REPUBLIC OF TURKEY ADANA ALPARSLAN TURKES SCIENCE AND TECHNOLOGY UNIVERSITY

GRADUATE SCHOOL OF SOCIAL SCIENCES

DEPARTMENT OF INTERNATIONAL TRADE AND FINANCE

ESTIMATION OF FAST FOOD BRAND PREFERENCES WITH MARKOV CHAINS

Azize Gizem FINDIKLI

MASTER OF SOCIAL SCIENCE

ADANA 2022

REPUBLIC OF TURKEY ADANA ALPARSLAN TURKES SCIENCE AND TECHNOLOGY UNIVERSITY

GRADUATE SCHOOL OF SOCIAL SCIENCES

DEPARTMENT OF INTERNATIONAL TRADE AND FINANCE

ESTIMATION OF FAST FOOD BRAND PREFERENCES WITH MARKOV CHAINS

Azize Gizem FINDIKLI

MASTER OF SOCIAL SCIENCE

SUPERVISOR

Asst. Prof. Dr. Fatma Feyza GÜNDÜZ

ADANA

I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all information that is not original to this work.

[Signature]

AZİZE GİZEM FINDIKLI

ABSTRACT

ESTIMATION OF FAST- FOOD BRAND PREFERENCES WITH MARKOV CHAINS

Azize Gizem FINDIKLI
Department of International Trade and Finance
Supervisor: Asst. Prof. Dr. Fatma Feyza GÜNDÜZ
February 2022, 74 pages

Many factors such as living away from families, lack of interest in cooking, time constraints, curiosity, desire to try different tastes, desire to reward themselves and socialize lead students to adopt the habit of eating out. The food choices of the students outside have been fast foods. The characteristics of the places where these foods are consumed are of great importance for students. This situation has led to the phenomenon of making a choice among businesses where food is preferred. There are many factors such as decor, staff attitude, atmosphere, food quality, easy accessibility, service speed, variety in the menu, and the availability of special products in university students' preference for fast food establishments. The aim of this study is to determine the reasons why consumers prefer fast-food brands and to try to predict the future status of the brands. If the future situations of these brands are predicted, various risk factors will be eliminated and the brand will be able to make a profit by turning this situation into an opportunity. In the study, an online questionnaire about fast food brand preferences was applied to 455 students studying at various universities in Turkey. With the data obtained from the surveys, the next fast food brand preferences of university students were estimated by the Markov Chain Analysis method, and the reasons for their preference were examined using the Hidden Markov Model method. In addition, after the brand preferences were estimated, the transition probability matrix was created and the brand loyalty of university students was calculated by calculating the long-term equilibrium vectors. As a result of the analysis of the data, it is seen that the probability of choosing the Burger King brand has the highest rate with 25.9%. It is seen that the probability of choosing the none option is 4.73%. The most preferred brand, Burger King, is respectively 20.64% KFC, 17.61% McDonalds, 13.85% Dominos, 5.54% Popeyes, 3.44% Pizza Hut, 3.38% Sbarro, 3.32%. Arby's is followed by Subway with 0.94% and other brands with 0.64%. It seems that the most

effective reason for choosing the Burger King brand is the hygiene option with the highest probability. It is seen that the "Hygiene" status, which is the hidden preference of the Burger King brand, is the underlying reason for the preference of brands such as Popeyes, KFC, Mc Donalds, Dominos, Pizza Hut, Sbarro and Arby's. The fact that the study was carried out during the Covid-19 process brought the hygiene option to the fore. In addition, it is seen that the underlying reason for choosing the Subway brand is "Campaigns" and the hidden situation underlying the preference of other brands is "Food Quality".

Keywords: Markov Chains, Hidden Markov Chains, Fast Food, Brand Preference.

ÖZET

FAST -FOOD MARKA TERCİHLERİNİN MARKOV ZİNCİRLERİ İLE TAHMİN EDİLMESİ

Azize Gizem FINDIKLI
ULUSLARARASI TİCARET VE FİNANSMAN ANABİLİM DALI
Danışman: Dr. Öğr. Üyesi Fatma Feyza GÜNDÜZ
Şubat 2022, 74 sayfa

Ailelerden uzak yaşama, yemek yapmaya olan ilgi eksiklikleri, zaman kısıtlılığı, merak, farklı tatlar deneme arzusu, kendilerini ödüllendirme ve sosyalleşme isteği gibi birçok faktör öğrencileri dışarıda yemek yeme alışkanlığı edinmeye itmektedir. Öğrencilerin dışarıdaki yemek tercihleri genellikle fast food diye adlandırılan hızlı yiyecekler olmuştur. Öğrenciler için bu yiyeceklerin tüketildiği yerlerin özellikleri büyük önem taşımaktadır. Bu durum yiyeceklerin tercih edildiği işletmeler arasında da bir seçim yapılması olgusunu meydana getirmiştir. Üniversite öğrencilerinin fast food işletmelerini tercih etmelerinde dekor, personelin tutumu, atmosfer, yiyecek kalitesi, kolay ulaşabilme, servis hızı, menüdeki çeşitlilik, özel ürünlerin olması gibi pek çok faktör bulunmaktadır. Bu çalışmanın amacı, tüketicilerin fast-food markalarını tercih etme nedenlerinin belirlenmesi ve markaların gelecekteki durumlarını tahmin etmeye çalışmaktır. Eğer bu markaların gelecekteki durumları tahmin edilirse, çeşitli risk faktörleri ortadan kalkabilecek ve marka bu durumu fırsata çevirerek kazanç sağlayabilecektir. Çalışmada, Türkiye'de çeşitli üniversitelerde eğitim gören 455 öğrenciye fast food marka tercihlerine yönelik online anket uygulanmıştır. Anketlerden elde edilen verilerle birlikte üniversite öğrencilerinin bir sonraki fast food marka tercihleri Markov Zinciri yöntemi ile tahmin edilmiş olunup, tercih nedenleri ise Saklı Markov Modeli yöntemi ile incelenmiştir. Ayrıca marka tercihleri tahmin edildikten sonra geçiş olasılıkları matrisi oluşturulmuş ve üniversite öğrencilerinin marka bağlılıkları uzun dönem denge vektörleri hesaplanılarak bulunmuştur. Verilerin analizi sonucunda Burger King markasının tercih edilme olasılığının % 25.9 ile en yüksek orana sahip olduğu görülmektedir. Hiçbiri seçeneğinin tercih edilme olasılığının ise % 4.73 oranında olduğu görülmektedir. En çok tercih edilen marka olan Burger King 'i sırasıyla %20.64 oran ile KFC, %17.61 oranı ile Mc Donalds,%13.85 oranı ile Dominos,%5.54 oranı ile Popeyes, %3.44 oranıile Pizza Hut, %3.38

oranı ile Sbarro, %3.32 oranı ile Arby's, %0.94 oranı ile Subway ve %0.64 oranı ile diğer markalar takip etmektedir. Burger King markasının tercih edilmesindeki en etkili nedenin ise en yüksek olasılığa sahip olan hijyen seçeneğinin olduğu görülmektedir. Burger King markasının saklı tercih nedeni olan "Hijyen" durumunun Popeyes, KFC, Mc Donalds, Dominos, Pizza Hut, Sbarro ve Arby's gibi markaların da tercih edilme durumlarının altında yatan saklı neden olduğu görülmektedir. Çalışmanın Covid – 19 sürecinde yapılmış olması hijyen seçeneğini ön plana çıkarmıştır. Ayrıca Subway markasının tercih edilmesinin altında yatan saklı nedenin "Kampanyalar" ve diğer markaların tercih edilmelerinin altında yatan saklı durumun ise "Yiyecek Kalitesi " olduğu görülmektedir.

Anahtar Kelimeler: Markov Zincirleri, Saklı Markov Zincirleri, Fast Food, Marka Tercihi.

My best memory is dedicated to my dear father and my greatest chance to my dear daughter…

ACKNOWLEDGEMENTS

I would like to thank my dear consultant Asst. Prof. Dr. Feyza GÜNDÜZ very much for supporting me at every stage of my study, guiding me with her knowledge and experience, and patiently helping me.

I want to thank my dear professor Asst. Prof. Selim GÜNDÜZ so much for his supports and the information he shared with me during my thesis process.

I would like to thank my lecturers at Adana Alpaslan Turkes Science and Technology University, Faculty of Business Department of International Trade and Finance, for whom I received help in every subject throughout my master's education period.

I would like to present my endless thanks to my parents whom I cannot express my love for them in words, that is to say, to my dear mother Gülşen YÜKSEKBAŞ, who supported me throughout my education and training life, who brought me to this day, who is with me in every step I take, and to my deepest wound, my most beautiful memory, my dear father Oğuz YÜKSEKBAŞ who has the most special place of my heart. You will always live in my heart dad.

I would like to thank my dear sister Işık Sinem BAYRAKAL and my dear brother Muhammed Ali YÜKSEKBAŞ who are with me all the time and give me strength and whom I feel the pride, beauty and happiness thanks to be a sister of them.

I would like to thank all my family and friends who have been with me throughout the process for believing and supporting me.

Finally, I would like to thank my dear husband Emrah FINDIKLI, whom I always grateful for being by my side and I'm happy with the power of his love, who gives countenance to me every time, and to my greatest chance in this life, my happiness, my dear little daughter Bilge FINDIKLI who has rendered my life meaningful since the day she joined to us and has made me feel taste of motherhood in the deepest meaning. I love you so much my angel girl.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Notion ‘brand’ is a concept improved by development of human being (Akalan et al., 2019). Brand is a symbol which make easier decision-making period of customers and satisfy their demands (Keller, 2003). Also, brand is a name and symbol, which expresses goods, dealers or dealer communities and enables these products and services to be distinguished from their rivals (Elitok, 2003). As being distinguished from the goods or services of another business, all kinds of symbols including the names of persons, especially words, images, letters, numbers, the shape or packages of the goods displayed by drawing or printed and reproduced similarly, define the brand (T.C.Official Newspaper, 27 June 1995: 556).

Brands are the most valuable power factor of the business. They secretly promote the business as long as the goods are on the market. With the interest of the customers towards the brand, the company can enter different markets. (Miller, 2005). Brand is the most important element of a business that distinguishes itself from competitors. Brands are the most important source of strategy that ensures the continuity of the business. The brand acts as a seal in the business and offers its customers a sense of trust. In other words, the brand is important in informing the customer clearly about the future and past thoughts, the path and decisions of the business. (Çakırer, 2013).

Considering the importance of the brand for consumers, the name of the brand carries messages of trust for the consumer. Kotler and Amstrong (2004) state that customers know that they will find the same features, benefits, quality and trust in every shopping they make from the same brand. The brand guides the consumer in the purchasing decision. The trust and loyalty provided by the brand is one of the important reasons that accelerate the sale of the consumer. Brand refers to the quality of the product. If the consumer likes the product he bought, he will re-purchase, and in the opposite case, the consumer will not prefer the same brand again (Çakırer 2013). From another perspective; the brand creates a sense of satisfaction in the consumer, creates cooperation with the consumer, expresses a culture, an exemplary person and creates value. All these affect consumers to prefer branded or even strong branded products. The brand is also considered as an identity and status indicator for the consumer (İslamlıoğlu and Fırat, 2016).

Since brands are in a marketing war today, one of the most functional investments of a business is undoubtedly branding. Producers should not look at the branding process as a short-term situation and should consider it as a vital process. In our age, all goods and services need to be branded in order to enable consumers to distinguish the goods produced by producers (Karpat, 2000).Branding is a former method of differentiation that helps a manufacturer differentiate his/her product from another (Engin, 2016). There are many conditions that branding brings to the business. These are ranked as the brand having the right place in the mind of the consumer, the promotion of the products to the outside world with the desire to grow and develop, the marketing and sales of the products, the positive support of the research and development methods, the image, the value, the personality of the company and the loyalty of the customers to the company thanks to the brand(Transmitter: İnaç and Yacan, 2018).

Brand loyalty is the determining factor of brand choices and brand behavior and attitudes in the future, with a more general viewpoint; a positive phenomenon of recurrent purchases of the product (Aktuğlu, 2004). Brand loyalty is the intense dedication and determination that leads to repetitive buying behavior for the same brand or set of brands, in spite of the potential marketing and other factual effects that may lead to behavior change, to repeat the preferred brand or service in the future, or to take the brand under surveillance again (Oliver, 1999). Each business takes aim at creating a consumer base that will remain loyal to the brand it owns in the long term. Consumers show loyalty to brands regarding their income levels. It is known that consumers with high income levels show more loyalty in comparison to consumers with low income levels (Akpınar and Yurdakul, 2008). Brand loyalty is also handled with regards to the purchase of the brand, rather than using a single brand. Today, the biggest aim of the companies is to create loyal consumers who are loyal to their own brands in competitive market conditions, where the price is taken into consideration. Brand loyalty is one of the main reasons for the importance and value that the brand has acquired in today's conditions (Uztuğ, 2005).

The social, economic and cultural power of states consists of institutions and organizations that produce products, services and knowledge and have become international brands in global markets. It is seen that the institutions and organizations that set the world standards in the production of products, services and information have taken place in competition instead

of states. The strongest and most effective aspect of these institutions and organizations are the names or brands that have been shaped over the years and have deep-rooted values (Çedikçi, 2008). Achievement and permanency in the financial and cultural world are based upon the brands that are built elaborately. Brands are the key to success and a part of life in many areas from economy to politics, from education to culture, to sports (Gürdoğan, 2008). In addition to all these, one of the sectors where the effects of branding are seen the most is the food sector.

Today, one of the sectors where competition is increasing around the world is the food sector (Kahraman and Dağlı, 2019). There are many factors that affect the choice of brand in food products. The first five of these elements are listed as packaging features, taste and consistency, brand image and availability, quality and economy (Akpınar and Yurdakul, 2008).

Nutrition is one of the common characteristics necessary for living things to survive (Soylu, 1978). In addition to meeting biological needs, eating is a situation where people mingle with each other, strengthen friendships, chat, have fun, share their happy and sad moments, celebrate and thus meet their socialization needs (Ciğerim, 2001). With the increase in the world population, the demands brought about by the need for nutrition also change. Therefore, the segment of the food sector is expanding and different options, especially for the young population, are increasing day by day. The choices of the young population are generally inclining toward fast food, which is defined as fast food. The fast food lifestyle understanding has started to take place in the daily lives of people in this range (Hamşıoğlu, 2013).

In this study, the recent preferred fast food brands and the next brand preferences of university students were estimated by the Markov chain method, and the reasons for their preferences were examined with the Hidden Markov Model.

The study continued with the subject of fast food, in the second part literature review, in the third part the structure and properties of Markov chains, in the fourth part the structure and properties of the Hidden Markov Models, in the fifth part the findings of the study, and in the last part, suggestions are given in line with the results and findings.

1.1. Fast Food

Fast food is defined as food that does not exceed a few minutes to prepare and present to the customer, is cheap, its packaging is generally disposable, is likely to deteriorate if not consumed for a long time, can be taken home in packs, the price is usually not very high, usually eaten by hand, and occasionally has plastic cutlery (Bulduk, 2005).

For university students in the young population, many factors such as living away from families, lack of interest in cooking, time constraints, curiosity, desire to try different tastes, rewarding themselves and the desire to socialize, push students to adopt the habit of eating outside (Kahraman, 2019). Based on this situation, fast food establishments have become places preferred by students. Factors such as decor, atmosphere, staff attitude, food quality, location, service speed, variety in the menu, and the availability of special products play an important role in young people preferences about choosing fast food establishments (Yazıcıoğlu et al., 2013). Fast food businesses can be defined as places where food is prepared and presented to the customer in a short time, many foods that are not high in price can be given to the customer in packages, in some cases, the number of employees is kept low and self-service is preferred, and their locations are generally central places (Kuldaş, 2018). Due to these advantages, they have recently gained an important place in the food and beverage industry.

Based upon the increasing competition in recent years, the situation of reaching consumers, determining the preferences of consumers, making innovations based on their wishes and obtaining satisfaction from the service has become increasingly difficult (Çınar, 2007). As preferring food products, consumers put the brand in the first place, the quality in the second place, the price in the third place, and the product packaging in the fourth place. The result of this finding shows that the brand is the most significant factor for the consumers and relying on the brand increases the willingness to buy (Tarkan Erbaş and Artukoğlu, 2016). Realizing this situation, fast food brands can increase the pleasure of their consumers with different strategies they will implement (menu, price, campaign difference, etc.) and provide the opportunity to attract the attention of potential consumers. When consumers hear or see the name of these brands, they are expected to have an idea, a thought about the brand. For this reason, consumers try to evaluate the brand in their minds regarding the products and services they receive and think to have an opinion about that brand (Kahraman and Dağlı, 2019).

1.1.1. Development of Fast Food Industry In The World

The history of fast food goes back to the 18th century. In the 1780s, Fish & Chips (fish and chips), the traditional fast food product of England, started to be sold on the streets of Northern England for the first time (Akdağ 2015). The joint sale of fish and chips in Lanceshire is known as the first applications of the fast food system (Erbay, 2007).

Fast food service examples were first seen in America in the 1800s. In the 1870s, restaurants were places where people with good economic conditions could go, they were quite expensive for ordinary workers, on the other hand, sandwiches, tarts and beverages were sold at affordable prices to workers in the UK in the form of a carriage (Kaya 2011). They have become small, affordable businesses that look like wagons where food can be consumed in mobile cars.

The hamburger, which is the most popular fast food today, is a fried steak in bread eaten by the local community living in the Baltic regions, and mostly by the Tatars (Tayfun and Uygur, 2008). At the Hamburg port, Tatars introduced it to the Germans during their commercial relations. The Germans have also made some changes to this product. When Germans immigrated to America, they introduced hamburgers to America (Acar, 2016).

Considered as the first design of fast food style foods, the hamburger chain was first established in America under the name "White Castle" in 1921. Small hamburgers, sold for five cents a piece, began to be found on menus in restaurants in the 1930s, along with french fries and drinks. In 1920, fast food businesses serving the car called "drive-in" were established (Tengiz,2018). However, its popularity increased in 1940, the first McDonald's restaurant was opened in the same year and it was established as a business that served cars in accordance with the conditions of the time. In 1948, McDonald's brothers started serving with paper cups and napkins in order to cope with the increasing competition. They also limited their menu to burgers, cheeseburgers, french fries, drinks and desserts (Mcdonald’s, 2021). They arranged the kitchen to work efficiently with few personnel, thus reducing the price of the hamburger by 50%. In addition, it was turned to car service, self and package service. With these regulations, the business became a preferred place not only for young people but also for their families with children. In this way, it achieved high profits and has become a chain (Kaya 2011).

The areas that emerged in the 20th century, where there is no living area and where meals are consumed on the stalls, have survived to the present day. With the establishment of McDonald's company in 1950, eating outside the home quickly became popular. In the 1960s, self-service practice became common in fuel stations. In the 1970s, people were used to using the self-service event in grocery stores and fuel stations. This fast and inexpensive consumption has reduced personnel costs in enterprises (Bingöl, 2005, Acar, 2016).

McDonald's is the first restaurant opened in the fast food system, and Burger King and Kentucky Fried Chicken (KFC) businesses with billions of dollars annual sales have also started to work in this system in the following years. The menu consisting of hamburgers, french fries and cola are well-known foods in the fast food system. The most preferred fast food restaurants by consumers are restaurants that offer foods such as hamburger, pizza, pita, doner, lahmacun (Özçelik and Sürücüoğlu, 1998).

Burger King opened its first restaurant in Miami in1954. The first restaurant opened in Puerto Rico in 1963 was the first restaurant opened outside the United States. The fast food sector started to spread rapidly in the USA in the 1960s and 1970s. In this period, the number of drive-in restaurants increased with the increase in the use of cars in America. Fast food restaurants, which are increasing in number on the roadside, have started advertisements with large billboards (Kaya, 2011). The main brands that have increased on the roadsides in these years are Burger King, Wendy's, Kentucky Fried Chicken (KFC), Arby's and Pizza Hut.

In the 1980s, when Domino's Pizza started take-out service, pizza became a well-known food. Between 1985-1988, Domino's Pizza increased its earnings %100 (Jacobson and Fritschner, 1991).

Today, businesses such as McDonald's, Domino’s Pizza, Burger King, KFC and Pizza Hut, which are the pioneers of internationalization in the fast food sector, continue to work around the world and continue to spread in different countries. Fast food businesses are the "trend food" in the country where they are opened and they especially appeal to the young population of the country (Yu, 1999).

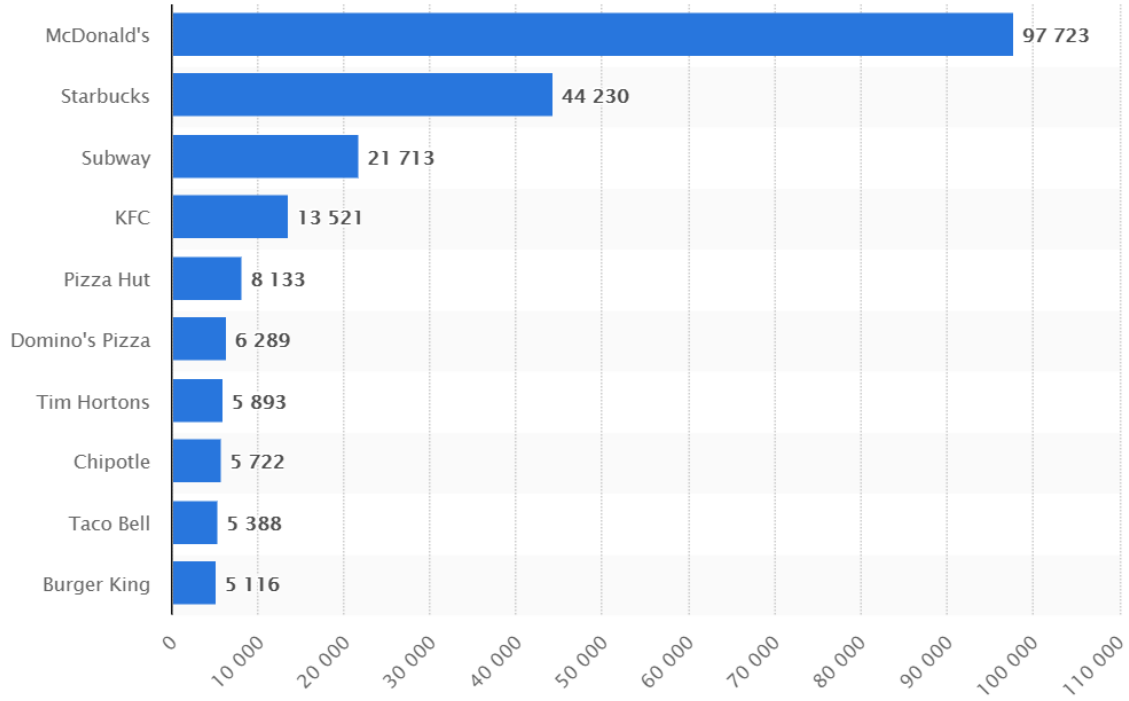
In addition to this information, information about fast food brands is given below with some visuals.

Table 1.1. Top 20 Fast Food Restaurants In The World By Number Of Restaurants In 2018 Chain.

	Fast Food Brands	**Number of Owned Restaurants**
1	Subway	44.229
2	McDonald's	36.900
3	Starbucks	25.085
4	KFC	20.404
5	Burger King	15.000
6	Dominos Pizza	14.200
7	Pizza Hut	13.728
8	Dunkin'Donuts	11.300
9	Baskin Robbins	7.300
10	Hunt Brothers Pizza	7.300
11	Taco Bell	6.500
12	Wendy's	6.490
13	Hardee's	5.812
14	Orange Julius	5.700
15	Sibylla	5.000
16	Dairy Queen	4.800
17	Little Caesars	4.800
18	Papa John's Pizza	4.700
19	Tim Hortons	4.590
20	CNHLS	4.000

Source : Kahraman, 2019.

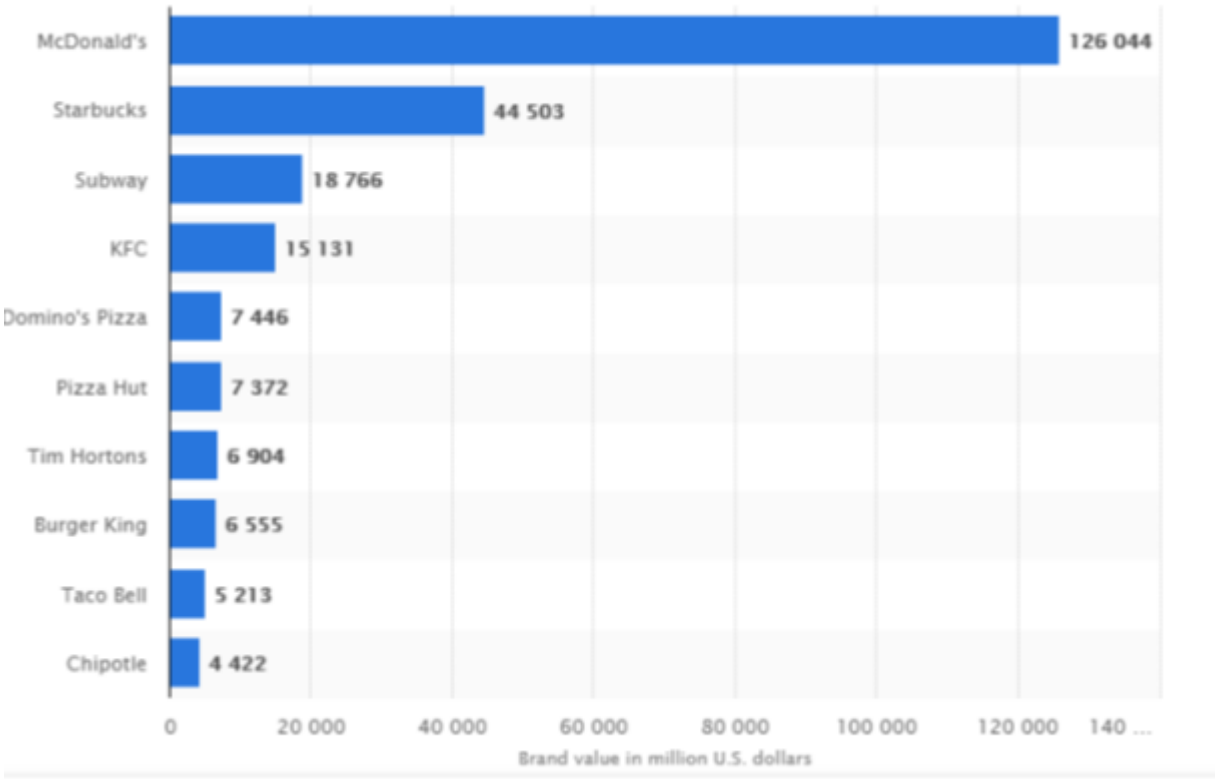
Table 1.1., lists the top 20 fast food restaurants in the world in 2018. In the first place is the Subway brand, which has the most restaurants with 44.229 restaurants.



Source : Kahraman, 2019.

Figure 1.1. Top 10 fast food chains in the world in 2017.

In Figure 1.1., the top 10 fast food chains in the world in 2017 are listed. It is seen that McDonald's brand is in the first place with 97.723 fast food restaurant chains.



Source: Güngör, 2019.

Figure 1.2. Top 10 fast food chains in the world in 2018.

In Figure 1.2., the top 10 fast food chains in the world in 2018 are listed. It is seen that McDonald's brand is in the first place with 126.044 fast food restaurant chains.

1.1.2. Development of Fast Food Industry in Turkey

The entry of international companies into the fast food sector in Turkey started in the 1980s. The process that started with the encouragement of exports in 1980, with the support of the media, affected the society with the concepts of being western and living like a westerner became the dominant thought in the country. Society turned to western style consumption habits. The shopping malls opened after 1980 and 1990, the cinemas and restaurants opened in this shopping center emerged as a result of this westernization idea (Özcan, 2007).

The increase in the young population in the society and the change of traditional habits have also reflected in the food sector. Similar to the change in food consumption habits around the

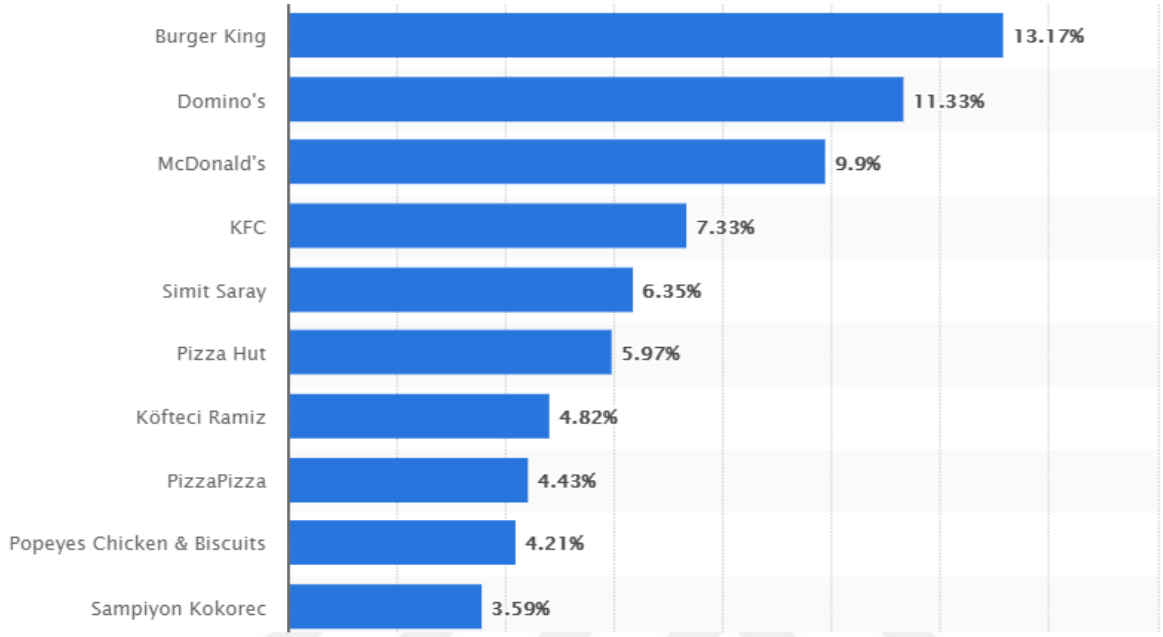
world, the first Mc Donald's restaurant opened in İstanbul Taksim Square has been experienced in our country since 1986 (Özdinç, 2004).

Following McDonald's entry into the market, most of the American foreign-funded fast food and food and beverage businesses, such as Burger King and Kentucky Fried Chicken, and the majority of domestic businesses concentrated their activities in big cities such as Istanbul, Ankara and Izmir (Yurtman 2001). Later, such places were opened in many places such as school campuses, museums, dormitories, airports, amusement parks and zoos, and the number of these enterprises has increased day by day (Özleyen 2005).

With the influence of the westernization movement in the 1980-1990s, changes in Turkish food culture began, as an alternative to pita, hamburger, pizza, etc. Consumption of food and soda instead of ayran has become widespread in Turkey (Orkun, 2009). In fact, simit, borek, pastry, rice, doner, etc. Foods that are consumed fast and can be sold in the car are the first examples of fast food in Turkish food culture (Sürücüoğlu and Çakıroğlu, 2000). However, the products consumed by the westernization movement have changed and the concept of fast food is hamburger, pizza, etc. It has become a concept mentioned with the products.

After opening McDonald's, the first international fast food restaurant in Turkey in 1986, in Taksim, it established its head office in Turkey in 1991. In 1995, Burger King brand was brought to Turkey by Tab Gıda Ticaret ve Sanayi A.Ş. within Ata Group (Gökşen, 2015). Today, fast food chains maintain their existence and increase their businesses with franchise systems in our country, as they do all over the world. It is known that the most franchised company in Turkey is TAB Gıda. Since TAB Gıda gained the right to open Burger King restaurants all over Turkey in 1995, it is in a position to control 40% of the entire fast food sector in the country. TAB Gıda operates a total of 1,132 restaurants together with some developed American companies (Asal, 2020). Restaurants operated by TAB Gıda are 651 Burger King restaurants, 200 Popeyes restaurants, 78 Sbarro pizza restaurants, 68 Arby's restaurants (Worldfood Istanbul, 2018). Domino’s Pizza, which has a leading market share in the field of pizza in Turkey and has been operating since 1996, has spread to 69 provinces and has 538 branches (www.dominos.com.tr, 2021). McDonald's, the first fast food chain to enter the Turkish market, today serves 100 million people a year with its 260 restaurants and around 6000 employees (www.mcdonalds.com.tr, 2021).

In addition to this information, images containing information about fast food in Turkey are given below.



Source : Kahraman,2019.

Figure 1.3. Which fast food restaurant in Turkey would you like to go to in 2016?

Fast food restaurants visited in Turkey in 2016 are given in Figure 1.3. According to this information, it is seen that the Burger King brand takes the first place with a rate of 13.17 percent.

2. LITERATURE REVIEW

Studies have been conducted in the literature on the fast food consumption habits of university students, their fast food preferences and elements affecting the reasons for fast food preferences (Özdinç, 2004; Unur and Kaya, 2010; Sayılı and Gözener, 2013; Sürücüoğlu and Çakıroğlu, 2000; Korkmaz, 2005), but there is no study on the prediction of the next fast food brand preferences. Studies on fast-food with different methods in the literature and studies on markov chains and hidden markov chains are given below.

Knutson (2000), in his study involving Michigan State University students, investigated the way students perceive fast food restaurant brands and the factors that affect their fast food consumption point preferences. This study revealed that thanks to its favourite hamburger Whopper, Burger King was perceived by students as a brand with a bigger and tastier hamburger, and the most important factor affecting students' fast food consumption point preferences was hygiene by 69%.

Uçar (2000) researched the class preferences in type of fast food and determined that 71% of the high-income consumers prefer international restaurant chains such as McDonalds and Burger King.

Sürücüoğlu and Çakıroğlu (2000) conducted a research on the fast food choices of Ankara University students in their study. The research was conducted on a total of 886 students to determine the preference of western style and traditional fast ready foods of undergraduate students at Ankara University. When the frequency of students going to fast food establishments was investigated, it was determined that students mostly preferred traditional style establishments.

The study of Özdinç (2004) is based on data obtained from face-to-face questionnaires applied to 357 students studying at Çukurova University. Within the scope of the study, the factors affecting the fast food consumption habits and consumption point preferences of university students were tried to be determined, various hypotheses related to the subject were

created and their validity was investigated. In his research, he found that 87% of the students consume fast food.

Korkmaz (2005), in his study titled “Effectiveness of competitive strategies in the fast food market: analysis of university youth preferences”, touched on the competitive strategies applied by fast food businesses and conducted a research to determine what the university students' opinions and choices about such businesses are. As a result of the study, it has been observed that kebab and lahmacun are the most preferred fast food types among students, and students buy this type of food because they find it clean, healthy and of high quality. In addition, it has been determined that the factors taken into account in the process of purchasing fast food products differ according to gender, university studied and income level.

Sormaz et al. (2005) emphasized in their studies that factors such as food quality, service speed, decor, easy accessibility, atmosphere, menu variety and special products have an important place in choosing fast food establishments. According to the preference score averages of the students' reasons for preferring fast food, they stated that male students consume fast food types because they like their tastes more, the service is fast and satisfying. It was stated that female students preferred fast food types mostly because they were very tasty, satisfying and close to their schools. In the consumption of fast food types; it was stated that it is statistically important to be preferred because it is delicious and the service is fast.

In Korea and Philippines, it has been concluded that the most effective factor in students' menu choices is the price of the menu. However, it was concluded that the cultural differences of the students of the two countries were not effective in their menu choices. While Korean students are more comfortable with this issue, students in the Philippines want better service speed. He stated that university students in Korea and the Philippines have a good experience when they consume fast-food. In addition, as they consume fast food, self-confidence and thus satisfaction of these students are provided (Baek et al., 2006).

Özbay et al. (2007) examined the factors that affect the choice of fast food establishments and aimed to reveal whether there is a difference between these factors and the demographic characteristics of consumers. In the study, a survey was applied to 736 customers who came to McDonald's fast food business, which is an international company operating in Izmit

province. In the factor analysis applied to the data obtained from the customers, six factors that affect the customers' choice of fast food businesses were determined. These elements are; product features, personnel behavior, speed, price policy, marketing activities and physical elements.

Tayfun and Uygur (2008) applied their studies on university students studying at Gazi University Faculty of Economics and Administrative Sciences. They made comparisons regarding the determinants of the fast food restaurant choices of university students and the choice of fast food restaurants of Turkish and foreign origin. Statistically, significant difference was observed between the origin of the preferred restaurant and the physical conditions and business image that were effective in buying the service.

Kaya (2011) conducted a research on the reasons of fast food consumption for the customers of the businesses belonging to local, national and international fast food chains in Mersin city center. The aim of the study is to determine why consumers consume fast foods so heavily. The study was applied to 1103 people using a questionnaire method. According to the data obtained from the study results, customers consume fast food because they are hungry while out, enjoy the taste, easily reach and get hungry while shopping.

Kayışoğlu and İçöz (2012) included the effect of education level on fast food consumption habits in their study. In the study, a questionnaire was applied to 900 people including Tekirdağ central secondary schools (high schools) and Namık Kemal University students to determine their fast-food consumption habits. The effect of education level on fast-food consumption was investigated with the survey questions directed to the students. 55.1% of high school students stated that they consume because they find it delicious, while 57.7% of college students, 46.2% of vocational school students and 52.8% of faculty students consume because they are prepared quickly. In the study on the reasons for preferring fast food, it was stated that the effect of education is important, and the rate of preferring fast-food meals decreases as the education level increases.

In their study, Sayılı and Gözener (2013) investigated the fast food consumption habits of students studying at Gaziosmanpaşa University and revealed the factors affecting these habits with chi-square analysis. In addition, they applied factor analysis on students' ideas about fast

food consumption places. In the research, the information obtained from 297 students through the survey in April-May 2010 period was used. According to the results of the research, most of the students (71.38%) consume fast food and this rate was found to be higher for female students. It has been determined that students mostly consume fast-food outside of the campus.

Hamşıoğlu (2013), in his study, gave place to an application to determine the lifestyles of consumers who buy fast food products. In the study, it is aimed to find the relationships between the lifestyle of consumers who buy fast food products in the city center of Kırıkkale and their behavior towards these products. According to the data obtained from the results, it has been concluded that consumers who have lifestyles, such as experiencers, builders, believers and thinkers, support fast food products in emergencies, also think that the fast food products provide convenience and saving of time, additionally, they are delicious and their prices are reasonable.

Kıngır et al. (2015) aim to determine the variables that may be effective in the choice of fast food products of the students studying at Diyarbakır Dicle University in the 2014-2015 academic year, according to their degree of importance and to reveal whether there is a difference according to demographic variables. Survey method was used as a data collection tool in order to make accurate evaluations for the purpose of the study. As a result of the analysis, the averages and standard deviations of the factors that affect fast food consumption were determined. The most important factors affecting the fast food consumption of the participating students are the features of the product, then the speed and price policy.

Rasool (2017) examined the fast food consumption behavior of consumers in Northern Iraq. The aim of the study is to investigate the fast-food consumption behavior of consumers living in Northern Iraq and the effect of sociodemographic variables on fast-food consumption. In the study, a questionnaire was applied to 380 people in Erbil, Süleymaniye and Duhok in the Northern Iraq region. As a result, it is seen that as the income of individuals increases, the amount of fast food consumption within the total food expenditures also increases. Increasing income of people increased the share of fast food consumption, but decreased fast food spending. There is a strong relationship between fast food consumption and income.

Tengiz (2018) included the evaluation of the attitudes and behaviors of university students towards consuming fast food in his study. The aim of the study; to determine whether there is a relationship between the lifestyle of university students and their reasons for preferring fast food. The study was conducted by applying a questionnaire to 347 people studying at Tekirdağ Namık Kemal University. As a result, it has been determined that there is a relationship between the lifestyle of the consumers and the reasons for consuming fast food products.

Veuphuteh (2018) examined the fast-food food quality perceptions, health awareness and price sensitivity of consumers who prefer fast-food restaurants and investigated the effects of these variables on purchasing thought. In the study, an online questionnaire was applied to 291 university students in Ankara and Toronto and the data were tested in this way. As a result of the study, the university in Canada students' price sensitivity towards fast-food products from the Turkish sample proved to be more. In addition, perceptions of food quality, health and well-being among university students in Turkey and Canada. There was no difference in their awareness levels and fast-food purchase intentions did not come out.

In their study, Akçadağ and Bozkurt (2019) included an application to determine the reasons for choosing fast food products for Sivas Cumhuriyet University students and to understand whether there is a difference with the demographic characteristics of the students for these reasons. In the study, a questionnaire was applied to the students studying at Sivas Cumhuriyet University. As a result of the study, it was observed that the students primarily paid regard to the product features, and among these features, it was found that the freshness of the food had the highest value.

Tumay Bulut (2019) included a research on the relationship between consumer behavior and lifestyle towards fast food products in his study. In the study, the relationship between the fast food consumption and lifestyles of the consumers in İzmir province was investigated. In addition, fast food consumption patterns, consumption frequency, consumption reasons and behavior of consumers towards fast food products were examined. The study data were reached through face-to-face questionnaires over 271 people whose basic material is proportional sampling volume. According to the results of the research, the most effective criteria in the decision of consumers to purchase fast food products were stated as being

economical, healthy and ubiquitous, respectively. The variables that least affect the decision to consume fast food are; it was stated as being delicious and satisfying.

Asal (2020) examined the brand value perception of university students on a fast food brand. The aim of the study is to examine the brand value perceptions of the fast food industry consumers and to determine whether the brand value perception differs according to demographic factors and consumption behaviors. The study was carried out with the participation of 392 students studying at Mersin University. According to the results of the research, the general brand value perception of university students is at a "medium" level. Brand value perceptions of students showed statistically significant variation according to monthly family income and gender variables.

Following the studies on fast food, the studies on the Markov chain method and the Hidden Markov Model used to determine the preferences of consumers and the reasons for these preferences are briefly summarized below.

Mengüç (1990) included an application on market share estimation and color television market with Markov chains. In the study, the short and long term market shares of the companies in the color television market between the years 1990-1995 were obtained in accordance with the Markov chain method and the assumptions that come with this method. As a result of the study, it was seen that the market shares of Vestel, Philips and Telra enterprises increased gradually between 1990-1995, İES was withdrawn from the market, and Bekoteknik was among the enterprises that decreased its market share the most.

In her study, Güler (1992) included an application on the estimation of the future market shares of companies in the vehicle engine oil market for Bursa city center using the Markov chain method. The aim of the study is to estimate the demand status of the products of known companies in the vehicle engine oil market in the city center of Bursa in the first quarter of 1989 and the changes in their market shares in the future using the Markov chain method. The data of the study were obtained by applying the survey method, and by evaluating these data, the transition probabilities matrix and the initial probabilities vector were formed. As a result, in the vehicle engine oil market, British Petrol, Mobil, Shell, Petrol Ofisi and Turkish Petrol companies have products and in the long run, Mobil is the most of these companies; it has

been observed that the market shares of vehicle engine oil products of Petrol Ofisi, Mobil and Shell companies have increased.

Can and Öz (2009) applied the hidden Markov model on brand preferences and preference reasons in their work. They obtained their data from the survey they applied to students studying at state universities in the province of Istanbul. The Hidden Markov Model was created based on the mobile phone brands used by the students and their reasons for preferring these brands. With this model, it has been estimated which brand will be preferred by university students and the reason for choosing any brand. Cell phone brands to be preferred as a result of the study are Nokia 43.45%, Samsung 22.92% and Sony-Ericsson 10.52%. The reasons for preferring these brands are advanced features for Nokia and Sony-Ericsson brands and price suitability for the Samsung brand.

Kıran (2009) examined the Markov chains by accepting stochastic processes as a starting point in her study named Markov chains and a business application. In the study, it has been shown with the help of Markov chains that consumers' next mobile phone brand preferences are only related to the mobile phone brands they are currently using. In the application part, by creating a transition matrix, the probabilities of switching between brands (transition from one brand to another brand) and the balance vector of the transition matrix are calculated to determine the brands that create the highest brand loyalty in the long run. Looking at the results of the thesis application, Nokia and Sony Ericsson were perceived as strong brands in terms of "a brand that pays for the price paid", "a known brand" and "a reliable brand", which are effective in brand preference in the market. On the other hand, it has been seen that the Samsung brand is an insufficient brand in terms of "a brand that pays for the price paid".

In his study, Soykan (2010) first identified the automobile tire brands available in the market, based on the information obtained from the managers of the companies operating in the automobile tire market. In line with this information, a questionnaire was applied to 400 people about the selected brands. As a result of the study, the market shares of the brands for the future periods have been determined.

Çetin and Alp (2016) included the analysis of mobile phone brand preferences with Markov chains in their studies. The data of the study were obtained by conducting a survey for 503

people. In line with the results obtained from the surveys, the Markov transition probability matrix and the long-term equilibrium vector were calculated, and information was obtained about the transition rates between brands and brand dependencies. Brand loyalty, in other words, the possibility of users to re-choose the same brand mobile phone, respectively, Iphone (86.6%), Sony (53.6%), Samsung (46.8%), LG (33.30%), HTC (26.2%), Turkcell (20.0%), Nokia (14.9%) and General Mobile (14.3%).

Senturk and Alp (2016) examined the analysis of mobile operator and internet service provider preferences using the Markov chain method. In the study, 790 people were surveyed for the analysis of mobile operator and internet service provider preferences. In line with the results obtained from the surveys, the Markov transition probability matrix and the long-term equilibrium vector were calculated, and information about transition rates and brand loyalty was obtained. The probability of users to choose the same brand for their MOP-ISS subscriptions was found as TurkcellTtnet, Vodafone-Ttnet, Avea-Ttnet, Vodafone-VodafoneNet, Avea-Superonline, Turkcell-Superonline, Turkcell-VodafoneNet, Turkcell-Other and Vodafone-Superonline, respectively.

In his study, Kıral (2018) tried to predict the mobile phone operator preferences of the users and their market share in the following years with the Markov chain technique. The study data were obtained by applying a questionnaire to 750 people residing in Adana in 2017. As a result of the study, the value of brand loyalty to Turkcell operator was 86.55%, this value was 88.58% for Vodafone and 87.64% for Türk Telekom operator. In addition, it was stated that the probability of preference for the Turkcell operator, which is in the best condition as of 2017, will decrease in the process and Vodafone operator will be ahead of other operators in the long term.

Ayaz and Alp (2018) performed an application regarding the factors affecting the GSM operator preferences of university students studying in Istanbul. With the Hidden Markov Model, the GSM operators used by the students and the reasons for choosing these operators were estimated. As a result, the GSM operators to be preferred were Turkcell 37.10%, Turk Telekom 31.78% and Vodafone 31.12%, respectively. According to the data obtained, it was determined that the reasons for preference of these GSM operators are coverage power for Turkcell and affordable price for Turk Telekom and Vodafone.

Dönmez and Alp (2018) carried out an application about brand preferences and reasons for preference in the sportswear industry by using the Hidden Markov Model. The data used in the study were obtained through questionnaires made to Yıldız Technical University (YTU) students. In the study, the first two problems of the "Three Basic Problems" of the Hidden Markov Model were used. As a result of the study, the percentages of preference of sportswear brands were found, and it was stated that the most important reason for preference was "Design and Fabric".

Gündüz and Kıral (2020) examined the factors affecting voter preferences using the Hidden Markov Model in their study. The aim of the study is to determine the reasons why university students prefer political parties. The study data were obtained by applying a questionnaire to 1219 people. As a result of the study, the most important reasons affecting the preferences of the voters studying at the university; It has been determined that the projects and promises presented by the party, the image and charisma of the party leader, the political tendencies of family and close friends, the strong and reliable of the party staff.

Ercan (2020) examined the sports shoe brand preferences of young people with the Markov chain method in her study. The study was applied on 217 young consumers aged 14-19 living in Ankara. As a result of the study, it was seen that the highest brand loyalty for sports shoes belonged to the Nike brand, the probability of choosing the same brand was 36.11% for Adidas, 18.18% for Reebok, 33.33% for Skechers, 14.29% for Puma, New Balance for 11.11%. In the long run, 33.02% of the young people are Nike, 30.47% other brands, 23.32% Adidas, 4.42% Puma, 3.72% New Balance, 1.87%. It is expected that Converse, 1.49% Skechers, 0.9% Reebok and 0.8% Asics sports shoes.

3. MARKOV CHAINS

The basis of the Markov chain method is based on the 20th century A.A.Markov's mathematical explanation of the structure and behavior of gas molecules in a closed box (Öz, 2009).

The concept of Markov analysis refers to a method used to predict the future behavior of the system, taking into account the current behavior of the system (Daşdemir and Güngör, 2002; Büyüktatlı et al. 2013). In addition, Markov chains have the ability to predict the long-term situation of the system as well as predicting the situation the system will be in at a certain time (Aytemiz and Şengönül, 2004).

For the Markov process, the system does not need to know what the previous states were, except for the previous case. The transition from one state to another depends only on the previous state of the system, not on the previous states. This feature is called the Markovian feature. In a system with a Markovian property, transition from one state to another is expressed by conditional probabilities that depend only on the previous state (Alp and Öz, 2009).

Application areas of Markov analysis; determining the market share of a product and its future situation, determining the probability of failure of a machine and the future failure of the machine, determining which amount of receivables becomes impossible to collect in the problem of collection of receivables, and determination of which amount of receivables is possible to be collected in short, medium and long terms, forecasting of future situations, determining the future status of the number of audience-readers for the media, determining the future status of the existence of a business, determining the future state of environmental values such as forest-sea can be given as examples (Timor, 2011).

Although the usage area of Markov chains is quite wide, it can be said that they are more widely used especially in the fields of production planning, marketing, finance, engineering, biology and statistics (Bäuerle and Rieder, 2011).

3.1. Stochastic Process

Stochastic processes (probabilistic processes) is a theory that studies systems developing over time based upon random rules (Kıran, 2009). Stochastic processes are used to model systems that change over time according to probability rules (Önalan, 2010). Today, it is used in many fields such as finance, economics, social sciences, science and engineering.

The set containing all the usual results of a random experiment is called the sample space and each subset of the sample space is called an event (Malliaris and Brock, 1999). The sample space, to be determined as Ω, is defined as a collection F of subsets of Ω with the following properties to be denoted by σ (Lawrance, 2001).

i. $\varphi, \Omega \in F$

ii. If $A \in F$, then $A^c = F$. ($A^c = \Omega - A$, complement of A.)

iii. If $A_1, A_2, \ldots \in F$, then $\bigcup_{k=1}^{\infty} A_k$ is $\bigcap_{k=1}^{\infty} A_k \in F$

As F being Ω's σ-algebra of subsets, in the situation of following conditions, transformation of $P : F \rightarrow [0,1]$ is called a probability criterion (Önalan, 2010).

i. $P(\varphi) = 0$, $P(\Omega) = 1$

ii. $A_1, A_2, \ldots \in F$ then $P\left(\bigcup_{k=1}^{\infty} A_k\right) \leq \sum_{k=1}^{\infty} P(A_k)$

iii. If $A_1, A_2, \ldots \in F$ is uncorrelated, then $P\left(\bigcup_{k=1}^{\infty} A_k\right) = \sum_{k=1}^{\infty} P(A_k)$ dır.

When any set from here is a σ-algebra in F, Ω subsets and a probability criterion over P, F, the triple is defined as a probability space (Lawrence, 2001).

In (Ω, F, P) probability space, for each $a \in$ R, if it is $\{w \in \Omega : X(w) \leq a\} \in F$, the function $X : \Omega \rightarrow$ R is defined as a random variable (Kloeden and Platen, 1995). In other words, the random variable is stated as a function that transforms each event in the sample space into real numbers (Can, 2006).

A stochastic process is a collection of specified real valued random variables on a fixed (Ω, F, P) probability space (Dupacova et al., 2002). A stochastic process is defined with

$X=(X(t), t\geq 0)$, $X=(X_t, t \in T)$ or $X = (X_t, t \geq 0)$.

Stochastic processes are used to explain the operation of time-dependent systems (Gnedenko and Ushakov, 1995). Each invariance, $w \in \Omega$ for X_t (w), is a function over. This (X_t (w), $w \in \Omega$) function over T is the sample way of ($X_t, t \in T$) process (Davis and Brockwell, 1987).

T given in the stochastic process definition indicates a parameter set that includes all possible values of t. In practice, T is mostly the time interval of the relevant situation, so it is also used as a time term instead of a parameter. The parameter set T can be specified discrete and continuous.

In general, depending on the parameter T is either discrete or continuous, X_t stochastic process is expressed as a discrete time stochastic process or a continuous time stochastic process, respectively.

When T is countable set, that is; T={0,1,2,3,... }, the process has discrete parameter. In terms of time , the process without discrete has a continous parameter. Space of parameter is shown as $T = \{t: t > 0\}$ or $T = \{t : -\infty < t < +\infty\}$ in a continous process. As the explanations about the parameter set reveal, in discrete parameter probabilistic processes, properties are observed only at determined times, while in continuous parameter probabilistic processes, the value observation process takes place at all possible points of the time dimension (Cinemre, 2003).

Each special value that T random variables take is called a case. State space $\{S\}$ defined the sample space for all possible values of X_t (Halaç, 1991).

When there is a transition between states in a system, the system gains a dynamic feature. When it comes to transition between states, this transition stage has been expressed as a step.

State spaces are examined in two groups according to the number of states they contain. If there are finite or countably infinite states in the state space, the process will be said to be a discrete state alien. If the state space is not discrete, that is, if it contains an infinite number of states, the steady state alien process has been in question (Cinemre, 2003).

3.1.1. Brownian Motion (Wiener Process)

Brownian motion is among the most important stochastic processes. The first important applications on this subject were carried out by Bachelier and Einstein in the fields of physics and finance. Later, these applications were created by Wiener on a mathematical structure (Steele, 2001).

In 1828, Scottish botanist Robert Brown observed that pollen grains suspended in liquid had an erratic movement. Later, this motion was explained as the random collisions of the liquid with its molecules. Accordingly, the position of w pollen particles at time t is expressed as B_t (w) stochastic process concept (Öz, 2009).

Real valued Wiener process $W(t)$ or Brownian motion B_t is, over the range of $[0,T]$, constantly a random variable depending on $t \in [0,T]$ and the conditions are attained as following:

i. $W(0) = 0$ (with 1 probability)

ii. For $0 \leq s < t \leq T$, random variable given by increase of $W(t) - W(s)$ is zero mean and normally distributed with $t - s$ variance. So, it's $W(t) - W(s) \sim N(0, t - s)$.

iii. For $0 \leq s < t < u < v \leq T$, increases of $W(t) - W(s)$ ve $W(v) - W(u)$ is independent.

Moreover, for each $t \geq 0$, $E(W(t))=0$ is $E(W^2(t))=t$. In brief, $W(t)$ Wiener process has zero mean and normal distribution with t variance (Lawrence, 2001).

It is known that the sum of independent, identically distributed random variables is among the first topics studied in probability theory (Önalan, 1996).

Let Z_n be a collection of random variables each taking the probabilities p and q and the values 1 and -1, respectively.

$$X_n = Z_1 + Z_2 + ... + Z_n, \quad n \geq 1, X_0 = 0 \tag{1}$$

Consisting of partial sums

$$X = \{ X_n; n = 0,1,2, ...\} \tag{2}$$

stochastic process is called random walk (Önalan, 1996).

3.1.2. Independent Increments Process

In the process of (X_t,$t \in T$), if the random variables defined below are independent of each other for $t_1 < t_2 < .... < t_n$, (X_t,$t \in T$) stochastic process is defined as the process with independent increments (Öz, 2009).

$$(X_{t_2} - X_{t_1}), (X_{t_3} - X_{t_2}), \ldots, (X_{t_n} - X_{t_{n-1}})$$

3.1.3. Fixed Independent Increments Process

In the process with independent increments, if increasing of ($X_{t+k} - X_t$) is independent from *t*, this process is called the process with fixed independent increments. In other words, if (X_t, $t \in T$) stochastic process has a special joint distribution without depending the time or joint distribution of random variable is unchanging over time, it is stationary. Stationary processes have emerged in operational research models where a process that changes over a long period of time is defined (Cinemre, 2003).

3.1.4. Reoccurring Processes

Probabilistic processes where there is a random point that renews the formation of the process are expressed as regenerated processes. A random point is known as the Markov point or repetitive point. Once such a point is reached, the past state of the process will in no way affect its future (Öz, 2009).

3.2. Mathematical Structure Of Markov Chains

Markov processes emerged as a result of the study of Russian mathematician Andrei Andreivich Markov in 1907 on stochastic processes purely theoretically and was named after Markov (Çelik, 2013). Markov applied his theoretical findings for the first time by examining the situation of the first 20,000 vowels and consonants in Alexander Pushkin's poetry-novel Eugene Onegin and summarized the results in his work in 1913. It shifted the technical probability theory developed by Markov to a new direction and enabled the application of stochastic processes in many different areas (www.matematiksel.org).

The first correct mathematical structure of the Markov process was established by N. Wiener in 1923, and the general theory of the Markov processes was developed in the 1930s and 1940s (Alp and Öz, 2009).

The most important element of Markov chains is the list of all possible situations in which the system can be found over time (Ching, Fung and Ng, 2002).

S, to show state-space;

$$P(\ X_{t+1} = j \mid X_t = i\ ) = p_{ij}\ ,\quad i, j \in S \tag{3}$$

This possibility is independent from *t*. According to this formula, the probability that the process in state *i* at time *t* is in state *j* at time *t +1* is denoted by P_{ij} . For Markov chain, P_{ij} s expresses possibilities of transition. Matrix that P_{ij} transition possibilities created is denoted by $P = [\ P_{ij}\ ]$ and it is described as matrix of the transition possibilities of Markov chain.
P_{ij} possibilities are called single step transition probabilities. The transition probability matrix shows the conditional probability of being in a state in the future from a given state (Winston, 1991; Chung and Walsh, 2005). The following equations are valid for the transition probabilities:

$$\begin{aligned} &0 \le P_{ij} \le 1\ ,\quad i, j \ge 0 \\ &\textstyle\sum_{j=0}^{n} P_{ij} = 1\quad , i = 0,1,2,3,\ldots \end{aligned} \tag{4}$$

In order to explain the Markov chain better, it is necessary to define the probabilities of events in the initial state q_i' or, in other words, $P(\ X_0 = i\ ) = q_i$.

Briefly, Markov chains are used for Markov analysis. The changes of the situations in the problem are linked by these chains. Each chain is expressed in a separate matrix and these resulting matrices are called stochastic matrices or transition matrices.

$Q=[q_1,q_2,\ldots,q_n]$ is the initial probability distribution vector for the Markov chain.

When the state space is finite in the form of $S = \{0,1,2,\ldots .., n\}$, the transition probability matrix for the Markov chain is written as follows:

$$P = [P_{ij}] = \begin{bmatrix} P_{11} & P_{12} & P_{13} \cdots & P_{1n} \\ \vdots & & \ddots & \vdots \\ P_{n1} & & \cdots & P_{nn} \end{bmatrix} \tag{5}$$

The formula used to calculate the elements of the transition probabilities matrix is given below(Kıral, 2018).

$$P_{ij} = n_{ij} / \sum n_{ij} \quad (6)$$

Markov chain theory is widely used in brand preferences or brand loyalty applications, in finding short or long term preference possibilities of brands. In Markov chain theory, the reason why a consumer who is currently using the X brand is likely to use the X brand again is not known.

If the reason for preference is not important for the researcher, the desired answer can be found using the Markov chain theory. If the reasons for preference are asked to be questioned, then the Markov chain structure will be insufficient. Therefore, in case of a more detailed research, the Hidden Markov Model theory is used. Considering the reasons for preference, the Markov chain theory is insufficient and the Hidden Markov Model, which investigates the reasons for preference due to its internal dynamics, constitutes the main idea of this study (Can and Öz, 2009).

3.3. Classification Of States In The Markov Chain

While analyzing the transitions and their structure in the Markov chain, classifying them according to certain properties in the Markov chain will create an easy situation for subsequent behavior. (Öztürk, 2012).

Classifying the states of a Markov chain according to certain properties will make it easier to determine the next behavior of the chain. Definitions on the subject are given below (Cinemre, 2003):

- The sequence of transitions from two states such as *i* and *j*, starting at *i* and ending in *j* and each having positive probability of occurrence is called a path.
- If the probability of transition from state *i* to *j* state after a certain period is positive, state *j* is called accessible state from *i*.
- If *j* can be accessed from *i* and *i* from *j*, then *i* and *j* are called connected states.

- A set of interconnected states is called a set of equivalence.
- If it is not possible to reach any state outside *S* from any state of the state space *S* of a Markov chain, *S* is a closed set.
- If the probability of leaving a state is zero P_{ij} = 0 or it is impossible to leave a state after entering it, so if P_{ij} = 1, i is an absorbing state.
- If the probability of not returning to the same state after a certain period when starting from state *j* is greater than zero, then *j* is called transition state.
- If *i* is not a transition state, then *i* is called a regenerative state. From a regenerative state, only regenerative states can be accessed.
- Suppose the chain starts in state *j*. If it returns to *j* only at times *t, 2t, 3t*,…, then j is called a cyclic (periodic) state with the *t* cycle (period).
- The Markov chain, whose all states form a closed set, is called the irreducible Markov chain.
- If the states that make up a Markov chain are all regenerative, not cyclical and interconnected, then the chain is ergodic.
- Except the transition states, if all states of Markov chain are absorbing, cyclic or a closed set states these chains are called reducible Markov chains. The Markov chain containing more than one set of equivalence is a reducible Markov chain. If all states of a Markov chain are ergodic then the chain cannot be reduced (Taha,2000).
- If a Markov chain has at least one absorptive state and it is possible to reach at least one absorptive state from all non-absorptive states, then the Markov chain is the absorber Markov chain.

3.3.1. Situation Probabilities

States space of a system *S* = {1,2,…, N } and the probability being in state i in the beginning of the system are shown as

$$P(X_0 = \text{i}) = \pi_i(0) = \pi_i \tag{7}$$

and

$$\pi(0) = (\pi_1(0),\ \pi_2(0),\ \pi_3(0),\ .....,\ \pi_N(0)) \tag{8}$$

vector is called the vector of initial state probabilities (Öz, 2009).

P_{ij} , shows the probability that a process that is in state *i* at time *t* is *j* in time *t + 1*. When the system is in state *i* at time *m*, the probability of being in state *j* after *n* steps is denoted as $P_{ij}{}^{n}$. This is the *n*-step transition probability. This *n* step transition probability is shown as follows:

$$P_{ij}{}^{n} = P\,(\,X_{n+m} = X_m = i\,) = P\,(X_n = j \setminus X_0 = i\,)\,,\ \ i,j \in S \tag{9}$$

Chapman-Kolmogorov equation is used to calculate *n*-step transition probability matrices. (Öz, 2009).

$$P_{ij}{}^{n+m} = \sum_{k=0}^{\infty} P_{ik}{}^{n} P_{kj}{}^{m} \tag{10}$$

for all $n,m \geq 0$ and all *i, j*.

3.3.2. Ergodic Markov Chains

The concepts of transition from one state to another state or not in the theory of Markov chains are extremely important as they give an idea about the Markov chain due to the structures of the states (Can, 2006).

A Markov chain where transition from each state to all other states is possible is called an ergodic chain.

There is no obligation to go from any situation to any other situation in one step. The important thing is the condition of getting from one situation to another, even if indirectly. In other words, it should be possible to switch between states.

Another matrix closely related to the fact that a Markov chain is an ergodic chain is a regular matrix.

If there is a positive integer of *k* in the way that all elements of a Markov transition probabilities matrix or all elements of P^k matrix are positive, *P* matrix is called regular matrix (Jacques Jansen and Raimondo Manca, 2007).

In other words, it is possible to go from one state to any state in exactly *n* steps for any *n* forces. In this case, it can be concluded that every regular chain is ergodic, but not every ergodic chain is regular.

3.3.3. Fixed Markov Chains

The equation *P* requires that all the columns of the transition probability matrix are 1.
or

$$P' .1=1 \tag{11}$$

is the vector of 1s in dimension 1 (Nx1). This equation shows that the identity matrix is the eigenvalue of the *P'* matrix and the (Nx1) dimensional 1 vector is the eigenvector. Since a matrix and its transpose have the same eigenvalues, the eigenvalue of the *P'* matrix assumes that the eigenvalue of the *P* matrix is unit and the other eigenvalues are inside the unit circle, and the Markov chain is said to be stationary (ergodic). Stationary probabilities for the stationary Markov are shown as the vector π of dimension (Nx1).

$$P.\pi=\pi \tag{12}$$

condition is attained. As sum of π eigenvalue vector's elements equals 1, π vector is said to be normalized and it is shown as: (Hamilton, 1994)

$$\lim_{n\to\infty} pm = \pi.1' \tag{13}$$

3.3.4. Periodic Markov Chains

If the Markov chain is not reducible, then there is only one eigenvalue equal to units. But there can be more than one eigenvalue on the unit circle, which means that not all reducible Markov chains are ergodic. For instance, suppose $P_{11} = P_{22} = 0$ in two-state Markov chain:

$$P = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \tag{14}$$

Both transition probability matrix eigenvalues $\lambda_1 = 1$, $\lambda_2 = -1$ are over unit circle. Thus, P^m matrix hasn't converged to a stationary value of the vector $\pi.1'$. Instead, it is clear that if the

system is in the first state at time t, it will be in the first state even when m goes to infinity at times *t + 2, t + 4, t + 6,* ..... . It is called two state Markov chain (Hamilton, 1994).

3.3.5. Equilibrium State Probabilities

In Markov analysis, the process is in equilibrium at the end of the long term and reaches a stationary condition. In this direction, strong and effective comments can be made about the future of the process.

If a v = (v_1 , v_2 , v_3 , …, v_m) vector doesn't have a negative component and $\sum_{i=1}^{m} v_i$ equals to 1 *v* vector is called probability vector (Cerit and Yüksel, 1993). As can be seen in the powers of *P*, as *n* grows, the values of P_{ij} approach a constant number or limit and the probability vectors $v_i{}^{m}$ tend to be equal for all values of *i*. As a result, two rules occur (Halaç, 1991).

i. The probability vectors $v_i{}^{m}$ for sufficiently large values of *n* are the same for all values of *i*.

For

$$v_i{}^{n+1} = v_i{}^{n} P \tag{15}$$

and

$$v_i{}^{n+1} = v_i{}^{n} \tag{16}$$

there is an equilibrium vector *V* equal to *V.P=V* equation (Gardy and Mokkadem, 2000).

ii. The correlation $V = \sum_{j=1}^{m} P_{ij} = 1$ provides an analytical method for obtaining these values. If *j*, elements are shown with v_j in the probability vector *V*, as *V* is a probability vector,

the correlation

$$\sum_{j=1}^{m} V_j = 1 \tag{17}$$

is valid. From number ii rule,

$$v = (v_1 , v_2 , v_3 , \ldots, v_m)\ P = [v_1 , v_2 , v_3 , \ldots, v_m] \tag{18}$$

is written. For a given stationary Markov chain *P* transition probabilities matrix, there is only

$$v = (v_1 , v_2 , v_3 , \ldots, v_r) \tag{19}$$

distribution of fixed probability and it is written a statement for P^n as below:

$$\lim_{n\to\infty} P_{ij}{}^{n} = v_j \quad v_j > 0 , 1 \le j \le r . \tag{20}$$

3.3.6. Continuous-Time Processes

Markov chains is a method often used to express stochastic processes. In Markov models, time parameters are divided into discrete time Markov process and continuous time Markov process (Marshall and Sterritt, 2005).

If $\{ X_t \}$ is shown with a stochastic continuous-time process:

In this line, $\{ X_t \}$ is an infinite set of random variables indexed with the continuous real variable t. In general, as the index t is considered as the time index, X_{t_1} random variable is the process state at time t_1 and X_{t_1} random variable, in condition of $t_0 < t_1$, is based on the process state at time t_0 , in other words, depends on X_{t_0} random variable. It is independent from previous situations. They are considered as X_{t_1} discrete random variables. In this case, the structure to be examined is discrete-state continuous-time stochastic processes.

For state-space S = $\{x_0 , x_1 , x_2 , ..., x_n \}$ and each of $t_0 , t_1 , \ldots, t_{n-1} , t_n$ real values that gives the condition $t_0 < t_1 < \ldots < t_{n-1} < t_n$, if

$$\mathrm{P}\,(X_{t_n} = x_n \,|X_{t_{n-1}} = x_{n-1} , \ldots, X_{t_0} = x_0) = \mathrm{P}\,(X_{t_n} = x_n \,|X_{t_{n-1}} = x_{n-1}) \tag{21}$$

Correlation is confirmed, it is said that the process has Markov property. Generally speaking, it will be a continuous time Markov process. When you pay attention, the future state of the process depends only on the present moment. It is independent of all past situations.

$$\mathrm{P}\,(X_{t_n} = x_n \,|X_{t_{n-1}} = x_{n-1}) \tag{22}$$

probability is the transition probability, as in the discrete time Markov chain. But there is only one difference, t time index is not necessarily an integer. In other words, while the state at time t_n depends upon x_n , the state at time t_{n-1} is up to x_{n-1} (Can, 2006).

4. HIDDEN MARKOV MODEL

Firstly, the theoretical infrastructure of the Hidden Markov Model was mentioned in the studies of Baum and Petrie (1966), Baum and Eagon (1967), Petrie (1969) and Baum (1972), and Rabiner (1989), speech recognition, Bing and Ding (2000) , character recognition, Ryden, Terasvirta and Asbrink (1998) found application areas in economics, molecular biology, biochemistry, tissue analysis and various subjects including stock profit changes (Fuh, 2003).

The Hidden Markov Model has a structure that includes the initial state probabilities and transition probabilities matrix of the Markov chains, as well as the observation probabilities. In the Markov chains theory, the state of the system is known, while in the Hidden Markov Model the state of the system is unknown. However, while the system is in any state, an observation occurs depending on the transition probabilities and this observation is known (Ewens and Grant, 2005). Not knowing the states in the transition probability matrix adds hidden meaning to the model. The probabilistic values of the observations that will occur while the system is in any state are given by the observation probability matrix.

In Markov chains, the status of the transition probability matrix in brand preferences or brand loyalty applications are accepted as brands and the preference possibilities of these brands in the short or long term are determined. In the Hidden Markov Model, situations are considered to be confidential. As the system switches between hidden states, an observation occurs at each step (Steeb et al., 2005). Therefore, in the Hidden Markov Model, the observations are known and the situations are not known directly. Observations occurring in hidden situations in the model correspond to the physical outputs of the system under investigation (Dönmez, Alp, 2019).

An Hidden Markov Model is expressed as follows:

- Situations are denoted by *N*. Generally, the situations are linked in themselves from one situation to another.

$$S = \{S_1 , S_2,\ldots, S_N\}$$

is situations cluster ve q_1 is the situation at time *t* .

- The number of observations for each situation is indicated by *M*. Observations are a dashed cluster.

Observation cluster is shown by

$$V = \{ V_1, V_1, \dots, V_M \}.$$

Observations depend on the state the system is in at the time of observation. Therefore, it is independent from the previous observation. (Schliep vd., 2004).

- Distribution of state transition probability is $A = \{a_{ij}\}$. $1 \le i, j \le$ N için a_{ij} numbers are non-negative numbers and *A* is a matrix in dimension of N×N, the sum of the values in each row of the matrix equals to 1 separately.

State transition probabilities shown in this direction do not change over time and these possibilities are independent from observations. (Bhar and Hamori, 2004).

- Distribution of observation probability is $B = \{b_j(k)\}$. This statement gives the probabilty of v_k observation when it is in the state *j* at time *t*.

For

$$1 \le \text{j} \le N, 1 \le \text{k} \le M, \ b_j(k)s$$

express non-negative numbers. *B* is a matrix in dimension of $N \times M$ and the sum of the values in each row equals to 1 separately.

- Distribution of initial state is denoted as $\pi = \{\pi_i\}$. The probability that the system is in S_i state at the time of startup is as follows (Bicego and Murino, 2004).

$$\pi_i = P [q_1 = S_i] , 1 \le i \le N \qquad (23)$$

For suitable values of *N*, *M*, *A*, *B* and π, by using Hidden Markov Model, $O=O_1O_2 \dots O_T$ observation series are created. *T* as the number of observations, each O_T observation becomes one of the observations $\{v_1, v_2, \dots, v_M\}$ (Rabiner, 1989).

In order to use the Hidden Markov Model in the application areas, three problems expressed as "Three Basic Problems of the Hidden Markov Model" in the literature need to be solved.

4.1. Three Basic Problems Of The Hidden Markov Model

The probability of occurrence of any observation or observation series in the future in the Hidden Markov Model is considered as the "First Problem" of the Hidden Markov Model, if the prediction of the hidden state or hidden state sequence underlying any observation or observation sequence is the "Second Problem" of the Hidden Markov Model, and finally, any observation or observation series. Re-determining the model parameters to maximize the probability of occurrence of the sequence sequence is called the “Third Problem” of the Hidden Markov Model. All these problems and their solution algorithms are expressed as "Three Basic Problems of the Hidden Markov Model ".

In order for the Hidden Markov Model to be used in real applications, three basic problems must be solved. These problems are based on what the probability of observation will be, how to estimate the hidden state sequence and how to reconstruct model parameters. The contents of these problems are briefly given below.:

Problem 1: For $\lambda = (A,B,\pi)$ parameters given in a Hidden Markov Model and $O=O_1O_2 \dots O_T$ sequence of observation, $P(O\backslash \lambda)$ shows how to calculate the probability of the observation sequence effectively. This problem is called an evaluation problem. It is a situation related to how the probability of generating the observation series by the model for the given model and the sequences of observations is calculated. In addition, this problem can be seen as the problem of how much a given model matches a given observation sequence. (Öz, 2009).

Problem 2: For the given observation sequence $O=O_1O_2 \dots O_T$ and model λ, it is how to determine state sequence $Q=q_1q_2 \dots q_T$ that explains these observations in the most correct way. The second problem is that the hidden state of the model is revealed, in other words, the correct state sequence is found. State sequences are determined depending on the number of

situations in the model. The second problem is to determine the most suitable of these sequences. Viterbi Algorithm is used to solve this problem. In the Viterbi Algorithm, which is a dynamic programming application, there is the optimal transition probability sequence in the state diagram for a given observation sequence. (Lou, 1995).

Problem 3: It is how to change the model parameters $\lambda = (A,B,\pi)$ to maximize probability of $P(O\backslash\lambda)$. This problem optimizes model parameters to best describe how a given set of observations is obtained. Since the observation series is used to re-determine model parameters, this process is called "Training". In the literature, this problem is generally included as "Training Problem". Basically, Baum-Welch Algorithm, which is an iterative process, is used to estimate the parameters (A, B,π) of the Hidden Markov Model during the training phase (Karlsson, 2004).

4.2. Solution For Three Basic Problems Of Hidden Markov Model

The algorithms commonly used for the three basic problems of the Hidden Markov Model are given below:

4.2.1. The Solution of Problem 1

For a given λ model, $O=O_1O_2 \ldots O_T$ probability of observation sequence the calculation of $P(O\backslash\lambda)$ being the probability of $O=O_1O_2 \ldots O_T$ observation sequence is overviewed here. The simplest method for this calculation is to number all possible states of length T. When q_1 shows initial state the sequence of the stationary state is shown as below:

Observation sequence O probability for the equation

$$Q = q_1 q_2 q_3 \ldots q_T \tag{24}$$

It is written as

$$P(O|Q,\lambda) = \prod_{t=1}^{T} P(O_T\backslash q_T,\lambda) \tag{25}$$

Assuming that the observations are statistically independent from each other, the following statements can be written:

$$P(O\backslash Q,\lambda) = b_{q_1}(O_1).\, b_{q_2}(O_2)\ldots..\, b_{q_T}(O_T) \tag{26}$$

The probability of such a sequence of states *Q* is expressed as:

$$P(Q|\lambda) = \pi_{q_1} a_{q_1 q_2} a_{q_2 q_3} \ldots a_{q_{t-1} q_t} \quad (27)$$

The probability of occurrence of *O* and *Q* sequences at the same time is expressed as the combined probability of *O* and *Q*.

$$P(O, Q\backslash \lambda) = P(O\backslash Q, \lambda).\ P(Q\backslash \lambda) \quad (28)$$

In the given model, the probability *O* is obtained by summing this combined probability over all possible sequences of states *q*.

$$P(O|\lambda) = \sum_{all\ Q} P(O|Q, \lambda).P(Q|\lambda) \quad (29)$$

$$P(O|\lambda) = \sum_{q_1, q_2, \ldots, q_T} \pi_{q_1}\, b_{q_1}(O_1) a_{q_1 q_2} b_{q_2}(O_2) a_{q_2 q_3} \ldots b_{q_T}(O_T) a_{q_{T-1} q_T} \quad (30)$$

The explanation of the equation above is like:

In the beginning, system *t = 1* is in the state of q_1 with the probability π_{q_1} and in this situation, it makes the observation O_1 with the probability $b_{q_1} O_1$. Passing from time *t* to time *t+1*, by passing from the state *(t = 2),* q_1 to the state q_2 with the probability $a_{q_1 q_2}$, it is obtained the observation O_2 with the probability $b_{q_2}(O_2)$ in the state q_2. The process continues until O_T observation is gained with $b_{q_T}(O_T)$ probability by passing with $a_{q_{t-1} q_t}$ probability from q_{T-1} to q_T at time *T*.

Since there are *N* cases in $O=O_1 O_2 \ldots O_T$ observation sequence, N^T number different state sequences can be $Q=q_1 q_2 q_3 \ldots q_T$. For calculating *P(O\ λ)* in line with its direct definition, it is needed *(2T-1)* N^T number multiplication and N^T-1 number addition (Öz, 2009).

A more effective method was needed to solve the Evaluation Problem, which is the first problem of the Hidden Markov Models. This method developed is called the back and forth

method in the literature and is less complex than direct calculation. This method can be handled in two ways, forward and backward. (Semerci,2006).

4.2.1.1. Forward/Backward Direction Algorithm

For the solution of the first problem, forward and backward direction algorithms are used. *P(O | λ)* probabilities calculated by both algorithms give the same result.

The Forward-Direction Algorithm calculates the probabilities of the observed situations from beginning to end according to a given model. The Backward direction algorithm calculates the same probabilities by running the model in the opposite direction.

Forward-Direction algorithm handles observations in a chain sequence one after the other. After handling the observations at time *t*, it computes the distribution of conditional states repeatedly.

Forward-direction variable is defined as $a_i = P\ (O_1 O_2 \dots\ O_t\ ,\ q_t = S_i \mid \lambda\ )$ and it is expressed as the probability of the partial observation sequence $O_1 O_2 \dots\ O_t$ of the system in S_i state at a time *t*. The Forward-Direction algorithm consists of 3 steps. These steps can be given as follows:

- The algorithm is started by calculating the probability of occurrence of O_1 observation for all cases at the start time.

$$a_1(i) = P\ (O_1 q_1 = S_i \mid \lambda) = P(O_1 \mid q_1 = S_i\ ,\ \lambda)\ P(\ q_1 = S_i \mid \lambda) \tag{31}$$

$$a_1(\mathrm{i}) = \pi_i b_i(O_1)\ ,\ t = 1\ ,\ i=1,\dots,N \tag{32}$$

- The transition from all D_i states to D_j at time *t+1* at any time *t* is calculated with variable a_{t+1} (j)

$$a_{i+1}\ (\mathrm{j}) = [\textstyle\sum_{i=1}^{N} a_t(i) a_{ij}]\ b_j(O_{i+1}\ )\ ,\quad t = 1,\dots,T\text{-}1\ ,\ j=1,\dots,N \tag{33}$$

- *P (O| λ)* probability taken in the last step is given as the sum of Forward Direction variables.

$$P\,(O|\,\lambda) = \sum_{i=1}^{N} P(O, q_t = S_i|\,\lambda) = \sum_{i=1}^{N} a_t(i) \tag{34}$$

The Back-Direction algorithm is a second way to solve the evaluation problem. It starts by defining the Back-Direction probability variable $\beta_t(i)$ as follows:

$$\beta_T(i) = P = [O_{i+1}\,, O_{i+2}\,, \ldots, O_T|\,S_i\,, \lambda\,] \qquad i= 1,\ldots,T \;\; S_i \in S \tag{35}$$

- At the start, for all *i* values, $\beta_T(i)$ values are accepted as 1.

$$\beta_T(\mathrm{i}) \;\; i = 1,\ldots,N$$

- Recursion:

$$\beta_T(\mathrm{i}) = \sum_{j=1}^{N} a_{ij} b_j(O_{t+1}) \qquad i = 1,\ldots,N \;\; t = T\text{-}1\,, T\text{-}2, \ldots, 1 \tag{36}$$

4.2.2. The Solution of Problem 2: Viterbi Algorithm

Viterbi algorithm is also defined as the parsing problem. This algorithm aims to reveal the optimum sequence of states that occur under the observed symbols.

This algorithm is used to find the best case sequence that will maximize the *P* * probability. The operation steps of the Viterbi algorithm are given below:

To find the best hidden state sequence $Q = \{q_1 q_2 \ldots q_t\}$ of observation sequence $O = \{O_1 O_2 \ldots O_t\}$

$$\delta_t(i) = \max_{q_1, q_2, \ldots, q_{t-1},} P[q_1 q_2 \ldots q_t = i\,, O_1 O_2 \ldots O_t|\lambda\,] \tag{37}$$

expression is defined. $\delta_t(i)$ shows the highest probability of the process that is in S_i state at time *t* along the path followed until time t. The expression $\delta_{t+1}(j)$ is obtained by applying the induction method to the variable $\delta_t(i)$.

$$\delta_{t+1}(j) = [\max_{i} \delta_t(\mathrm{i}) a_{ij}]\, b_j(O_{t+1}) \quad (38)$$

To access the real state array, the argument that maximizes the expression $\delta_{t+1}(j)$ needs to be followed. This process is shown by $\psi_t(j)$

- Start

$$\delta_1(i) = \pi_i \mathrm{b}_i(\mathrm{O}_1) \quad , 1 \le i \le N \quad (39)$$

$$\psi_1(i) = 0 \quad (40)$$

- Recursion

$$\delta_t(j) = \max_{1 \le \mathrm{i} \le \mathrm{N}} [\delta_t(i) a_{ij}]\, b_j(O_t) \quad , \quad 2 \le t \le T \,,\, 1 \le i \le N \quad (41)$$

$$\psi_t(j) = \operatorname*{argmax}_{1 \le \mathrm{i} \le \mathrm{N}} [\delta_{t-1}(i) a_{ij}] \quad , 2 \le t \le T \,,\, 1 \le i \le N \quad (42)$$

- Termination

$$P^* = \max_{1 \le \mathrm{i} \le \mathrm{N}} [\delta_T(i)] \quad (43)$$

$$q_t^* = \operatorname*{argmax}_{1 \le \mathrm{i} \le \mathrm{N}} [\delta_T(i)] \quad (44)$$

- Path (State Sequence) backtracking

$$q_t^* = \psi_{t+1}(q_{t+1}) \quad , \quad t = T-1, T-2, \ldots, 1 \quad (45)$$

4.2.3. The Solution of Problem 3: Baum-Welch Algorithm

For the Baum-Welch algorithm, the term forward / backward direction algorithm is also used. For the model λ and for any sequence of observations, at time t in case S_i and $t+1$ instant S_j the probability of being in the state is represented by the variable $\xi_t(i, j)$.

$$\xi_t(i,j) = P(q_t = S_i, q_{t+1} = S_j | O, \lambda) \tag{46}$$

Using the definitions of forward-backward direction variables, $\xi_t(i,j)$ can be written as:

$$\xi_t(i,j) = \frac{a_t(i) a_{ij} b_j(O_{t+1}) \beta_{t+1}(j)}{P(O|\lambda)} \tag{47}$$

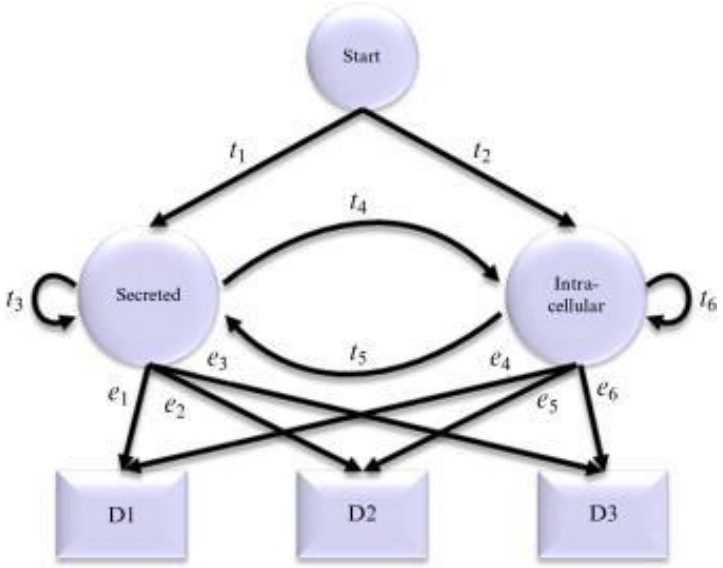
For a given set of observations and models *S* at time *t* probability of being when denoted by $\gamma_t(i)$ the following relation between $\gamma_t(i)$ and $\xi_t(i,j)$ can be written:

$$\gamma_t(i) = \sum_{j=1}^{N} \xi_t(i,j) \tag{48}$$

The equations expressed above are used to re-estimate Hidden Markov Model parameters. The new parameters are indicated by *(A,B,π)*. The equations used for the estimation of the *(A,B,π)* parameters are given below:

$$\overline{\pi_\iota} = \gamma_1(i), \overline{a_{\iota J}} = \frac{\sum_{t=1}^{T-1} \gamma_t(i,j)}{\sum_{t=1}^{T-1} \gamma_t(i)}, \overline{b_J}(k) = \frac{\sum^{T}_{t=1 \quad o_t = v_k} \gamma_t(j)}{\sum_{t=1}^{T} \gamma_t(j)} \tag{49}$$

4.3. Emission Matrix



Source: Kıral, 2020

Figure 4.1. Hidden Markov Display

The figure given above is a basic expression of the Hidden Markov Model. The D's (D1, D2, D3) in the image indicate the observations that may occur after the system becomes certain, and the e's (e_1, e_2, e_3, e_4, e_5, e_6) indicate the possibilities of these observations, in other words, the emission probabilities. The t's (t_1,t_2, t_3, t_4, t_5, t_6) in the image represent the transition probabilities from one state to another in the Hidden Markov Model. In the hidden Markov model, transition states from events to another event and from these events to investigations are transferred with emission and transition probabilities and the hidden states in the model are found by multiplying the transition and emission probabilities.

5. APPLICATION ON FAST-FOOD BRAND PREFERENCES

In the study, a questionnaire about fast food brand preferences was applied to 455 university students. However, during the applying stage of the poll, because of the Covid 19 outbreak, the surveys were applied online, not face-to-face, in order to avoid risky situations. With the data obtained from the surveys, the next fast food brand preferences of university students were estimated by the Markov chain analysis method, and the reasons for their preference were examined by the Hidden Markov Model method. Furthermore, after the brand preferences were estimated, the transition probability matrix was created and the brand loyalty of university students was calculated by calculating the long-term equilibrium vectors.

Markov analysis is based on the mathematical modeling of the arbitrary motions of gas molecules in a closed box known as Brownian motion by the Russian mathematician Andrey Markov in the early 20^{th} century. The mathematical structure of the Markov process was correctly established by the American mathematician Norbert Wiener for the first time in 1923. The general theory of Markov processes was developed in the 1940s by A. N. Kolmogorov (1948) and W. Feller (1949) (Öztürk, 2012).

Markov chains have applications in many different fields. Markov chains have had the opportunity to be applied in special fields of social sciences such as production, economy, finance, marketing and management (Ayaz and Alp, 2018). Firms use Markov processes to determine their market shares and analyze the impact of brand loyalty in their market (Kotler, 1993). Social and personal factors affect the purchasing decisions of customers in today's marketing approach. For this reason, brands have to approach customers in a more systematic way in order to make fast and correct decisions. Brands in various sectors must apply some models and techniques in order to gain an advantage over their competitors. Markov chains are one of these models (Ercan, 2020).

Markov chains technique is used in the study because it has many advantages in terms of predicting future situations. Markov chains can be defined as the situation in which an event or action expected to occur in the future depends only on the current situation, not on past events (Alp and Karaca, 2017). In the study, the fast food brand that will be preferred in the

future depends only on the last preferred fast food brand, and this situation shows us the Markov feature.

The required sample size of the data obtained in the study was calculated using the following formula:

$$n = \frac{z^2 p(1-p)}{e^2} \quad \text{(Smith,2013)} \qquad (50)$$

n: Required Sample Size

z: Standart Error

p: Variability/ Standard Deviation

e: Required Maximum Percentage of Error (Taherdoost, 2016)

While calculating the sample size in the study, variability (p) was 0.5, standard error (z) was 1.96, and required maximum percentage of error € was 0.05. When these values are substituted in the equation, the resulting sample size is as follows:

$$\frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} \approx 384$$

As seen in the expression above, the sample size required for 95% confidence level and ± 5% precision was found to be 384.In line with the results obtained, although the survey about fast food brand preferences of 384 university students and the factors affecting these preferences was sufficient, more university students were surveyed in order for the study to yield more accurate and reliable results.

Below, in the survey conducted with 455 university students, the fast food brands visited by the students are given in a table. If these students have not visited any of the fast food brands in the survey before, this situation was determined as none.

Table 5.1. Fast Food Brands

Item No	**Fast Food Brands**
1	None
2	Burger King
3	Popeyes
4	Mc Donald’s
5	KFC
6	Sbarro
7	Dominos
8	Arby’s
9	Pizza Hut
10	Subway
11	Other

The order numbers of the fast food brands in the survey are shown in Table 5.1.

5.1. Determining the Next Fast Food Brand Preferences Using the Markov Chain Method

Table 5.2. The Transition Matrix

		Next Fast Food Brand to Be Preferred										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
The Last Preferred Fast Food Brand	**1**	21	5	1	3	4	0	2	0	1	0	1
	2	5	103	11	6	11	4	16	4	0	1	4
	3	1	3	19	4	5	0	4	0	0	2	0
	4	2	10	3	37	6	0	5	0	0	1	1
	5	2	7	1	2	28	0	1	2	1	0	0
	6	2	0	0	1	1	3	1	0	1	1	0
	7	1	11	2	2	4	0	15	0	0	2	3
	8	2	1	1	1	0	0	0	1	0	0	0
	9	1	2	0	0	0	0	1	0	3	0	1
	10	2	0	0	2	0	0	0	1	0	1	0
	11	3	2	3	5	8	2	1	0	0	0	11

In Table 5.2., the Markov transition matrix was created with the help of the data obtained from the questionnaire.

The numbers showing the rows in generated the transition matrix are the fast food brands in Table 5.1. and show the previous fast food brand preferences. The numbers showing the columns are the fast food brands in Table 5.1., and show the next fast food brand preferences. The point where any column and row intersect gives the number of passes from the previous preferred fast food brand to the next fast food brand that is considered to be preferred.

Table 5.3. Transition Probability Matrix

		Next Fast Food Brand to Be Preferred										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
The Last Preferred Fast Food Brand	**1**	0,5526	0,1315	0,0263	0,0789	0,1052	0	0,0526	0	0,0263	0	0,0263
	2	0,0303	0,6242	0,0666	0,0363	0,0666	0,0242	0,0969	0,0242	0	0,0060	0,0242
	3	0,0263	0,0789	0,5	0,1052	0,1315	0	0,1052	0	0	0,0526	0
	4	0,0307	0,1538	0,0461	0,5692	0,0923	0	0,0769	0	0	0,0153	0,0153
	5	0,0454	0,1590	0,0227	0,0454	0,6363	0	0,0227	0,0454	0,0227	0	0
	6	0,2	0	0	0,1	0,1	0,3	0,1	0	0,1	0,1	0
	7	0,025	0,275	0,05	0,05	0,1	0	0,375	0	0	0,05	0,075
	8	0,3333	0,1666	0,1666	0,1666	0	0	0	0,1666	0	0	0
	9	0,125	0,25	0	0	0	0	0,125	0	0,375	0	0,125
	10	0,3333	0	0	0,3333	0	0	0	0,1666	0	0,1666	0
	11	0,0857	0,0571	0,0857	0,1428	0,2285	0,0571	0,0285	0	0	0	0,3142

In Table 5.3., there is the Markov transition probabilities matrix, which is determined in the Markov transition matrix (Table 5.2.) and is formed by considering the number of transitions from any fast food brand to another fast food brand. Markov transition probability matrix; It is created by dividing the number in each cell of the transition matrix by the total value of the row in which it is located.

Markov transition probabilities matrix given in Table 5.3. shows the next preference rates of each fast food brand by university students. The diagonal elements of the Markov transition probability matrix show the university students' loyalty to fast food brands, that is,

the situation where the previous preferred fast food brand and the next preferred fast food brand are the same.

Looking at the transition probability matrix in Table 5.3., the probability of university students choosing the same brand in their next fast food brand preferences, in other words, their loyalty to the brand, respectively, 63% KFC, 62% Burger King, 56% McDonalds, 55% None, 50% Popeyes, 37% Dominos, 37% Pizza Hut, 31% Other, 30% Sbarro, 16% It was seen that it was in the form of Arby's at the rate of 16% and Subway at the rate of 16%.

Table 5.4. Initial Probability Vector

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
0,0835	0,3626	0,0835	0,1428	0,0967	0,0219	0,0879	0,0131	0,0175	0,0131	0,0769

Table 5.4. shows the initial probability vector. The initial probability vector was found by calculating the ratio of the sum of rows in the transition matrix to the number of university students participating in the survey.

The stationary values in the analysis part of the study are obtained by multiplying the initial probability vector in Table 5.4. with the Markov transition probability matrix consecutively until the stationarity is reached. The multiplication process continues until stationarity is reached in the initial probability vector. In this study, it was observed that the initial probability vector was fixed at the end of 13 periods. In other words, stability has been achieved at the end of 13 periods.

Table 5.5. Equilibrium (Fixed) Vector

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
0,1048	0,2894	0,0880	0,1329	0,1986	0,0125	0,0982	0,0227	0,0136	0,0175	0,0304

Table 5.5., shows the Equilibrium (Fixed) Vector. When looking at the Equilibrium (Fixed) Vector, it is seen that the most preferred brand is Burger King with 28%, and according to the top three preferences, Popeyes and Mc Donalds follow the Burger King brand, respectively. It is seen that the rate of not selecting any brand is 10%. On the other hand, it can be said that KFC, Dominos, Arby's, Subway brands are among the brands that increase the preference

possibilities, while Sbarro and Pizza Hut brands are among the brands that reduce the possibility of preference.

5.2. Determining the Reasons for Fast Food Brand Preference of University Students by Using the Hidden Markov Model

Table 5.6. Data on Survey Participants

Variables	Groups	Percent	Variables	Groups	Percent
Gender	Women	% 59.5	Amount Spent on Monthly	100 TL and less	% 17.3
	Men	% 40.5	Fast Food Consumption	101-500 TL	% 55.6
			(Outside of Home)	501-1000TL	% 17.6
				1001-2000 TL	% 6.3
				2001-6000 TL	%1.1
				Other	%1.99
Range of Age	10-20	% 33.8	Amount Spent on Monthly	0-500 TL	% 87
	21-30	% 46.6	Fast Food Consumption	501-1000 TL	% 8.4
	31-40	% 12.7		1001-3000 TL	% 1.6
	41-51	% 6.4		Other	% 3
	Other	% 0.5			
Education Level	Associate	% 6.8			
	Undergraduate	% 63.3			
	Postgraduate	% 29.5			
	Other	% 0.4			

Information on the university students who participated in our study is given in Table 5.6. When the information given in Table 5.6. was examined, it was determined that 59.3% were women and the rest were men. The age range of the participants was mostly between the ages of 46.6% and 21-30, followed by the age range of 10-20 with 33.8%. It is seen that 63.3% of the students are undergraduate. The amount (TL) spent on monthly out-of-home food consumption was 101-500 TL with 55.6%, and the amount (TL) spent on monthly consumption of fast food was found to be 0-500 TL with 87%.

To the 455 students participating in the survey; "Which fast food brand did you preference from last time?", "What is the most important reason why you preferred the fast food brand you went to last time? What was the most important reason for you to choose your last

preferred fast-food brand?", "Which brand do you want to preference for your next fast food preference?" What is the most important reason for you to prefer? "questions were asked, and according to the answers obtained, the transition probability matrix and emission matrix were created.

Table 5.7. The Reasons Why Fast Food Brands Are Preferred by University Students

Symbol	**Reason For Fast Food Brand To Be Preferred**
D1	Hygiene
D2	Price
D3	Campaings
D4	Menu Contents
D5	Used Ingredients
D6	Atmosphere \ Decor
D7	Food Quality
D8	Location/Accessibility
D9	Service Speed
D10	Staff Attitude
D11	Other

Transition probability matrix was established by using the previous and next preference reasons for fast food brand preference reasons. Brand preference reasons are shown in Table 5.7.

Di's shows Hidden Markov Model states. (i=1,2,…,11)

Table 5.8. Transition Number Matrix

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
D1	19	0	3	2	0	0	2	0	0	0	0
D2	2	25	7	3	0	2	1	0	0	0	0
D3	4	9	16	5	2	0	9	1	0	0	0
D4	7	8	9	73	12	0	9	2	3	0	0
D5	1	0	0	2	13	0	6	0	0	0	0
D6	0	0	0	0	0	4	0	0	0	0	0
D7	9	4	1	5	2	0	94	0	1	1	0
D8	3	3	3	7	5	1	7	17	0	0	0
D9	2	0	0	2	0	0	7	1	4	1	1
D10	0	0	0	0	0	0	0	1	0	2	0
D11	1	0	0	0	0	0	0	0	0	0	9

The transition number matrix was created in Table 5.8. with the data obtained from the survey. The cell where the row intersects with any column in Table 5.8. shows the number of passes. These cells were created with the data showing the reason for choosing the fast food brand, which is considered to be the next preferred fast food brand.

For example, if hygiene is the last fast food brand that students prefer, and the fast food brand they think they will prefer next, the campaigns were switched from D1 to D3. In addition, there are 7 students who chose the previous fast food brand (D2) because of the price and will choose the fast food brand they think they would prefer next because of the campaigns (D3).

Table 5.9. Transition Probability Matrix

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
D1	0,7307	0,0000	0,1153	0,0769	0,0000	0,0000	0,0769	0,0000	0,0000	0,0000	0,0000
D2	0,05	0,625	0,175	0,075	0,0000	0,05	0,025	0,0000	0,0000	0,0000	0,0000
D3	0,0869	0,1956	0,3478	0,1086	0,0434	0,0000	0,1956	0,0217	0,0000	0,0000	0,0000
D4	0,0569	0,0650	0,0731	0,5934	0,0975	0,0000	0,0731	0,0162	0,0243	0,0000	0,0000
D5	0,0454	0,0000	0,0000	0,0909	0,5909	0,0000	0,2727	0,0000	0,0000	0,0000	0,0000
D6	0,0000	0,0000	0,0000	0,0000	0,0000	1	0,0000	0,0000	0,0000	0,0000	0,0000
D7	0,0769	0,0341	0,0085	0,0427	0,0170	0,0000	0,8034	0,0000	0,0085	0,0085	0,0000
D8	0,0652	0,0652	0,0652	0,1521	0,1086	0,0217	0,1521	0,3695	0,0000	0,0000	0,0000
D9	0,1111	0,0000	0,0000	0,1111	0,0000	0,0000	0,3888	0,0555	0,2222	0,0555	0,0555
D10	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3333	0,0000	0,6666	0,0000
D11	0,1	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,9

Transition probability matrix was created by proportioning each cell in the pass number matrix to the sum of the row in which it is located, and it is shown in Table 5.9. Table 5.9. shows the rate of transition from each state to another state.

In the transition probability matrix, each element on the diagonal shows the dependency ratio on the factor that influences the fast food brand selection. So; a university student who prefers a fast food brand will choose another fast food brand with a rate of 73% due to "Hygiene (D1)", and will choose again due to hygiene in the next fast food brand preference, 62% for the next fast food brand preference due to "Price (D2)". Because of the "Campaigns (D3)", 34% will choose the next fast food brand because of the campaigns, and 59% will choose again due to the menu contents in the next fast food brand preference due to the "Menu Contents (D4)". will make a choice because of the "Materials Used (D5)", 59% will choose the next fast food brand because of the reused materials, and due to the "Atmosphere/Decor (D6)", the next fast food brand will be chosen again at a rate of 100% will choose because of the décor, due to "food quality (D7)", 80% will choose again due to food quality in the next fast food brand preference, and 36% will choose again due to location / accessibility in the next fast food brand preference due to "Location / Accessibility (D8)" due to the "Speed of Service (D9)", 22% will choose the next fast food brand again due to the speed of service, and 66% will choose again due to the attitude of the staff in the next fast food brand preference

due to the "Attitude of Staff (D10)". It can be said that he will make a choice in the next fast food brand choice at a rate of 90% for the same reasons. In line with these results, it can be said that which of the factors affecting fast food brand preferences is more important for university students. E.g; Considering the highest rate (90%) of other reasons (D11) for university students, it is seen that it is very important in influencing brand preferences. Students will want to go to their preferred fast food brand for other reasons. To give another example, university students still prefer these brands for food quality (D7) at a high rate (80%) and they will prefer the same brand for food quality in their next preferences.

Table 5.10. Emission Matrix

	V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**
D1	1	6	1	5	6	1	4	1	1	0	0
D2	5	17	3	4	3	1	3	0	0	2	2
D3	2	17	4	6	5	1	4	1	2	3	1
D4	10	49	16	15	14	2	12	2	0	2	1
D5	4	6	1	2	4	0	2	2	1	0	0
D6	1	3	0	0	0	0	0	0	0	0	0
D7	12	26	11	17	25	3	13	2	2	1	5
D8	5	15	3	7	2	1	8	0	0	0	5
D9	1	3	0	4	6	0	0	0	0	0	4
D10	1	0	0	0	1	0	0	0	0	0	1
D11	0	2	2	3	1	0	0	0	0	0	2

The emission matrix was created by taking into account which fast food brand the university students participated in the survey last bought and the reasons for choosing this brand, and it is shown in Table 5.10. V_is in table 5.10. shows fast food brands in table 1. (i=1,2,…,11)

When the emission matrix is examined, the distribution of the reasons for preference according to the fast food brands can be easily reached. For example; 49 students chose the Burger King (V2) brand for “Menu Contents (D4)” and 25 students chose the KFC (V5) brand for “Food Quality (D7)”.

Table 5.11. Emission Probability Matrix

	V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**
D1	0,0384	0,2307	0,0384	0,1923	0,2307	0,0384	0,1538	0,0384	0,0384	0,0000	0,0000
D2	0,125	0,425	0,075	0,1	0,075	0,025	0,075	0,0000	0,0000	0,05	0,05
D3	0,0434	0,3695	0,0869	0,1304	0,1086	0,0217	0,0869	0,0217	0,0434	0,0652	0,0217
D4	0,0813	0,3983	0,1300	0,1219	0,1138	0,0162	0,0975	0,0162	0,0000	0,0162	0,0081
D5	0,1818	0,2727	0,0454	0,0909	0,1818	0,0000	0,0909	0,0909	0,0454	0,0000	0,0000
D6	0,25	0,75	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
D7	0,1025	0,2222	0,0940	0,1452	0,2136	0,0256	0,1111	0,0170	0,0170	0,0085	0,0427
D8	0,1086	0,3260	0,0652	0,1521	0,0434	0,0217	0,1739	0,0000	0,0000	0,0000	0,1086
D9	0,0555	0,1666	0,0000	0,2222	0,3333	0,0000	0,0000	0,0000	0,0000	0,0000	0,2222
D10	0,3333	0,0000	0,0000	0,0000	0,3333	0,0000	0,0000	0,0000	0,0000	0,0000	0,3333

The emission probability matrix is obtained by dividing each number in the emission matrix by the sum of its rows. The matrix obtained is shown in Table 5.11.

Table 5.12. Probability of Fast Food Brands Being Preferred and Hidden States

	Observation	Probability (%)	Hidden State
None	V1	4.73	D1
Burger King	V2	25.9	D1
Popeyes	V3	5.54	D1
Mc Donald’s	V4	17.61	D1
KFC	V5	20.64	D1
Sbarro	V6	3.38	D1
Dominos	V7	13.85	D1
Arby’s	V8	3.32	D1
Pizza Hut	V9	3.44	D1
Subway	V10	0.94	D3
Other	V11	0.64	D7

The underlying reasons for university students' preferences were analyzed using the Transition probability matrix and Emission matrices. Matlab program was used for this analysis. Analysis results are shown in Table 5.12.

For the first problem of the Hidden Markov Model, the next preference probabilities of fast food brands were calculated using the Forward-Backward Direction Algorithm. Looking at the results in Table 5.12., it is seen that the probability of preference for the Burger King brand is the highest with 25.9%. It is seen that the probability of choosing none option is 4.73%.Burger King, which is the most preferred, is 17.61% McDonalds in 20.64% KFC, 13.85% Dominos, 5.54% Popeyes, 3.44% Pizza Hut, 3.38% Sbarro, 3.32% Arby's, 0.94% Subway and Other brands follow with a rate of 0.64%. It is seen that the reasons for preference are hygiene (D1) for None, Burger King, Popeyes, McDonald's, KFC, Sbarro, Dominos, Arby's and Pizza Hut, campaigns for Subway (D3), and food quality (D7) for other brands.

Table 5.13. Hidden States Underlying Transition Between Fast Food Brands

	V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**
V1	D1										
V2		D1									
V3			D1								
V4				D1							
V5					D1						
V6						D1					
V7							D1				
V8								D1			
V9									D1		
V10										D3	
V11											D7

The matrix showing the hidden situations underlying university students' preference for the fast food brands they will prefer next is given in Table 5.13.

For the second problem of the Hidden Markov Model, using the Viterbi Algorithm, the underlying reason for the preference possibilities of fast food brands, namely the hidden situations, was determined. Accordingly, it can be said that the underlying reason for choosing the Burger King brand with the highest probability of preference is “Hygiene (D1)”. It can be said that the hygiene situation, which is the hidden reason for the preference of the

Burger King brand, is the underlying reason for the preference of brands such as Popeyes, KFC, McDonalds, Dominos, Pizza Hut, Sbarro and Arby's. Looking at Table 5.12., it is seen that the underlying reason for choosing the Subway brand is "Campaigns (D3)" and the underlying reason for other brand preferences is "Food Quality (D7)".

6. CONCLUSION & RECOMMENDATIONS

There are many reasons that encourage university students to eat out. Examples of some of these include living away from their families, indifferent and reluctant behaviors towards cooking, lack of time, curiosity, the desire to try different flavors, the desire to reward themselves and socialize.The food preferences of the students outside have been fast foods. Therefore, a choice has been made among the businesses where these foods are preferred. There are many factors such as staff attitude, atmosphere/ decor, food quality, easy accessibility, service speed, variety in the menu, and the availability of special products in university students' preference of fast food establishments.

By using the products, the brand creates the opportunity to know which products the consumer is satisfied with. The brand name informs the consumer about its quality. Apart from this, if the brand name is great in after-sales services, it has confidence. In case of an opposite event, it will be possible to prefer rival companies. If the brand has brought the feeling of trust to its consumers, the consumer will continue to follow the brand if they introduce new products to the products under the brand or to the market (Odabaşı, 1995). Many consumers are more likely to prefer a product from a brand they know and trust, rather than trying a new brand product. Most of the time they don't take the risk of opting for an anonymous brand. The consumer can be persuaded to pay more than the price they can pay for the brand they trust (De Chernatony and McDonald, 1992).

Within the scope of this study, an online questionnaire was applied to 455 students studying at various universities in Turkey regarding their fast food brand preferences in order to take precautions due to the Covid 19 epidemic in the world. By arranging the survey data, the next brand preferences of university students in fast food consumption were estimated with the Markov chain method, stochastic processes were compiled, transition probability matrix was created, and the fast food brand preferences of university students were calculated by calculating long-term balance vectors. Factors affecting the fast food brand preferences were analyzed using the Hidden Markov Model.

In this study, it has been seen that the Burger King brand is the most preferred brand by university students. Similarly, San (2009) stated in his study that the most preferred restaurant by consumers was Burger King with a rate of 75%, and McDonalds was the preferred restaurant afterwards. In his study, Biçer (2019) found that 51% of students preferred Burger King more than others in the findings of university students' perceptions of popular fast food restaurant brands. In a study conducted by Insigt Research and Mediabrands, where almost half of the participants were between the ages of 16-34, when asked to choose the restaurant chains most preferred by the Turkish nation; It was stated that Burger King was in the first place, followed by Dominos and McDonalds (Worlfood Istanbul, 2018). To give another example of a similar to this study, Kuldaş (2018) stated in his study that the fast food brands most preferred by children are Burger King and McDonald's.

In this study, the reasons for choosing fast food brands were examined with the Hidden Markov Model, and it was seen that the reason for choosing the brands included in the study was hygiene with the highest rate. Similarly, Knutson (2000) revealed in his study that the most important factor affecting students' fast food consumption point preferences is hygiene with a rate of 69%.

Hygiene comes first for people all over the world, as the process in which this study was conducted was the period of the Covid 19 global epidemic and the beginning of the pandemic. Considering the data obtained from the study, it is seen that the hygiene status is the most important factor in the choices of individuals.

In this study, it was seen that the reason for choosing other brands was food quality. Similarly, Akdağ (2015) in his study in which he investigated the determination of fast food consumption status and habits of high school students, concluded that food quality is the primary reason for students to prefer food restaurants. Again, Ivkov et al. (2015) stated in their study that students give importance to the food quality factor when they prefer fast food. Kıngır et al. (2015), in a study conducted to determine the reasons for university students to prefer fast food, stated that despite their low income level, students give importance to quality before price.

In this study, if we look at the reasons for preference of all fast food brands in the future, it has been concluded that after the Burger King brand, KFC, McDonald's, Dominos, Popeyes, Pizza Hut, Sbarro, Arby's will be preferred for hygiene reasons. In addition, it is also seen that the fact that no brand is chosen is due to the hygiene option with a high probability. In addition, it has been seen that the campaigns for the reason Subway brand is preferred and the food quality is effective for the preference of other brands. It is also possible that the reason for choosing a brand will be chosen for the same reason in the future. For example, the choice of a brand due to hygiene (D1 = 73%) indicates that that brand may be selected for the same reason in the future.

In the study, a university student who prefers a fast food brand, "Hygiene (D1)" in 73%, "Price (D2)" 62%, "Campaigns (D3)" 34%, "Menu Contents (D4)" 59% due to “Materials used (D5)”, 100% due to “Atmosphere/Decor (D6)”, 80% due to “Food quality (D7)”, “Location/ Accessibility (D8)” It was concluded that 36% could choose the next fast food brand again for the same reasons, with a rate of 36% due to "Speed of Service (D9)", 66% due to "Staff Attitude (D10)" and 90% for other reasons. In line with these results, it can be said that which of the factors affecting fast food brand preferences is more important for university students. For example; It is seen that food quality (D7) is very important for university students. Students will want to go to their preferred fast food brand again because of the quality of the food. To give another example, university students highly prefer these brands for other reasons and they will prefer the same brand for other reasons in their next preference.

In this study, it is seen that the most important reasons for preference are hygiene, followed by campaigns and food quality. It was concluded that more importance was given to the reason for choosing hygiene, especially during the pandemic period when the data of the study were collected. Therefore, if brands want to continue to be preferred, they should continue to give due importance to the issue of hygiene. From another point of view, in addition to the importance that businesses give to hygiene in order to make themselves stand out, they also give importance to price, campaigns, menu contents, materials used, atmosphere/decor, food quality, location/accessibility, service speed, staff attitude and other reasons. may be suggested that they should be given. Thus, brands will be preferred for many

different reasons, not just for one reason, and they will be able to increase their share in the market and gain more profit by consolidating their position.

It is thought that the results obtained from this study will help businesses by providing useful information to increase their market shares and at least protect their shares. In this perspective, it is believed that it will be useful for businesses by providing a scientific framework. Knowing the underlying reasons why university students prefer these brands, it is thought that businesses can improve themselves and reach better levels by creating a competition between them. In addition, the hidden reasons underlying the brands preferred by university students or another community in different sectors and the brands they will prefer next can be determined with the Hidden Markov Model. In other words, different sectors (electronics, clothing, health, communication, etc.) can be addressed in future studies. In fact, studies can be carried out with the same method in different sectors and the results can be compared with this study.

REFERENCES

Acar, A., (2016). Yerli Ve Yabancı Fastfood Ürünlerinin Gençlerin Tercih Nedenlerinin Belirlenmesi Üzerine Bir Alan Çalışması: Muğla Sıtkı Koçman Üniversitesi Örneği. Sosyal Ve Beşeri Bilimler Araştırmaları Dergisi, 17(38), 3- 5.

Akalan, G., Göktaş, B., & Tarakçı, İ. , (2019). Branding Activities: The Survey of A SME's Which Coffee Chain in Turkey, Journal Of Business Research, 11(2), 787-805.

Akçadağ, M., & Ahıskalı Bozkurt, T . , (2019). Determination Of The Reasons For Prefence Of Fast Food Products: An Application On Students Of Sivas Republic University, Journal of Life Economics , 6 (4) , 449-462 .

Akdağ, H.N., (2015). Determination of Fast Food Consumption Status and Habits of High School Students, Okan University Health Sciences Institute, Department of Nutrition and Dietetics, Master's Thesis.

Akpınar, M. G., & Yurdakul, O., (2008). Factors Effecting Brand Preferences for Food Products. Journal of Akdeniz University Faculty of Agriculture, 21 (1), 1-6 .

Aktuğlu I., (2004). Marka Yönetimi. İstanbul: İletişim Yayınevi.

Alp, S., & Öz, E. (2009), "Markov Zinciri Yöntemi İle Taşınabilir Bilgisayar Tercihlerinin Analizi", Akademik İncelemeler Dergisi, 4(2), 37-54.

Alp, S., & Çetin, N., (2016). Analysis of Mobile Phone Brand Preferences by Using Markov Chain, Erzincan University Journal of Science and Technology, 9 (3) , 126-138 .

Alp, S., & Karaca, M., (2017). Analysis of the Relationship Between the Gold Prices and BIST 100 Index Using Markov Chain Method, Journal of Social Sciences and Humanities Researches, 18 (40), 1-12.

Arıtan, T., & Akyüz, A., (2015). An Analysis On Consumers' Brand Loyalty And Preferences Towards Car Brands, Int. Journal of Management Economics and Business, 11(26), 195 – 220.

Asal, A. , (2020). Üniversite Öğrencilerinin Marka Değeri Algılarının İncelenmesi: Bir Fast Food Markası Örneği, Hasan Kalyoncu Üniversitesi Sosyal Bilimler Enstitüsü, Yüksek Lisans Tezi.

Ayaz, O., & Alp, S., (2018). Analysis of GSM Operator Preference of University Students in İstanbul By Using Hidden Markov Model, Çukurova University Journal of Engineering and Architecture Faculty, 33(4), 203-212.

Aytemiz, T., & Şengönül, A., (2004). "Markov Zincirlerinin Ekonomik Bir Probleme Uygulanması: Perakende Alışverişlerde Bireysel Olarak Kullanılan Madeni Para Stratejilerinin Karşılaştırmalı Analizi" Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 6(4), 29- 43.

Baek, S.H., Ham, S., & Yang, I.S., (2006). A Cross-Cultural Comparison of Fast Food Restaurant Selection Criteria Between Korean and Filipino College Students", Hospitality Management, (25), 683-698.

Bhar, R., & Hamori, S., (2004). Hidden Markov Models Applications To Financial Economics. Kluwer Academic Publishers, The Netherlands.

Bicego, M., & Murino, V., (2004). Investigating Hidden Markov Models' Capabilities In 2D Shape Classification. IEEE Transactions on Pattern Analysis and Machine Intelligence, 26(2), 281-286.

Biçer, Ş., (2019). The Impact of Popular Culture on Fast Food Consumption of The University Students, Gazi University Institute of Education Sciences, Master's Thesis.

Bingöl, R., (2005). Restoran İşletmeciliği, Timaş Yayınları, İstanbul.

Brockwell, P. J., & Davis, R. A. (2013). Time series: theory and methods. Springer Science & Business Media, (9).

Bulduk, S., (2018). Beslenme İlkeleri ve Mönü Planlama. Güncellenmiş 4.Baskı. Ankara: Detay Yayıncılık.

Büyüktatlı, F., İşbilir, S., & Çetin, E., (2013). An Estimation Application According to Annual Allowances with Markov Analysis, International Journal of Alanya Faculty of Business, 5(1), 1-8.

Bäuerle, N., & Rieder, U., (2011). Markov Decision Processes with Applications to Finance, Springer, New York.

Can, T., & Öz, E.,(2009). Applying Hidden Markov Model To Brand Choices And Its Reasons, Eskişehir Osmangazi University Journal of Social Sciences,10(2), 167-186.

Can, T. (2006). Sektörler arası iliskilerin markov zincirleri ile analizi ve tahmini: Türkiye örneği. İstanbul: Derin Yayınları.

Cerit, C., & Yüksel, M., (1993). Olasılık. Üçüncü Baskı, İstanbul: Beta Yayınevi.

Ching, W. K., Fung, E. S., & Ng, M. K. (2002). A Multivariate Markov Chain Model for Categorical Data Sequences and Its Applications in Demand Predictions. IMA Journal of Management Mathematics, 13(3), 187-199.

Chung, K. L., & Walsh, J. B., (2005). Markov Processes, Brownian Motion, and Time Symmetry, (249). Springer Science & Business Media.

Ciğerim, N., (2001). Batı Ve Türk Mutfağı'nın Gelişimi, Etkileşimi Ve Yiyecek-Içecek Hizmetlerinde Türk Mutfağı'nın Yerine Bir Bakış, Türk Mutfak Kültürü Üzerine Araştırmalar. Türk Halk Kültürünü Araştırma Ve Tanıtma Vakfı Yayınları, 28, 49-61.

Cinemre, N. (2003). Yöneylem araştırması. İstanbul: Evrim Yayınevi

Çakırer, A. M., (2013). Marka yönetimi ve Marka Stratejileri. Bursa: Ekin Basımevi.

Çedikçi, T., (2008). The Place of Branding in Turkish Economy: A Case Study in The Textile Industry, Istanbul Kültür University Institute of Social Sciences, Master's thesis.

Çelik, İ., (2013). Fundamental Properties and Several Applications of Markov Chain. Ordu University Institute of Science and Technology Department of Mathematics, Master's thesis.

Çınar, T., (2007). Application Focused on The Customer Service and Customer Satisfaction in Firms and The Definition of Customer Satisfaction in Different Banks and Regions. Adnan

Menderes University, Institute of Social Sciences, Department of Business Administration, Master's thesis.

Daşdemir, İ., & Güngör, E., (2002). Multıvarıate Decısıon-Makıng Methods and Theır Usıng

Areas in Forestry. Zonguldak Karaelmas University Journal of Bartın Faculty of Forestry, 4(4), 1-19.

De Chernatony, L., & McDonald, M.H.B., (1992). Creating Powerful Brands, Butterworth.

Driskel, J. A., Meckna, B. R., & Scales, N. E., (2006). Differnces Exist in The Eating Habits of University Men and Fast Food Restaurants, Nutrion Resarch (26), 524-530.

Dönmez, İ., & Alp, S., (2019). Application of Hidden Markov Model for Brand Preferences and Reasons of Preferences in Sportswear Sector. Pamukkale University Journel of Engıneering Sciences, 25(1), 115-120.

Dupacova, Jitka, Hurt, J., & Stepan, J., (2002). Stochastic modeling in economics and finance. Kluwer Academic Publishers, United States Of America.

Elitok, B., (2003). Hadi Markalaşalım. İstanbul: Sistem Yayınevi.

Engin, H., (2016). Brand Equity Within The Framework Of Branding Concept. Marmara University Proposal Journal, 12(46), 277-294.

Erbaş, E., & Artukoğlu, M. , (2016). Tendencies of Consumers' Preferences for Branded Food Product : The Case of Olive Oil, Ege University, Journal of the Faculty of Agriculture, 53 (4), 425-434.

Erbay, A., (2007). Popüler Kültür ve Beslenme Biçimleri Örnek Olay: Döner Kebap, Ankara Üniversitesi, Yüksek Lisans Tezi.

Ercan, Ö., (2020). Determination of Sports Shoes Preferences of Young People with Markov Chains Modeling, R&S - Research Studies Anatolia Journal, 3(2), 131-141.

Ewens, W., & Grant, G., (2005). Statistical Methods in Bioinformatics: An Introduction, Second Edition, United States of America: Springer Science+Business Media Inc.

Fuh, Cheng-Der., (2003). SPRT and Cusum in Hidden Markov Models. The Annols of Statistics, 31(3).

Gardy, D., & Mokkadem, A., (2000). Mathematics and Computer Science, Algorithms, Trees, Combinatorics and Probabilities.

Gnedenko, B., & Ushakov, I. A. (1995). Probabilistic reliability engineering. John Wiley & Sons.

Gökşen, A., (2015). Modelling Factors Which Affecting Site Selection of Fast Food Restaurants: Case Study of Istanbul, Istanbul Technical University Institute of Science and Technology, Master Thesis.

Güler, N., (1992). An Application Trial on The Determination of Market Shares of Markov Chain and Vehicle Engine Oils in Bursa. Uludag University Institute Of Social Sciences, Unpublished Master's Thesis.

Gündüz, S.,& Kıral, S, (2020). Determination of Factors Affecting Voter Preferences Using The Hidden Markov Model. Çukurova University Journal of Social Sciences Institute, 29 (3) , 414-428 .

Güngör, H., (2019). The Inventory Management Of The Chain Stores At The Fast Food Sector And An Application, Istanbul Aydin University Institute Of Social Sciences, Master's Thesis.

Gürdoğan, N., (2008). Global Çarşıda Silahlarla Değil Markalarla Savaşılır. Efaltun Eğitim Danışmanlık Hizm., www.efaltun.com.tr/makaleler/Prof.Dr.NazifGundogan

Halaç, O., (1991). Kantitatif karar verme teknikleri (Yöneylem Araştırması). İstanbul: Evrim Dağıtım.

Hamilton, J. D., (1994). Time series analysis (Vol. 2). Princeton: Princeton University press.

Hamşıoğlu, B., (2013). An Application on Determining The Life-Style Of Consumers Who Consume Fast-Food Products, International Journal of Economic and Administrative Studies, Issue 11.

Ivkov, M., Blesic, I., Raljic, J. P., Dzigurski, A. I., Pivac, T., & Jovanovic, T., (2015). Visitors Motives For Attending A Hybrid Event: A Case Study of Agricultural Fair. Ekonomika Poljoprivrede, 62(1), 9.

İnaç, H., & Yacan, İ., (2018). The Brandıng Process of Countrıes and The Concept Brand, Journal of the International Academy of Management, 1(3), 317-331.

İslamlıoğlu, A. H., & Fırat, D., (2016). Stratejik Marka Yönetimi, Ankara: Beta Basım A.Ş.

Jacobson, M.F.,& Fritschner, S., (1991). The Completely Revised and Updated Fast-Food Guide. New York: Workman Publishing.

Jansen, J.,& Manca, R., (2007). Semi-Markov Risk Models for Financa, Insurance and Reliability, United States of America: Springer Science+Business Media LLC.

Kahraman, M., & Dağlı, S., (2019). Comparative Analysis Of Relations Brand Perception, Customer Satisfaction And Brand Preferences According To X And Y Generation, Master Thesis, Bahçeşehir University Institute of Social Sciences.

Karlsson, M., (2004). Hidden Markov Models. http://www.math.chalmers.se/~olleh/Markov_Karlsson.pdf (Erişim Tarihi: 15.10.2021).

Karpat, I., (2000). Marka Yönetimi Süreci ve Tanıtımın Rolü. Yayınlanmamış Doktora Tezi, Ege Üniversitesi, İzmir.

Kaya, D., (2011). Reasons Of Consuming Fast Food Inlocal, National And İnternational Chain of Fast Food Business in The City Center of Mersin, Mersin University Institute of Social Sciences, Master's Thesis.

Kayışoğlu, S., & İçöz, A., (2012). The Effect of Education Level on Fast-Food Consumption. Journal of Tekirdag Agricultural Faculty, 9(2), 17.

Keller, K.L. (2003). Strategic Brand Management, Building, Measuring and Managing Brand Equity (Second Edition). N.J.: Upper Saddle River, Prentice Hall. Pearson Education.

Kıngır, S., Karakaş, A., Şengün, H., & Çenberlitaş. İ., (2015). Determining The Reasons of University Students' Fast Food Preferences: Dicle University Case. Journal of Travel and Hospitality Management, 12(3), 102-119.

Kıral, E. (2018). Determination of Mobile Phone Operator Prefrences Markov Analysis: An Application of Adana Province. Journal of Çukurova University Institute of Social Sciences, 27(1), 35-47.

Kıral, S.G. ,(2020). Estimation of Voter Movements with Markov Chains, Adana Alparslan Türkes Science and Technology University Social Sciences Institute, Master's Thesis.

Kıran, S.B., (2009). Markov Chains And An Application On Business, Marmara University Social Sciences Institute, Master's Thesis.

Kloeden, P. E., & Platen E., (1995). Numerical Solution of Stochastic Differential Equations, Second Corrected Printing, United States of America: SpringerVerlag, s.5.

Kuldaş, E., (2018). The Reasons of Children's Fast Food Brand, Selcuk University Institute of Social Sciences, Master Thesis.

Knutson, B.J., (2000). College Students and Fast Food , Cornell Hotel and Restaurant Administration Quarterly, (June), 68-74.

Korkmaz, S., (2005). The Influence Of The Competitive Strategies On Fast-Food Sector: The Analysis Of The Preferences Of The University Students, Journal of Commerce and Tourism Education Faculty, (2), 25-39.

Kotler, P., (1974). Marketing Decision Making A Model Building Approach. Great Britain: A Holt İnternational Edition.

Kotler, P., & Armstrong, G., (2004). Principles of Marketing, Upper Saddle River, NJ: Pearson Prentice Hall.

Lawrence, C., (2001). An introduction to stochastic differential equations lecture notes, Version 1.2., California.

Lou, H. L. (1995). Implementing the Viterbi algorithm. IEEE Signal processing magazine, 12(5), 42-52.

Malliaris, A.G., & Brock, W.A., (1999). Stochastic Methods in Economics and Finance, The Netherlands: Elsevier Science B.V.

Marshall, A. H., & Sterritt, R., (2005, August). Clustering gene expression data using continuous Markov models. In Computational Systems Bioinformatics Conference. Workshops and Poster Abstracts. IEEE (pp. 314-321). IEEE.

Mengüç, B., (1990). Market Share Estimation of Colored Tv With Markov Chains for The Period Of 1990-1995 , Istanbul Technical University Institute Of Science And Technology, Master's Thesis.

Miller, J., (2005). Business of Brands, John Wiley And Sons, Incorporated Hoboken, NJ.

Oliver, R. L., (1999). Whence Consumer Loyalty?, Journal of Marketing, 63, 33- 44.

Odabaşı, Y., (1995). Pazarlama İletişimi, Eskişehir.

Orkun, N. D., (2009). Küreselleşmenin Değiştirdiği Yemek Kültürü: İstanbul Beyoğlu: 2002-

2009, Yayınlanmamış Yüksek Lisans Tezi, Marmara Üniversitesi Sosyal Bilimler Enstitüsü.

Önalan, Ö., (1996). Hisse Senedi Fiyat Değişimlerinin Stokastik Süreç Olarak Analizi, Yayınlanmamış Doktora Tezi, Marmara Üniversitesi Sosyal Bilimler Enstitüsü.

Önalan, Ö., (2010). Stokastik Süreçler, İstanbul: Avcıol Yayınevi, 39-69.

Öz, E., (2009). Saklı Markov Modelleri ve Finansal Bir Uygulama, Yayınlanmamış Doktora Tezi, Marmara Üniversitesi Sosyal Bilimler Enstitüsü, İstanbul.

Özbay, G., Öncü, M., & Çatı, K., (2007). Hızlı Yiyecek İşletmelerinin Tercihinde Etkili Olan Faktörler, Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi ,9(1), 317-336.

Özcan, B., (2007). Sosyolojik Olarak Tüketim ve Boş Zaman: İstanbul Olivium Outlet Center ve Galleria Alışveriş Merkezi Örnekleri, Yüksek Lisans Tezi, İstanbul Üniversitesi, Sosyal Bilimler Enstitüsü.

Özçelik, A. Ö., & Sürücüoğlu, M. S., (1998). Fast Food Preferences of The Consumers', Food , 23 (6), 437-447 .

Özdinç, İ. Y., (2004). Üniversite Öğrencilerinin Fast Food Tüketim Alışkanlıkları ve Tüketim Noktası Tercihlerini Etkileyen Faktörler, Anatolia: Turizm Araştırmaları Dergisi, 15 (1), 71-79.

Özleyen, G., (2005). Fast Food İşletmelerde Tüketici Davranışı Analizi. Bolu Abant İzzet Baysal Üniversitesi, Yüksek Lisans Tezi.

Öztürk A., (2012). Yöneylem Araştırması, Ekin Basım Yayın Dağıtım, Bursa.

Rabiner, L.R., (1989). A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition, Proc. IEEE, 77(2), 257-286.

Rasool, Z., (2017). Fast Food Consumption Behavior of Consumers: The Case of Northern Iraq, Kahramanmaraş Sütçü İmam University Institute of Natural and Applied Sciences Master Thesis.

San, Z., (2009). A Research On Relation Between Consumers' Life Style and Service Quality Perception Of Fast Food Restaurants, Sakarya University Institute of Social Sciences, Master Thesis.

Sayılı, M., & Gözener, B., (2013). Evaluation of the Fast-Food Consumption Habits of Students at Gaziosmanpasa University, Çankırı Karatekin University, Journal of Social Sciences Institute, 4(2), 11-28.

Schliep, A., Georgi, B., Rungsarityotin, W., Costa, I., & Schonhuth, A., (2004). The General Hidden Markov Model Library: Analyzing Systems with Unobservable States, Proceedings of The Heinz-Billing-Price, 121-135.

Semerci, Z., (2006). Saklı Markov Modellerinde Üç Temel Problemin İncelenmesi, Hacettepe Üniversitesi Fen Bilimleri Anabilim Dalı, Yüksek Lisans Tezi.

Smith, S.M., (2013). Determining Sample Size, How to Ensure You Get the Correct Sample Size ?.

Sormaz, Ü., Sürücüoğlu, M., & Akan, L., (2005). Beslenme Kültüründeki Eğilim: Fast Food Yemek Tercihleri, Ankara Üniversitesi Ev Ekonomisi Yüksekokulu, Beslenme Bilimleri Bölümü, Ankara.

Soykan, Y. (2010). Markov Zincirleri ile Pazar Payı Araştırma Modeli ve Otomobil Lastiği Pazarında Bir Uygulama, Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, (27).

Soylu, G., (1978). Anadolu'nun Prehistorik Devirlerinde Avcılık Izleri. Antropoloji, 8, 27-31.

Steeb, W. H., Hardy, Y., & Stoop, R. (2005). The Nonlinear Workbook, 3rd Edition, Singapore: World Scientific Publishing Co. Pte. Ltd.

Steele, J. M. (2001). Stochastic calculus and financial applications. New York: SpringerVerlag.

Sürücüoğlu, M. S., & Çakıroğlu, F. P., (2000). The Research on Fast Food Preferences of University Students of Ankara, Journal of Agricultural Sciences, 6(3), 116-121.

Şentürk, S., & Alp, S., (2016). Analysis of Preferences of GSM Operators and Internet Service Providers By Using Markov Chain, Gaziosmanpaşa Scientific Research Journal, (13) , 133-151.

Taha, H. A., (2000). Yöneylem Araştırması 6. Basımdan Çeviri, İstanbul: Literatür Yayıncılık.

Taherdoost, H., (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research.

Tayfun, A., & Uygur, S. M., (2008). A Research Over The Factors That Affect The Students Chosing Of Fast Foot Restaurants, Gazi University, Faculty of Commerce and Tourism Education, Third Sector Cooperatives, 43(1), 120-131.

T.R. Official newspaper. Law on Protection of Trademarks. 27 June 1995, issue: 556.

Tengiz, Z., (2018). Evaluation of University Students' Attitudes and Behaviors Towards Fast Food Consumption, Tekirdağ Namık Kemal University, Graduate School of Science and Technology, Master's Thesis.

Timor, M., (2011). Yöneylem Araştırması, Türkmen Kitabevi, İstanbul.

Tumay Bulut, E., (2019). A Research On The Relationship Between Consumer Behaviors And Life Style Towards Fast Food Products: The Case Of Izmir Province, Ege University Institute of Science, Department of Agricultural Economics, Master's Thesis.

Uçar, Ş., (2000). Fast Food Habits: Clarification of Class Preferences in Fast Food, Power, (July): 90-92.

Unur, K., & Kaya, D., (2010). The Characteristics of Fast Food Consumers and Factors Affecting Their Preferences: A Case of Mersin, Çağ University Journal of Social Sciences, 7 (2) , 105-122.

Uztuğ, F., (2005). Markan Kadar Konuş. (İstanbul: Media-Cat Yayınları).

Veuphuteh, F.M., (2018). The Effect Of Food Quality, Health Consciousness And Price Sensitivity On Fast-Food Purchase Intention: A Comparative Study Between Consumers In Turkey And Canada, Hacettepe University Institute of Social Sciences, Master Thesis.

Wınston, W.L., (1991). Operations Research Applications and Algorithms, Duxbury Press, California

Yazıcıoğlu, İ., Işın, A., & Koç, B., (2013). The Reasons of University Students' Preference to Fast Food Products, Journal of Tourism and Gastronomy Studies, 1(1), 36-41.

University Students' Preference to Fast Food Products

Yıldırım, F., & Çengel, Ö., (2013). A Research Over The Relationship Between Fast Food Consumption and Consumer's Values&Lifestyles in Turkey, Online Academic Journal of Information Technology, 4(35), 63–80.

Yu, L., (1999). The International Hospitality Business Management and Operations. New York: The Haworth Hospitality Pres.

Yurtman, A., (2001). Fast Food Sektör Profil Araştırması.

https://www.matematiksel.org (Accessed Nov 18, 2021)

https://www.mcdonalds.com.tr (Accessed Dec 10, 2021)

https://www.dominos.com.tr (Accessed Dec 10, 2021)

http://www.avsarkurgun.com.tr (Accessed Sept 24, 2021)

APPENDIX

Codes entered in MATLAB to identify hidden states in the HMM.

```
>> clear
emis = xlsread('Emission.xlsx');
trans = xlsread('Transition.xlsx');
[PSTATES,logpseq,FORWARD,BACKWARD,S] = hmmdecode(1,trans,emis);
[estTRbw ,estEbw] = hmmtrain([1,2,3,4],trans,emis);
[seq,states] = hmmgenerate(1,trans,emis);
estimatedStates = hmmviterbi(seq,trans,emis)
```