saved is calculated by multiplying 22.1 seconds by the number of transactions and then dividing by 3600 to convert it to hours. This results in 6,699 working hours saved per season. This represents a 32% reduction compared to the total of 21,154 working hours required at the normal counters. Consequently, 32% less personnel would need to be deployed. With an average wage of €25 per hour, this translates to an annual savings of €167,477.32.

The same calculations are applied to the cost efficiency of the automated beer tap system. However, it is recommended to deploy one service employee to assist during the ordering process, as people are less familiar with this SST. Additionally, the service employee can ensure that no supporters under the age of 18 are ordering beer. In this case, 790 hours can be saved out of a total of 1,330 hours, representing a nearly 60% reduction in working hours. This translates to a total cost saving of €19,762.50 per season.

Lastly, regarding the snack wall, the total service times for the service employees are 32.2 seconds and 5.0 seconds, respectively. The 5.0 seconds is an estimate, based on the 10.0 seconds it takes to serve a supporter for specific orders. For the snack wall, orders do not require preparation based on the specific order. In this case, 872 working hours can be saved out of a total of 5,983 hours, corresponding to a reduction of 14.5

Table IX provides an overview of the cost efficiency for each SST. Productivity is measured by the revenue in euros generated per hour per employee at each type of counter.

| **Counter** | **Δ working hours** | **%** |
|---|---|---|
| *SOK* | 6669 | -32% |
| *Automated beer* | 790.5 | -59.5% |
| *Snack wall* | 872 | -14.5% |
| | **Δ productivity** | **%** |
| *SOK* | 116€ | 46% |
| *Automated beer* | 465€ | 146% |
| *Snack wall* | 24€ | 17% |
| | **Cost Reduction** | |
| *SOK* | €167,477 | |
| *Automated beer* | €19,763 | |
| *Snack wall* | €21,800 | |

TABLE IX

SUMMARY OF COST EFFICIENCY BY COUNTER TYPE

In summary, SST can add value in terms of waiting times if additional counters are implemented. For supporters' experience, SSTs can add value when the attributes of SST counters significantly exceed those of normal counters. Lastly, SSTs can add value through substantial reductions in the working hours currently handled by service employees.

## V. DISCUSSION

In this section the methods used will be discussed. Furthermore, it will reflect on the scientific and societal contribution, as well as the limitations of the study and potential future research that can be done.

The primary consideration in choice modeling is that it is based on stated preferences. The main drawback of stated preference is the potential hypothetical bias, as respondents might not make the same choices in real life, especially when faced with immediate consequences like missing part of a match. Furthermore, the demographics of the survey respondents, with more than half of respondents aged 51 and older, raise concerns about representativeness, which may impact the validity of the results.

The waiting times and arrival rates were estimated based on observations at a single counter during four Feyenoord matches, which may not reflect the actual averages across all counters at Stadion Feijenoord. Similar methods were used for the SOKs at the Johan Cruijff Arena and the snack wall at Rotterdam Central Station, but each was observed only once, potentially affecting reliability. Additionally, during the snack wall observations, the absence of queues gave individuals more time to make decisions, positively influencing the service time. Despite the limited number of observations, the estimates for waiting times and service times appear reasonable and are likely not far from the true values.

Furthermore, considering the supporters experience, it is important to note that the introduction of additional SST counters will not necessarily negatively influence the supporters' experience, since those who prefer normal counters do not have to adjust their behavior. In this research it is assumed that the normal counter will be replaced by a SST counter, this will likely decrease the supporters experience as the attribute levels stays equal. However, the addition of SST counters to the public catering system could only enhance the supporters experience. This potential enhancement is not measured.

This study contributes to the understanding of current ordering processes and the potential SST ordering processes in public catering systems at football stadiums and extends its relevance to large events like sports matches, concerts, and festivals. The study evaluates the efficiency and effectiveness of various counter types, focusing on service times and employee productivity. The snack wall and beer counter excel in terms of service times, while traditional counters and SOKs take longer. The automated beer tap system significantly boosts productivity, leading to substantial personnel cost savings. Overall, each SST counter shows significant savings in personnel costs and deployment, which can help overcome staffing problems. These findings are valuable for large event organizers facing staffing and cost challenges, as SST counters can reduce costs and enhance efficiency.

Additionally, this study explores the role of human interaction in the ordering process at football stadiums, as revealed by a survey with over 1,200 respondents. The findings indicate that customers place a value on human interaction, frequently favoring traditional counters over SSTs, even if it results in an additional wait of two minutes. Interestingly, younger respondents were less concerned about choosing between SST and traditional counters. These insights are crucial for designing effective public catering systems at football stadiums.

One limitation of the study is that the adoption process of innovation in the public catering system at Stadion Feijenoord has not been considered. For the new situation with the implementation of SST counters, the calculations assume the same arrival rate as the current situation. As the adoption of SST counters could take time, this may lead to less favorable outcomes regarding cost savings and employee productivity, as the calculations in this study assume a constant arrival rate.

Furthermore, as mentioned, the sample representativenes. The survey sample may not accurately represent the actual population during a match, as more than half of the respondents were 51 years old or older, with only 13% under the age of 31. Hence, the results might not fully match the real preferences. In the future, this could affect the estimation of parameters, potentially leading to a lower value for $\beta_{normalcounter}$ than currently estimated.

The survey comparing traditional counters to SST counters does not address preferences among different SST types. This generalization assumes that supporters view all SST counters similarly, which may not be accurate. From a scientific perspective, understanding the nuances in supporter preferences among different SST types could contribute significantly to the literature on consumer behavior. Future research should focus on these differences to provide a more detailed understanding of customers' preferences and how they might influence the success of different SST implementations. Additionally, studying the adoption process of SSTs in existing implementations could contribute to theories on technology acceptance and diffusion of innovation within a public catering system setting. This understanding would enable more accurate calculations of the potential revenue increase resulting from the implementation of SSTs.

## VI. CONCLUSION

After the comprehensive analysis of the various SSTs is conducted, including the snack wall, SOK, and automated beer tap, and MOP, their potential impact on the public catering system at football stadiums is determined. This analysis can also be applied to a broader range of contexts, including large events like concerts and festivals.

It has been identified that the MOP as an SST in the public catering system of a football stadium is unsuitable for implementation, primarily due to technical issues and the need for maintaining control over orders. The implementation of SSTs such as the SOK, snack wall, and automated beer tap systems offers potential but requires careful consideration. The snack wall stands out for its quick service time, making it ideal for peak hours, while the SOK and automated beer tap systems, though innovative, may increase waiting times when used as a 1:1 replacement for the current traditional counters.

From a cost efficiency perspective, SSTs can significantly reduce personnel costs, cutting working hours by 15 to 60% and boosting productivity per employee by 17 to 146%, depending on the type of SST. However, the supporters' experience is a crucial factor. For example, Feyenoord supporters show a strong preference for traditional counters, with 64% favoring them over SSTs when all attributes are equal. Supporters are willing to wait over two additional minutes for traditional service, highlighting the importance of human interaction, particularly among older fans.

These findings highlight the need to balance efficiency gains with customer preferences when integrating SSTs into public catering systems at large events, ensuring that the design meets the diverse needs of supporters.

## APPENDIX

### A. Stated Choice experiment example question

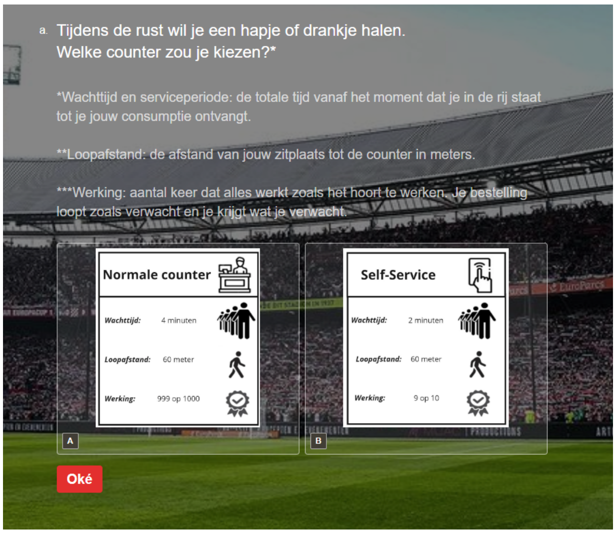


Fig. 5. One question to supporters at the stated choice experiment

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## A.2. Stated Choice experiment


Figure A.1: Explanation in Dutch to all respondents

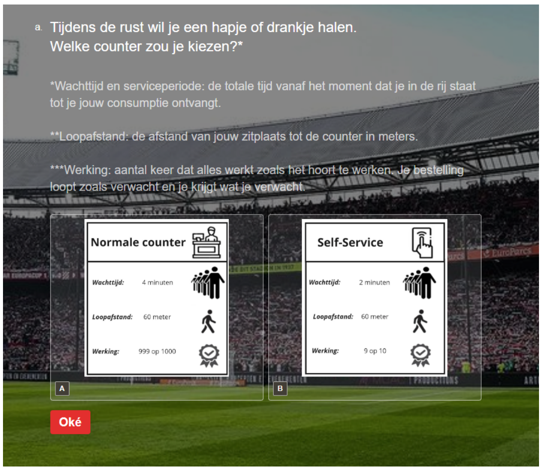


Figure A.2: Survey question 1


Figure A.3: Survey question 2


Figure A.4: Survey question 3


Figure A.5: Survey question 4

## A.3. Ngene Code

Syntax - DCE Feyenoord.ngs*

```
? DCE block 0
design
;alts = normaal, SST
;rows = 18
;block = 6
;orth = sim
;model:
U(normaal) = b0 + b1 * tijd[2,4,6] + b2 * afstand[20,60,100] + b3 * werking[0.9,0.99,0.999]/
U(SST) = b1 * tijd + b2 * afstand + b3 * werking
$
```

Figure A.6: Syntax Ngene code to construct choice sets

| Design | | | | | | | |
|---|---|---|---|---|---|---|---|
| Choice situation | normaal.tijd | normaal.afstand | normaal.werking | sst.tijd | sst.afstand | sst.werking | Block |
| 1 | 4 | 60 | 0.999 | 2 | 60 | 0.9 | 2 |
| 2 | 4 | 100 | 0.9 | 6 | 60 | 0.9 | 2 |
| 3 | 6 | 20 | 0.99 | 2 | 20 | 0.99 | 3 |
| 4 | 6 | 20 | 0.9 | 4 | 100 | 0.999 | 2 |
| 5 | 2 | 20 | 0.99 | 6 | 100 | 0.99 | 3 |
| 6 | 6 | 100 | 0.99 | 6 | 20 | 0.99 | 3 |
| 7 | 4 | 60 | 0.999 | 6 | 60 | 0.999 | 1 |
| 8 | 6 | 60 | 0.999 | 4 | 100 | 0.9 | 1 |
| 9 | 4 | 100 | 0.9 | 2 | 60 | 0.999 | 1 |
| 10 | 2 | 20 | 0.9 | 4 | 20 | 0.9 | 1 |
| 11 | 2 | 100 | 0.99 | 2 | 100 | 0.99 | 3 |
| 12 | 2 | 60 | 0.999 | 4 | 20 | 0.999 | 2 |

Figure A.7: Constructed choice sets through Ngene

## A.4. R Input and Code

**Input**

The data is ordered to the following format shown in Table A.1. This is the input data of one respondent. Choice 1 and 2 corresponds to Normal and SST counter, respectively. Moreover, alternative A and B corresponds to Normal and SST counter, respectively. Normally all respondents answer exactly the same choice sets, however as with the help of blocking three versions are created each respondent answer one of the three versions of four choices each.

| ID | Set | Choice | WTA | LAA | WEA | WTB | LAB | WEB |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 4 | 60 | 0.999 | 2 | 60 | 0.9 |
| 1 | 2 | 1 | 4 | 100 | 0.9 | 6 | 60 | 0.9 |
| 1 | 3 | 2 | 6 | 20 | 0.9 | 4 | 100 | 0.999 |
| 1 | 4 | 1 | 2 | 60 | 0.999 | 4 | 20 | 0.999 |

Table A.1: Data set input format

**Code**

```
### Load Apollo library
library(apollo)

### Initialise code
apollo_initialise()

### Set core controls
apollo_control = list(
  modelName  ="MNL_1",
  modelDescr ="MNL_Model_Thesis_StadionFeyenoord",
  indivID    ="ID"
)


#### LOAD DATA
database = read.delim("data_goed2.txt",header=TRUE)

### Vector of parameters, including any that are kept fixed in estimation
apollo_beta=c(BETA_Wachttijd   = 0,
              BETA_Loopafstand   = 0,
              BETA_Werking  = 0,
              BETA_Normaal   = 0)

### Vector with names (in quotes) of parameters to be kept fixed at their starting value
###in apollo_beta, use apollo_beta_fixed = c() if none
apollo_fixed = c()

#### GROUP AND VALIDATE INPUTS
apollo_inputs = apollo_validateInputs()


#### DEFINE MODEL AND LIKELIHOOD FUNCTION
apollo_probabilities=function(apollo_beta, apollo_inputs, functionality="estimate"){

  ### Attach inputs and detach after function exit
  apollo_attach(apollo_beta, apollo_inputs)
  on.exit(apollo_detach(apollo_beta, apollo_inputs))

  ### Create list of probabilities P
  P = list()

  ### List of utilities: these must use the same names as in mnl_settings, order is irrelevant
  V = list()
  V[['A']]  = BETA_Normaal + WTA * BETA_Wachttijd + LAA * BETA_Loopafstand + WEA * BETA_Werking
  V[['B']]  = WTB * BETA_Wachttijd + LAB * BETA_Loopafstand + WEB * BETA_Werking
```

```
  ### Define settings for MNL model component
  mnl_settings = list(
    alternatives  = c(A=1, B=2),
    avail         = list(A=1, B=1),
    choiceVar     = CHOICE,
    V             = V
  )

  ### Compute probabilities using MNL model
  P[['model']] = apollo_mnl(mnl_settings, functionality)

  ### Take product across observation for same individual
  P = apollo_panelProd(P, apollo_inputs, functionality)

  ### Prepare and return outputs of function
  P = apollo_prepareProb(P, apollo_inputs, functionality)
  return(P)
}


#### MODEL ESTIMATION
model = apollo_estimate(apollo_beta, apollo_fixed, apollo_probabilities, apollo_inputs)


#### MODEL OUTPUTS
apollo_modelOutput(model,modelOutput_settings=list(printPVal=TRUE))

apollo_saveOutput(model)
```

## A.5. R output

**Output all data**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                 : MNL_1
Model description                          : MNL_Model_Thesis_StadionFeyenoord
Model run at                               : 2024-06-10 15:01:09
Estimation method                          : bgw
Model diagnosis                            : Relative function convergence
Optimisation diagnosis                     : Maximum found
     hessian properties                    : Negative definite
     maximum eigenvalue                    : -1038.34384
     reciprocal of condition number        : 0.000255965
Number of individuals                      : 1241
Number of rows in database                 : 4964
Number of modelled outcomes                : 4964

Number of cores used                       :  1
Model without mixing

LL(start)                                  : -3440.78
LL at equal shares, LL(0)                  : -3440.78
LL at observed shares, LL(C)               : -3284.26
LL(final)                                  : -3095.3
Rho-squared vs equal shares                 :  0.1004
Adj.Rho-squared vs equal shares             :  0.0992
Rho-squared vs observed shares              :  0.0575
Adj.Rho-squared vs observed shares          :  0.0566
AIC                                        :  6198.6
BIC                                        :  6224.64

Estimated parameters                       : 4
Time taken (hh:mm:ss)                      :  00:00:0.84
     pre-estimation                        :  00:00:0.34
     estimation                            :  00:00:0.32
          initial estimation               :  00:00:0.29
          estimation after rescaling       :  00:00:0.02
```

```
      post-estimation                       :  00:00:0.18
Iterations                                  :  7
      initial estimation                    :  6
      estimation after rescaling            :  1

Unconstrained optimisation.

Estimates:
                        Estimate        s.e.    t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd       -0.244675     0.01418     -17.258    0.000000     0.01488      -16.441
0.000
BETA_Loopafstand     -0.005152  6.9678e-04      -7.394   7.117e-14  6.9411e-04       -7.423
5.740e-14
BETA_Werking          0.001464  4.9757e-04       2.943    0.001624  3.8608e-04        3.793
7.437e-05
BETA_Normaal          0.559837     0.03093      18.101    0.000000     0.04023       13.917
0.000
```

**Output per age group**
**Output 60 plus data**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                  : MNL_1
Model description                           : MNL_Model_Thesis_StadionFeyenoord
Model run at                                : 2024-06-10 16:06:06
Estimation method                           : bgw
Model diagnosis                             : Relative function convergence
Optimisation diagnosis                      : Maximum found
      hessian properties                    : Negative definite
      maximum eigenvalue                    : -604.028459
      reciprocal of condition number        : 0.000244549
Number of individuals                       : 722
Number of rows in database                  : 2888
Number of modelled outcomes                 : 2888

Number of cores used                        :  1
Model without mixing

LL(start)                                   : -2001.81
LL at equal shares, LL(0)                   : -2001.81
LL at observed shares, LL(C)                : -1879.06
LL(final)                                   : -1797.07
Rho-squared vs equal shares                  :  0.1023
Adj.Rho-squared vs equal shares              :  0.1003
Rho-squared vs observed shares               :  0.0436
Adj.Rho-squared vs observed shares           :  0.042
AIC                                         :  3602.14
BIC                                         :  3626.02

Estimated parameters                        : 4
Time taken (hh:mm:ss)                       :  00:00:0.41
      pre-estimation                        :  00:00:0.21
      estimation                            :  00:00:0.1
           initial estimation               :  00:00:0.06
           estimation after rescaling       :  00:00:0.03
      post-estimation                       :  00:00:0.11
Iterations                                  :  8
      initial estimation                    :  6
      estimation after rescaling            :  2

Unconstrained optimisation.

Estimates:
                        Estimate        s.e.    t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
```

```
BETA_Wachttijd      -0.217756     0.01856     -11.730     0.00000     0.01890     -11.523
0.00000
BETA_Loopafstand    -0.004004  9.3049e-04      -4.303   8.435e-06  8.8394e-04      -4.529
2.958e-06
BETA_Werking       9.8859e-04  6.4154e-04       1.541     0.06166  4.7741e-04       2.071
0.01919
BETA_Normaal         0.637166     0.04056      15.709     0.00000     0.05475      11.637
0.00000
```

**Output ages 31-50**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                  : MNL_1
Model description                           : MNL_Model_Thesis_StadionFeyenoord
Model run at                                : 2024-06-10 15:43:49
Estimation method                           : bgw
Model diagnosis                             : Relative function convergence
Optimisation diagnosis                      : Maximum found
     hessian properties                     : Negative definite
     maximum eigenvalue                     : -294.14321
     reciprocal of condition number         : 0.000261978
Number of individuals                       : 362
Number of rows in database                  : 1448
Number of modelled outcomes                 : 1448

Number of cores used                        :  1
Model without mixing

LL(start)                                   : -1003.68
LL at equal shares, LL(0)                   : -1003.68
LL at observed shares, LL(C)                : -966.2
LL(final)                                   : -890.23
Rho-squared vs equal shares                  :  0.113
Adj.Rho-squared vs equal shares              :  0.109
Rho-squared vs observed shares               :  0.0786
Adj.Rho-squared vs observed shares           :  0.0755
AIC                                         :  1788.46
BIC                                         :  1809.58

Estimated parameters                        : 4
Time taken (hh:mm:ss)                       :  00:00:0.47
     pre-estimation                         :  00:00:0.27
     estimation                             :  00:00:0.11
          initial estimation                :  00:00:0.09
          estimation after rescaling        :  00:00:0.02
     post-estimation                        :  00:00:0.1
Iterations                                  :  7
     initial estimation                     :  6
     estimation after rescaling             :  1

Unconstrained optimisation.

Estimates:
                       Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd      -0.278224    0.026819     -10.374     0.00000    0.029935      -9.294
0.000000
BETA_Loopafstand    -0.007265    0.001304      -5.570   1.277e-08    0.001358      -5.350
4.395e-08
BETA_Werking         0.001879  9.4473e-04       1.989     0.02335  7.4783e-04       2.513
0.005990
BETA_Normaal         0.527945    0.058060       9.093     0.00000    0.070336       7.506
3.042e-14
```

**Output ages 15-30**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
```

```
www.ApolloChoiceModelling.com

Model name                              : MNL_1
Model description                       : MNL_Model_Thesis_StadionFeyenoord
Model run at                            : 2024-06-10 15:27:33
Estimation method                       : bgw
Model diagnosis                         : Relative function convergence
Optimisation diagnosis                  : Maximum found
     hessian properties                 : Negative definite
     maximum eigenvalue                 : -134.213284
     reciprocal of condition number     : 0.000288986
Number of individuals                   : 157
Number of rows in database              : 628
Number of modelled outcomes             : 628

Number of cores used                    :  1
Model without mixing

LL(start)                               : -435.3
LL at equal shares, LL(0)               : -435.3
LL at observed shares, LL(C)            : -430.69
LL(final)                               : -393.87
Rho-squared vs equal shares              :  0.0952
Adj.Rho-squared vs equal shares          :  0.086
Rho-squared vs observed shares           :  0.0855
Adj.Rho-squared vs observed shares       :  0.0785
AIC                                     :  795.75
BIC                                     :  813.52

Estimated parameters                    : 4
Time taken (hh:mm:ss)                   :  00:00:1.13
     pre-estimation                     :  00:00:0.96
     estimation                         :  00:00:0.09
          initial estimation            :  00:00:0.07
          estimation after rescaling    :  00:00:0.02
     post-estimation                    :  00:00:0.08
Iterations                              :  6
     initial estimation                 :  5
     estimation after rescaling         :  1

Unconstrained optimisation.

Estimates:
                    Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd     -0.293138    0.039657      -7.392   7.239e-14    0.042226        -6.942
1.931e-12
BETA_Loopafstand   -0.005795    0.001865      -3.108  9.4245e-04    0.001909        -3.036
0.001198
BETA_Werking        0.003434    0.001510       2.274     0.01148    0.001305         2.631
0.004262
BETA_Normaal        0.286608    0.086151       3.327  4.3923e-04    0.108912         2.632
0.004250
```

**Output Yellow Side**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                              : MNL_1
Model description                       : MNL_Model_Thesis_StadionFeyenoord
Model run at                            : 2024-06-10 17:01:00
Estimation method                       : bgw
Model diagnosis                         : Relative function convergence
Optimisation diagnosis                  : Maximum found
     hessian properties                 : Negative definite
     maximum eigenvalue                 : -231.770982
     reciprocal of condition number     : 0.000256676
Number of individuals                   : 272
Number of rows in database              : 1088
```

```
Number of modelled outcomes                 : 1088

Number of cores used                        :  1
Model without mixing

LL(start)                                   : -754.14
LL at equal shares, LL(0)                   : -754.14
LL at observed shares, LL(C)                : -726.55
LL(final)                                   : -683.94
Rho-squared vs equal shares                  :  0.0931
Adj.Rho-squared vs equal shares              :  0.0878
Rho-squared vs observed shares               :  0.0587
Adj.Rho-squared vs observed shares           :  0.0545
AIC                                         :  1375.87
BIC                                         :  1395.84

Estimated parameters                        : 4
Time taken (hh:mm:ss)                       :  00:00:1.57
     pre-estimation                         :  00:00:1.27
     estimation                             :  00:00:0.2
          initial estimation                :  00:00:0.15
          estimation after rescaling        :  00:00:0.05
     post-estimation                        :  00:00:0.1
Iterations                                  :  7
     initial estimation                     :  6
     estimation after rescaling             :  1

Unconstrained optimisation.

Estimates:
                    Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd     -0.258063    0.029996      -8.603     0.00000    0.031545        -8.181
1.110e-16
BETA_Loopafstand   -0.003105    0.001455      -2.133     0.01645    0.001334        -2.327
0.009990
BETA_Werking        0.001283    0.001052       1.219     0.11136  7.6111e-04         1.686
0.045892
BETA_Normaal        0.499670    0.065500       7.629   1.188e-14    0.087419         5.716
5.459e-09
```

**Output Orange Side**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                  : MNL_1
Model description                           : MNL_Model_Thesis_StadionFeyenoord
Model run at                                : 2024-06-10 17:12:01
Estimation method                           : bgw
Model diagnosis                             : Relative function convergence
Optimisation diagnosis                      : Maximum found
     hessian properties                     : Negative definite
     maximum eigenvalue                     : -163.012087
     reciprocal of condition number         : 0.000235926
Number of individuals                       : 202
Number of rows in database                  : 808
Number of modelled outcomes                 : 808

Number of cores used                        :  1
Model without mixing

LL(start)                                   : -560.06
LL at equal shares, LL(0)                   : -560.06
LL at observed shares, LL(C)                : -534.03
LL(final)                                   : -494.48
Rho-squared vs equal shares                  :  0.1171
Adj.Rho-squared vs equal shares              :  0.11
Rho-squared vs observed shares               :  0.0741
Adj.Rho-squared vs observed shares           :  0.0684
```

```
AIC                                      :  996.96
BIC                                      :  1015.74

Estimated parameters                     : 4
Time taken (hh:mm:ss)                    :  00:00:0.27
     pre-estimation                      :  00:00:0.15
     estimation                          :  00:00:0.05
          initial estimation             :  00:00:0.04
          estimation after rescaling     :  00:00:0.01
     post-estimation                     :  00:00:0.06
Iterations                               :  7
     initial estimation                  :  6
     estimation after rescaling          :  1

Unconstrained optimisation.

Estimates:
                     Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd      -0.293206    0.036979      -7.929   1.110e-15    0.038480        -7.620
1.266e-14
BETA_Loopafstand    -0.006060    0.001777      -3.410  3.2499e-04    0.001857        -3.263
5.5051e-04
BETA_Werking         0.001609    0.001203       1.337     0.09054  9.8785e-04         1.629
0.05164
BETA_Normaal         0.581385    0.077931       7.460   4.319e-14    0.101468         5.730
5.029e-09
```

**Output Blue Side**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                               : MNL_1
Model description                        : MNL_Model_Thesis_StadionFeyenoord
Model run at                             : 2024-06-10 17:23:49
Estimation method                        : bgw
Model diagnosis                          : Relative function convergence
Optimisation diagnosis                   : Maximum found
     hessian properties                  : Negative definite
     maximum eigenvalue                  : -365.925684
     reciprocal of condition number      : 0.000257686
Number of individuals                    : 435
Number of rows in database               : 1740
Number of modelled outcomes              : 1740

Number of cores used                     :  1
Model without mixing

LL(start)                                : -1206.08
LL at equal shares, LL(0)                : -1206.08
LL at observed shares, LL(C)             : -1157.31
LL(final)                                : -1088.28
Rho-squared vs equal shares               :  0.0977
Adj.Rho-squared vs equal shares           :  0.0944
Rho-squared vs observed shares            :  0.0597
Adj.Rho-squared vs observed shares        :  0.0571
AIC                                      :  2184.56
BIC                                      :  2206.4

Estimated parameters                     : 4
Time taken (hh:mm:ss)                    :  00:00:0.34
     pre-estimation                      :  00:00:0.21
     estimation                          :  00:00:0.07
          initial estimation             :  00:00:0.05
          estimation after rescaling     :  00:00:0.01
     post-estimation                     :  00:00:0.07
Iterations                               :  7
     initial estimation                  :  6
     estimation after rescaling          :  1
```

```
Unconstrained optimisation.

Estimates:
                       Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd        -0.243918    0.023910     -10.201     0.00000    0.024584        -9.922
0.00000
BETA_Loopafstand      -0.005856    0.001184      -4.946   3.786e-07    0.001209        -4.843
6.398e-07
BETA_Werking           0.001439  8.4291e-04       1.708     0.04385  6.6346e-04         2.170
0.01502
BETA_Normaal           0.529767    0.052112      10.166     0.00000    0.066286         7.992
6.661e-16
```

**Output Green Side**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                   : MNL_1
Model description                            : MNL_Model_Thesis_StadionFeyenoord
Model run at                                 : 2024-06-10 17:32:38
Estimation method                            : bgw
Model diagnosis                              : X- and relative function convergence
Optimisation diagnosis                       : Maximum found
     hessian properties                      : Negative definite
     maximum eigenvalue                      : -67.150038
     reciprocal of condition number          : 0.000331518
Number of individuals                        : 72
Number of rows in database                   : 288
Number of modelled outcomes                  : 288

Number of cores used                         :  1
Model without mixing

LL(start)                                    : -199.63
LL at equal shares, LL(0)                    : -199.63
LL at observed shares, LL(C)                 : -194.15
LL(final)                                    : -190.57
Rho-squared vs equal shares                   :  0.0454
Adj.Rho-squared vs equal shares               :  0.0253
Rho-squared vs observed shares                :  0.0184
Adj.Rho-squared vs observed shares            :  0.003
AIC                                          :  389.15
BIC                                          :  403.8

Estimated parameters                         : 4
Time taken (hh:mm:ss)                        :  00:00:0.69
     pre-estimation                          :  00:00:0.5
     estimation                              :  00:00:0.09
          initial estimation                 :  00:00:0.07
          estimation after rescaling         :  00:00:0.02
     post-estimation                         :  00:00:0.1
Iterations                                   :  7
     initial estimation                      :  6
     estimation after rescaling              :  1

Unconstrained optimisation.

Estimates:
                       Estimate        s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd        -0.121313    0.051989     -2.3335    0.009812    0.053993       -2.2468
0.012326
BETA_Loopafstand      -0.002180    0.002699     -0.8077    0.209639    0.002747       -0.7935
0.213746
BETA_Werking         7.5449e-04    0.002298      0.3283    0.371331    0.002163        0.3488
0.363604
```

```
BETA_Normaal          0.405345     0.121982       3.3230   4.4527e-04     0.164265          2.4676
0.006801
```

**Output Yellow Side**

```
Model run by titus using Apollo 0.3.2 on R 4.2.3 for Windows.
Please acknowledge the use of Apollo by citing Hess & Palma (2019)
  DOI 10.1016/j.jocm.2019.100170
  www.ApolloChoiceModelling.com

Model name                                  : MNL_1
Model description                           : MNL_Model_Thesis_StadionFeyenoord
Model run at                                : 2024-06-10 17:01:00
Estimation method                           : bgw
Model diagnosis                             : Relative function convergence
Optimisation diagnosis                      : Maximum found
     hessian properties                     : Negative definite
     maximum eigenvalue                     : -231.770982
     reciprocal of condition number         : 0.000256676
Number of individuals                       : 272
Number of rows in database                  : 1088
Number of modelled outcomes                 : 1088

Number of cores used                        :  1
Model without mixing

LL(start)                                   : -754.14
LL at equal shares, LL(0)                   : -754.14
LL at observed shares, LL(C)                : -726.55
LL(final)                                   : -683.94
Rho-squared vs equal shares                  :  0.0931
Adj.Rho-squared vs equal shares              :  0.0878
Rho-squared vs observed shares               :  0.0587
Adj.Rho-squared vs observed shares           :  0.0545
AIC                                         :  1375.87
BIC                                         :  1395.84

Estimated parameters                        : 4
Time taken (hh:mm:ss)                       :  00:00:1.57
     pre-estimation                         :  00:00:1.27
     estimation                             :  00:00:0.2
          initial estimation                :  00:00:0.15
          estimation after rescaling        :  00:00:0.05
     post-estimation                        :  00:00:0.1
Iterations                                  :  7
     initial estimation                     :  6
     estimation after rescaling             :  1

Unconstrained optimisation.

Estimates:
                     Estimate         s.e.   t.rat.(0)  p(1-sided)    Rob.s.e. Rob.t.rat.(0)
p(1-sided)
BETA_Wachttijd      -0.258063     0.029996      -8.603     0.00000    0.031545        -8.181
1.110e-16
BETA_Loopafstand    -0.003105     0.001455      -2.133     0.01645    0.001334        -2.327
0.009990
BETA_Werking         0.001283     0.001052       1.219     0.11136  7.6111e-04         1.686
0.045892
BETA_Normaal         0.499670     0.065500       7.629   1.188e-14    0.087419         5.716
5.459e-09
```

## A.6. Transaction data all counters

| Pinterminal | Counter | Type/Location | Transactions | Transactions during break | Av. Transaction time (s) | Spending during break (€) | Total spending (€) | Average spending (€) | Productivity per hour (€) |
|---|---|---|---|---|---|---|---|---|---|
| POS Counter B 8 | Biercounter Olympia | Beercounter | 379 | 65 | 16,6 | € 899,45 | € 4.784,95 | € 12,63 | € 578,55 |
| POS Counter T 2 | Biercounter Stadion | Beercounter | 213 | 55 | 19,6 | € 915,75 | € 3.172,95 | € 14,90 | € 576,78 |
| POS Counter L2 | Biercounter Maas | Beercounter | 324 | 53 | 20,4 | € 767,25 | € 4.573,80 | € 14,12 | € 671,26 |
| POS 2e Ring QQ 1 | 2e ring 4 | Upper ring | 298 | 52 | 20,8 | € 695,80 | € 3.472,00 | € 11,65 | € 285,91 |
| POS 2e Ring VV 2 | 2e ring 1 | Upper ring | 280 | 51 | 21,2 | € 523,65 | € 3.206,30 | € 11,45 | € 349,15 |
| POS Counter H Bar | Biercounter Marathon | Beercounter | 182 | 50 | 21,6 | € 673,20 | € 2.267,10 | € 12,46 | € 356,81 |
| POS 2e Ring EE 3 | 2e ring 9 | Upper ring | 188 | 48 | 22,5 | € 478,30 | € 1.736,22 | € 9,24 | € 206,65 |
| POS Lichtmast J 2 | Lichtmast J | Outer ring | 310 | 47 | 23,0 | € 555,60 | € 3.692,75 | € 11,91 | € 306,51 |
| POS 2e Ring GG 2 | 2e ring 10 | Upper ring | 215 | 46 | 23,5 | € 582,35 | € 2.419,10 | € 11,25 | € 266,55 |
| POS Counter H Bar | Marathon 2 | Inner ring | 349 | 46 | 23,5 | € 572,20 | € 4.366,65 | € 12,51 | € 435,71 |
| POS 2e Ring BB 2 | 2e ring 7 | Upper ring | 287 | 45 | 24,0 | € 625,50 | € 3.326,20 | € 11,59 | € 375,15 |
| POS 2e Ring UU 2 | 2e ring 2 | Upper ring | 231 | 44 | 24,5 | € 594,90 | € 2.907,45 | € 12,59 | € 302,49 |
| POS Foodcounter U | Foodcounter Stadion U | Foodcounter | 340 | 44 | 24,5 | € 259,50 | € 2.389,90 | € 7,03 | € - |
| POS Heineken Bar : | Heinekenbox Maasstraat | Outer ring | 213 | 40 | 27,0 | € 445,45 | € 2.503,55 | € 11,75 | € 228,45 |
| POS Lichtmast U 3 | Lichtmast U | Outer ring | 329 | 40 | 27,0 | € 573,80 | € 4.290,45 | € 13,04 | € 344,82 |
| POS 2e Ring JJ 1 | 2e ring 11 | Upper ring | 198 | 39 | 27,7 | € 480,35 | € 2.071,65 | € 10,46 | € 250,54 |
| POS Lichtmast E 2 | Lichtmast E | Outer ring | 319 | 39 | 27,7 | € 514,95 | € 4.062,00 | € 12,73 | € 353,66 |
| POS Foodcounter H | Foodcounter Marathon H | Foodcounter | 224 | 37 | 29,2 | € 224,60 | € 1.574,80 | € 7,03 | € - |
| POS Foodcounter N | Foodcounter Olympia N | Foodcounter | 324 | 37 | 29,2 | € 239,20 | € 2.281,10 | € 7,04 | € - |
| POS Lichtmast Q 3 | Lichmast Q | Outer ring | 231 | 35 | 30,9 | € 529,05 | € 3.148,10 | € 13,63 | € 442,49 |
| POS 2e Ring PP 2 | 2e ring 5 | Upper ring | 222 | 34 | 31,8 | € 372,85 | € 2.146,40 | € 9,67 | € 247,99 |
| POS Foodcounter C | Foodcounter Stadion Q | Foodcounter | 246 | 33 | 32,7 | € 226,80 | € 1.725,90 | € 7,02 | € - |
| POS Counter B 5 | Olympia 3 | Inner ring | 254 | 33 | 32,7 | € 395,90 | € 2.940,30 | € 11,58 | € 331,36 |
| POS Containerbar \ | Containerbar Vereeniging | Outer ring | 283 | 32 | 33,8 | € 506,60 | € 3.896,70 | € 13,77 | € 472,18 |
| POS Counter F 10 | Marathon 1 | Inner ring | 291 | 32 | 33,8 | € 452,05 | € 3.555,30 | € 12,22 | € 413,43 |
| POS Counter D 2 | Olympia 4 | Inner ring | 185 | 32 | 33,8 | € 348,65 | € 2.014,40 | € 10,89 | € 248,99 |
| POS 2e Ring RR/TT : | 2e ring 3 | Upper ring | 203 | 31 | 34,8 | € 455,70 | € 2.741,05 | € 13,50 | € 446,45 |
| POS Counter P 3 | Olympia 1 | Inner ring | 330 | 31 | 34,8 | € 501,45 | € 4.159,50 | € 12,60 | € 515,84 |
| POS Drankencount | Maas 1 | Inner ring | 228 | 29 | 37,2 | € 433,80 | € 3.371,45 | € 14,79 | € 393,76 |
| POS Counter K 3 | Maas 2 | Inner ring | 186 | 29 | 37,2 | € 396,20 | € 2.426,00 | € 13,04 | € 286,04 |
| POS Counter Q 3 | Stadion 2 | Inner ring | 406 | 29 | 37,2 | € 466,15 | € 5.852,85 | € 14,42 | € 452,59 |
| POS 2e Ring DD 4 | 2e ring 8 | Upper ring | 192 | 28 | 38,6 | € 236,75 | € 1.774,05 | € 9,24 | € 237,23 |
| POS Foodcounter E | Foodcounter Marathon E | Foodcounter | 219 | 27 | 40,0 | € 192,50 | € 1.645,40 | € 7,51 | € - |
| POS Counter T 3 | Stadion 1 | Inner ring | 213 | 27 | 40,0 | € 385,70 | € 2.850,10 | € 13,38 | € 390,09 |
| POS Foodcounter M | Foodcounter Maasstraat | Foodcounter | 212 | 26 | 41,5 | € 148,50 | € 1.366,80 | € 6,45 | € - |
| POS 2e Ring KK 2 | 2e ring 12 | Upper ring | 189 | 24 | 45,0 | € 273,15 | € 1.970,85 | € 10,43 | € 249,53 |
| POS 2e Ring OO 2 | 2e ring 6 | Upper ring | 209 | 23 | 47,0 | € 318,85 | € 2.527,80 | € 12,09 | € 323,27 |
| Counter Stadion | Koffiecounter Stadion | Coffee | 55 | 9 | * | € 34,75 | € 177,99 | € 3,24 | € 25,06 |
| Counter Maas | Koffiecounter Maas | Coffee | 55 | 10 | * | € 32,75 | € 194,75 | € 3,54 | € 16,93 |
| POS Foodcounter A | Foodcounter Olympia A | Foodcounter | 76 | 13 | * | € 94,20 | € 656,70 | € 8,64 | € - |
| Counter Marathon | Koffiecounter Marathon | Coffee | 98 | 15 | * | € 63,25 | € 394,25 | € 4,02 | € 46,38 |
| Counter Olympia | Koffiecounter Olympia | Coffee | 138 | 16 | * | € 57,50 | € 538,25 | € 3,90 | € 69,45 |

Figure A.8: Data per counter

## A.7. Jupyter Notebook Code - Linear Regression

```
import numpy as np
from sklearn.linear_model import LinearRegression

# De gegeven punten en omzet
punten = np.array([45, 33, 32, 35, 41, 35, 34, 41, 34, 41, 27, 23, 34, 33, 39, 34, 3
omzet = np.array([334000, 202000, 252000, 241000, 305000, 243000, 234000, 307000, 26

# Instantieer het lineaire regressiemodel
model = LinearRegression()

# Train het model
model.fit(punten, omzet)

# Haal de helling (coëfficiënt) en intercept (bias) op
multiplier = model.coef_[0]
intercept = model.intercept_

print("De multiplier voor de punten is:", multiplier)
print("De intercept (bias) is:", intercept)
```

```
De multiplier voor de punten is: 8946.461728904476
De intercept (bias) is: -73496.69898906542
```

Figure A.9: Linear regression code in Jupyter Notebook

## A.8. Valuation of each characteristic

| Tijdstip | Waardering |
|---|---|
| Zondagmiddag | 7 |
| Ditmdoavond | 8 |
| Vrijdagavond | 9 |
| Zondagavond | 4 |
| Zaterdagavond | 9 |

| Tegenstander | Waardering |
|---|---|
| Ajax/PSV | 10 |
| Subtop | 7 |
| Middenmoot | 6 |
| Degradatie | 5 |
| Europa | 8 |

| Type | Waardering |
|---|---|
| Eredivisie | 7 |
| Beker t/m kwartfinale | 6 |
| Bekerhalve finale | 8 |
| Bekerfinale | 10 |
| CL groepsfase | 9 |
| CL knockout | 10 |
| EL groepsfase | 8 |
| EL knockout | 9 |
| Oefen | 6 |

| Belang | Waardering |
|---|---|
| Extreem | 10 |
| Hoog | 8 |
| Middel | 7 |
| Laag | 6 |

| Weer | Waardering |
|---|---|
| Goed | 8 |
| Redelijk | 6 |
| Slecht | 4 |

Figure A.10: Valuation per characteristic

## A.9. Prediction of revenue per match full data

| Wedstrijd | Omzet | Tijdstip | W1 | Type | W2 | Weer | W3 | Tegenstander | W4 | Belang | W5 | Opmerking | W6 | Totaal | Voorspelling | Verschil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JC PSV | € 334.000,00 | Zaterdagavond | 9 | Bekerfinale | 10 | Redelijk | 6 | Ajax/PSV | 10 | Extreem | 10 | | | 45 | € 329.250,00 | € 4.750,00 |
| Fortuna | € 202.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 33 | € 221.850,00 | € -19.850,00 |
| Almere | € 252.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Degradatie | 5 | Middel | 7 | | | 32 | € 212.900,00 | € 39.100,00 |
| Heerenveen | € 241.000,00 | Zaterdagavond | 9 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 35 | € 239.750,00 | € 1.250,00 |
| Celtic | € 305.000,00 | Ditmdoavond | 8 | CL groepsfase | 10 | Redelijk | 6 | Europa | 8 | Hoog | 9 | | | 41 | € 293.450,00 | € 11.550,00 |
| GAE | € 243.000,00 | Zaterdagavond | 9 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 35 | € 239.750,00 | € 3.250,00 |
| Vitesse | € 234.000,00 | Zaterdagavond | 9 | Eredivisie | 7 | Redelijk | 6 | Degradatie | 5 | Middel | 7 | | | 34 | € 230.800,00 | € 3.200,00 |
| Lazio | € 307.000,00 | Ditmdoavond | 8 | CL groepsfase | 10 | Redelijk | 6 | Europa | 8 | Hoog | 9 | | | 41 | € 293.450,00 | € 13.550,00 |
| AZ | € 207.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Subtop | 7 | Middel | 7 | | | 34 | € 230.800,00 | € -23.800,00 |
| Atleti | € 247.000,00 | Ditmdoavond | 8 | CL groepsfase | 10 | Redelijk | 6 | Europa | 8 | Hoog | 9 | | | 41 | € 293.450,00 | € -46.450,00 |
| PSV | € 184.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Ajax/PSV | 10 | Middel | 7 | Pinstoring | -10 | 27 | € 168.150,00 | € 15.850,00 |
| Volendam | € 162.000,00 | Ditmdoavond | 8 | Eredivisie | 7 | Redelijk | 6 | Degradatie | 5 | Middel | 7 | Doordeweeks Eredivisie | -10 | 23 | € 132.350,00 | € 29.650,00 |
| Utrecht | € 244.000,00 | Ditmdoavond | 8 | Beker t/m kwartfin | 6 | Redelijk | 6 | Subtop | 7 | Middel | 7 | | | 34 | € 230.800,00 | € 13.200,00 |
| NEC | € 168.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 33 | € 221.850,00 | € -53.850,00 |
| PSV | € 292.000,00 | Ditmdoavond | 8 | Beker t/m kwartfin | 6 | Redelijk | 6 | Ajax/PSV | 10 | Hoog | 9 | | | 39 | € 275.550,00 | € 16.450,00 |
| Twente | € 221.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Subtop | 7 | Middel | 7 | | | 34 | € 230.800,00 | € -9.800,00 |
| AZ | € 287.000,00 | Ditmdoavond | 8 | Beker t/m kwartfin | 6 | Redelijk | 6 | Subtop | 7 | Hoog | 9 | | | 36 | € 248.700,00 | € 38.300,00 |
| Sparta | € 168.000,00 | Zondagavond | 4 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 30 | € 195.000,00 | € -27.000,00 |
| AS Roma | € 293.000,00 | Ditmdoavond | 8 | EL knockout | 9 | Redelijk | 6 | Europa | 8 | Hoog | 9 | | | 40 | € 284.500,00 | € 8.500,00 |
| RKC Waalwijk | € 154.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Degradatie | 5 | Middel | 7 | Net na uitschakeling | -5 | 27 | € 168.150,00 | € -14.150,00 |
| Groningen | € 280.000,00 | Ditmdoavond | 8 | Bekerhalve finale | 8 | Redelijk | 6 | Middenmoot | 6 | Hoog | 9 | | | 37 | € 257.650,00 | € 22.350,00 |
| Heracles | € 162.000,00 | Zondagavond | 4 | Eredivisie | 7 | Redelijk | 6 | Degradatie | 5 | Middel | 7 | | | 29 | € 186.050,00 | € -24.050,00 |
| Utrecht | € 222.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Middenmoot | 6 | Middel | 7 | | | 33 | € 221.850,00 | € 150,00 |
| Ajax | € 360.000,00 | Zondagmiddag | 7 | Eredivisie | 7 | Redelijk | 6 | Ajax/PSV | 10 | Hoog | 9 | Recordoverwinning | 10 | 49 | € 365.050,00 | € -5.050,00 |

Figure A.11: Revenue prediction per match

*The last two columns show the prediction of revenue and the difference between the actual and predicted revenue. This is based on the total valuation of third column from the right side.*

## A.10. Observation data snack wall at Rotterdam central station

These observations were conducted at ’Smullers’ at Rotterdam Central Station on June 24th from 3:45 PM to 4:15 PM.

| **Transaction** | **Time (s)** | **Transaction** | **Time (s)** |
|---|---|---|---|
| 1 | 9.35 | 16 | 5.76 |
| 2 | 7.98 | 17 | 7.21 |
| 3 | 6.06 | 18 | 14.14 |
| 4 | 5.93 | 19 | 6.65 |
| 5 | 10.26 | 20 | 5.05 |
| 6 | 9.32 | 21 | 10.34 |
| 7 | 11.15 | 22 | 5.56 |
| 8 | 9.98 | 23 | 10.9 |
| 9 | 13.67 | 24 | 6.04 |
| 10 | 8.68 | 25 | 12.64 |
| 11 | 6.89 | 26 | 8.16 |
| 12 | 7.84 | 27 | 4.95 |
| 13 | 7.06 | 28 | 10.68 |
| 14 | 8.59 | 29 | 9.73 |
| 15 | 5.39 | 30 | 10.21 |
| | | **Average (s)** | 8.5 |
| | | **Standard deviation (s)** | 2.48 |

Table A.2: Observations average service time of the snack wall at Rotterdam central station