ANALYZING PARAMETERS OF SUSTAINABLE DESIGN IN OFFICE FURNITURE SECTOR IN TÜRKİYE

MERON BELAY

SEPTEMBER 2022

ÇANKAYA UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF INTERIOR ARCHITECTURE

MASTER'S THESIS IN

INTERIOR ARCHITECTURE

ANALYZING PARAMETERS OF SUSTAINABLE DESIGN IN OFFICE FURNITURE SECTOR IN TÜRKİYE

MERON BELAY

SEPTEMBER 2022

ABSTRACT

ANALYZING PARAMETERS OF SUSTAINABLE DESIGN IN OFFICE FURNITURE SECTOR IN TÜRKİYE

BELAY, Meron

Master of Science in Interior Architecture

Supervisor: Assoc. Prof. Dr. Özge SÜZER

September 2022, 138 pages

Utilizing sustainable development and production methods results in more socially and economically sustainable products while minimizing negative environmental impacts. The aim of this study is to determine the parameters of sustainable design in furniture, to find out the level of awareness of selected prominent Turkish furniture companies as to the implications of these parameters, and to determine the possibilities and drawbacks considering the production of sustainable Turkish furniture. The research includes analyses of the three dimensions of sustainable design, which are: environmental, economic, and social dimensions. Additionally, it assesses both green-labeled and not-green-labeled furniture firms that originated in Türkiye. The methods used to achieve the study's goal included a literature review, a questionnaire survey, and a parameter-based comparative analysis on selected case products. The questionnaire was conducted on 8 office furniture firms, which were selected based on criteria. The collected data was analyzed in detail using the Statistical Package for Social Science (SPSS). Furthermore, a parameter-based comparative analysis was conducted on selected case products of the firms relying on the information collected about the products within the questionnaire survey. The study concludes that selected furniture firms are aware of sustainability, particularly in the environmental dimension, considering the fact that they aim to receive

the TSE certification in order to achieve market competitiveness and enhance their brand image. However, parameters, where low performances are recovered by the firms are identified. Finally, recommendations were given to the firms on what design strategies to use in order to improve their performance in achieving sustainability in all three dimensions.

Keywords: Sustainable Design, Environmental Parameters, Social Parameters, Economic Parameters, Turkish Furniture Firms

ÖZ

TÜRKİYE'DE OFİS MOBİLYALARI SEKTÖRÜNDE SÜRDÜRÜLEBİLİR TASARIM PARAMETRELERİNİN ANALİZİ

BELAY, Meron

İç Mimarlık Yüksek Lisans

Danışman: : Dr. Öğr. Üyesi Özge SÜZER

Eylül 2022, 138sayfa

Sürdürülebilir kalkınma ve üretim yöntemlerinin kullanılması, olumsuz çevresel etkileri en aza indirirken, sosyal ve ekonomik olarak daha sürdürülebilir ürünlerle sonuçlanır. Bu çalışmanın amacı, mobilyada sürdürülebilir tasarım parametrelerinin belirlenmesi, seçkin Türk mobilya firmalarının bu parametrelerin etkileri konusunda farkındalık düzeyinin belirlenmesi ve sürdürülebilir Türk mobilya üretimi göz önünde bulundurularak olasılık ve dezavantajların belirlenmesidir. Araştırma, sürdürülebilir tasarımın çevresel, ekonomik ve sosyal boyutlar olmak üzere üç boyutunun analizlerini içermektedir. Ayrıca, Türkiye menşeli hem yeşil etiketli hem de yeşil etiketli olmayan mobilya firmalarını değerlendirmektedir. Çalışmanın amacına ulaşmak için kullanılan yöntemler arasında bir literatür taraması, bir anket anketi ve seçilen vaka ürünleri üzerinde parametreye dayalı karşılaştırmalı bir analiz yer aldı. Anket, kriterlere göre seçilen 8 ofis mobilyası firması üzerinde gerçekleştirilmiştir. Toplanan veriler, Sosyal Bilimler İstatistik Paketi (SPSS) kullanılarak ayrıntılı olarak analiz edildi. Ayrıca, anket anketinde yer alan ürünler hakkında toplanan bilgilere dayanarak firmaların seçilmiş vaka ürünleri üzerinde parametreye dayalı karşılaştırmalı bir analiz yapılmıştır. Çalışma, seçilen mobilya firmalarının, almayı hedefledikleri gerçeği göz önüne alındığında, özellikle çevresel boyutta sürdürülebilirliğin farkında oldukları sonucuna varmıştır pazar rekabet gücünü

sağlamak ve marka imajını geliştirmek için TSE sertifikası. Ancak firmalar tarafından düşük performansların geri kazanıldığı parametreler tespit edilmiştir. Son olarak, her üç boyutta da sürdürülebilirliğe ulaşmada performanslarını artırmak için firmalara hangi tasarım stratejilerinin kullanılacağı konusunda tavsiyelerde bulunulmuştur.

Anahtar Kelimeler: Sürdürülebilir Tasarım, Çevresel Parametreler, Sosyal Parametreler, Ekonomik Parametreler, Türk Mobilya Firmaları

ACKNOWLEDGMENT

First and foremost, I would like to thank God for giving me strength and guiding me through all the challenges. I would also like to express my gratitude to my thesis advisor, Assoc. Prof. Dr. Özge SÜZER, for her support, guidance, and encouragement throughout the study. I would like to thank the individuals who participated and played a role in the accomplishment of the study. Finally, I would like to thank my family for their endless support and patience throughout the study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

DfX:	Design for X
DfE:	Design for Environment
DfD:	Design for Disassembly
DfR:	Design for Recycling
C2C:	Cradle to Cradle
NO2:	Nitrogen dioxide
SO2:	Sulfur dioxide
CH4:	Methane
CO2:	Carbon dioxide
UD:	Universal Design
LCSA:	Life Cycle Sustainability Assessment
LCA:	Life Cycle Assessment
LCC:	Life Cycle Costing
SLCA:	Social Life Cycle Assessment
EU:	European Union
ISO:	International Organization of Standardization
EPD:	Environmental Product Declaration
BIFMA:	Business and Institutional Furniture Manufacturers Association's
LEED:	Leadership in Energy and Environmental Design
TSE:	Turkish Standards Institute

CHAPTER 1

INTRODUCTION

Environmental problems such as air and water pollution, deforestation, and many more have increasingly become significant issues around the world. The excessive consumption and production of products have a great role in causing these environmental problems. Rapid industrial production processes make it harder for nature to recover from environmental damages. Therefore, mankind should have an awareness regarding the global environmental effects of industrialization and take proper action against it.

Sustainability has become an important concept in every field to provide solutions that will lessen the environmental impact and offer socially satisfactory and economically feasible solutions. A sustainable approach is also crucial regarding the improvement of health conditions for human beings. Since people tend to spend most of their time indoors and fulfill their physiological and psychological needs, by creating sustainably built environments, the productivity of users can be increased. Compared to standard methods, designing a sustainable product is a difficult and complex task. Early engagement in the sustainable product design process allows for decisions to be made concerning the product's life cycle in order to reduce its environmental effect (Seyajah 2016: 21). Designers play a significant role in offering solutions to create a sustainable future. Furthermore, the production and usage of furniture has a significant responsibility in polluting the environment. Yet, achieving sustainability in this fundamental element of interior architecture requires a broad perspective, embracing its all dimensions, namely; economic, social, and environmental aspects.

1.1.AIM AND SCOPE

Due to the global environmental risk we are facing today, it is a well-known fact that sustainability is a fundamental approach that should be considered. Furniture is an important part of interior architecture that has a significant responsibility on environmental pollution. Therefore, sufficient attention should be given to its potential environmental impact. This study aims to determine the parameters of sustainable design in furniture, to find out the level of awareness of selected prominent Turkish office furniture companies as to the implication of these parameters, and determine the possibilities and drawbacks considering the production of sustainable Turkish furniture.

The scope of the research includes the analyses of the three dimensions of sustainable design, which are; - environmental, economic, and social dimensions. Additionally, it focuses on furniture design assessing both green-labeled and not green-labeled furniture of the related companies that originated in Türkiye.

The research questions of this study are as follows:

- Q1: What are the parameters of sustainable design in the furniture industry?
- Q2: What is the level of awareness of the selected firms regarding the implication of sustainable design parameters?
- Q3: Which parameters are the most and least implemented in the selected furniture firms?
- Q4: What are the possibilities and drawbacks of the production of sustainable Turkish furniture?

1.2. METHOD OF STUDY

Through descriptive research, an extensive literature review on sustainable design and its parameters was done to identify the evaluation criteria of sustainable furniture. The study also includes a comparison between green-certified and uncertified iconic products according to identified parameters of sustainable design. Additionally, a questionnaire survey on related company authorities and the designers of green products was conducted. Therefore, the structure of the study can be summarized as follows:

Literature review

- Literature review on sustainable furniture design.

- Literature review on examples of international sustainable furniture and their analyses.
- Identification of the parameters of sustainable furniture design.
- Literature review on both iconic Turkish products and products declared as green or sustainable

Analysis

- Questionnaire survey on related company authorities and the designers of iconic and green products.
- Analyzing and comparing green-certified and uncertified iconic products according to the identified parameters of sustainable furniture design.

Findings

- Deriving conclusions on the level of awareness of Turkish furniture companies as to the implication of parameters of sustainable design.
- Finding out the possibilities and drawbacks of the production of sustainable Turksih furniture.

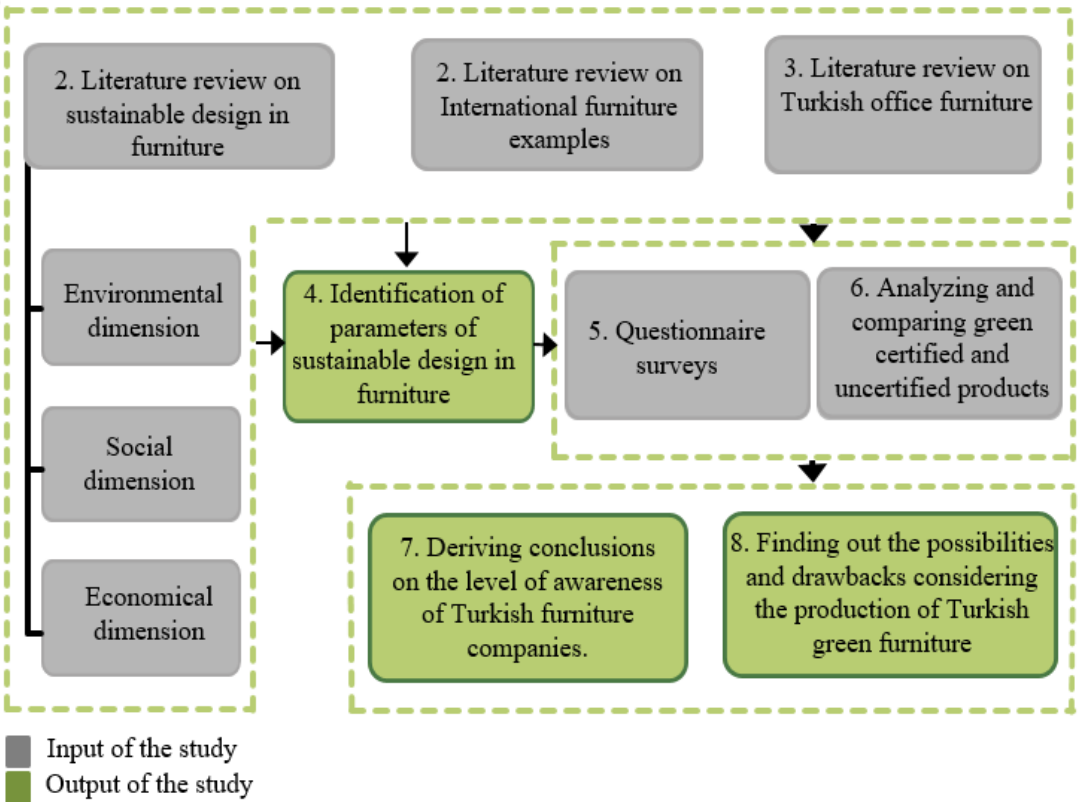


Figure 0.1: The methodological framework of the study

CHAPTER 2

SUSTAINABLE DESIGN IN FURNITURE

Two definitions of sustainability given by the Cambridge dictionary are "*the quality of being able to continue over a period of time*" and "*the quality of causing little or no damage to the environment and therefore able to continue for a long time*". In the 1980s, sustainable development is defined by Brundtland Commission as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987: 43). Continuing and durable balance regarding the environment, society, and the economy at the global scale is sustainable development's ultimate objective. This can be achieved by a combination of environmental, social, and economic concerns all throughout the managerial procedure (Emas 2015: 2). Sustainability is the ability to avoid the exploitation of natural resources to create environmental balance on a global scale. According to the common model of defining the three dimensions of sustainable development, planet represents the environmental dimension, the social dimension is represented by people, and economic dimension is represented by profit as seen in Figure 2.1.

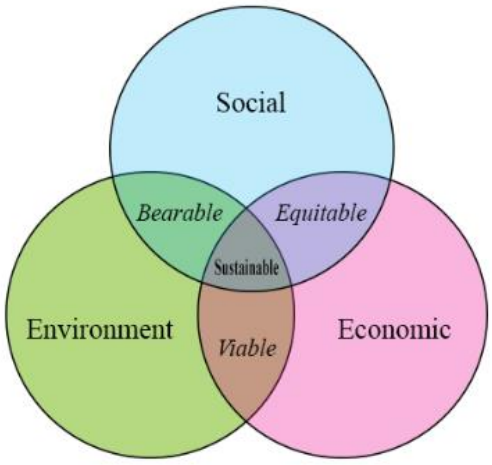


Figure 2.1: The three dimensions of Sustainable development (Seyajah 2016: 14)

In their book “Design for Sustainability”, Bhamra and Lofthouse (2007: 4) recognized three stages in the emergence of the sustainability period. The first phase arose from a rising environmental awareness in the 1960s and 70s, as a result of NGOs’ efforts to affect radical change through government policies and laws. In the 1980s and early 90s, the second phase arose when customers requested an environmentally friendly procedure in response to growing environmental concerns. The third phase was sparked in 1987 by the Brundtland Commission’s publication of ‘Our Common Future’, which created the term ‘sustainable development’. Sustainable design was considered more than green or eco-design because it went beyond simply producing a “*green”* product.

Understanding true sustainability requires the perception of the connection between society, the environment, and the economy. Environmental sustainability is necessary if the aim is for the natural resources to meet the needs of future generations. In addition, social sustainability is a concept related to the equal distribution of rights and opportunities. Society is not sustainable if it consumes its resources faster than they can be renewed through natural processes. Economic sustainability is about growth and profit margins, taking into account a product's entire life cycle, from processing raw materials, production, provision and delivery, utilization, repair, maintenance, and recycling.

All over the world, architects, engineers, builders, and developers are trying to understand how to bring their services to reflect a new way of design. As the architect Sym Van der Ryn expressed in many years, the environmental crisis is a design crisis (Aziz et al. 2012: 4). Therefore, the current problems in the environment are the result of how things are made, how landscapes are used, and how buildings are constructed.

2.1. ENVIRONMENTAL DIMENSION

Environment is the first dimension to be considered in the process of achieving sustainability. A furniture product affects the environment throughout its lifecycle. Ottman et al. (2006: 24) noted that despite the fact that no consumer product has a zero environmental effect, expressions such as 'green products' and 'environmental products' are often used in the business world to explain items that safeguard or improve the environment by conserving resources and/or energy, minimize the use of harmful agents, pollution, and waste.

A case study was conducted in Brazil aiming to examine sustainability strategies in wood-based furniture by using a life cycle assessment model. The study mainly focuses on three stages of furniture design: material selection, production, and distribution of a wardrobe. The result of the study shows that two of the stages; *i*) material selection and *ii*) distribution and supply stages create 68% of the overall environmental impact, whereas the production stage only creates a 7% environmental impact of the overall life cycle (Iritani et al. 2015: 308). This elaborates the fact that a product does not harm the environment only when it is produced.

2.1.1. Approaches to Environmental Sustainability

Approaches are mostly researchers-developed initiatives and promote the "ideal" concept of sustainability, meaning that ideas that fall within the range of approaches assist in determining the general structure of the researcher's sustainability goal (Okursoy 2012: 8). The well-known environmental sustainability approaches are described below.

2.1.1.1. Life Cycle Thinking

Life cycle includes all procedures that are found in the whole life span of any product. Unlike techniques that focus on particular stages within the life cycle of a product, such as green manufacturing, buying, or green logistics, it considers every stage of the product life cycle (Dyllick and Rost, 2017: 9). The difference between life cycle thinking and traditional design is that life cycle thinking broadens the designer's attention from the manufacturing and design stage of the product to additional steps. The product's lifespan contains phases such as material selection, design, manufacturing, transportation, utilization, and disposal (end of life cycle stage) as seen in Figure 2.2.

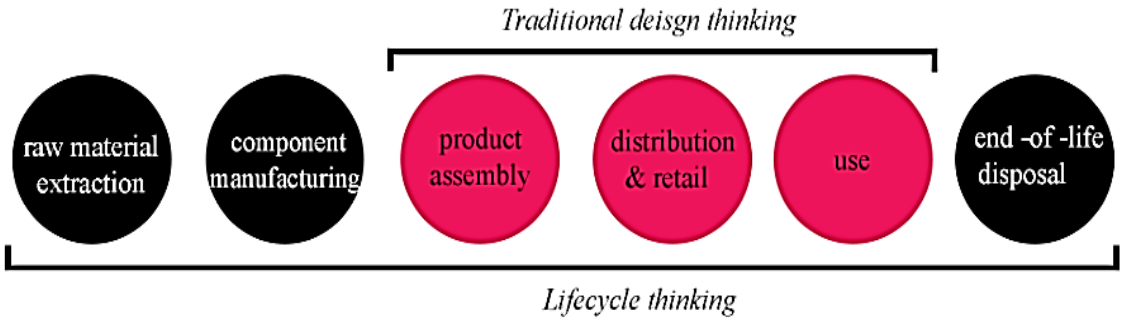


Figure 2.2: Life cycle thinking (Prendeville 2014: 33)

A variety of approaches and strategies for managing product sustainability are based on the life cycle perspective (Zamagni et al. 2013: 1). Life cycle design is a technique of calculating and measuring the environmental impacts during the lifecycle. This evaluation gives information such as the efficiency of resources and the amount of waste production. This life cycle design takes place from raw material selection of a product, designing, processing, manufacturing, use, end of life, and disposal (Karaca, 2018: 20).

William Mcdonough stated that if a product's life cycle is not calculated it most likely has the potential to be a solid waste. If a solid waste does not exist, it is most likely to be *"recycled*" rather than being recyclable, it is "*down-cycled*", which means non-recyclable. Down cycling is a concept of recycling material into a lower quality one; the product achieved through this process is lower in quality and cheaper than the original. When trying to recycle a product that cannot be recycled or cannot be reused, there will be an energy loss causing more damage to nature (Mcdonough and Braungart 2002).

2.1.1.2. Design for X

Design for X (DFX) is an important practice in product development to enhance both the product and the service at the same time (Eastman 2012: 1). This approach is not only used in achieving sustainability, it can also be integrated with manufacturing, cost management, use, ergonomics, and other aims (Okursoy 2012: 9). This approach aims to decrease the environmental effect of a product and enhance its recyclability all the way through the life cycle of a product. However, the drawback of this approach is that if only one environmental problem is addressed, it may have a negative impact on other concerns, increasing the product's environmental impact (Uysal 2014: 13). The concept of this approach to achieving environmental sustainability are as follows:

Design for environment (DfE): A design method that has a purpose of lessening a product's environmental effect during its life cycle is referred to as Design for Environment (DfE). Since 1990, multiple methodologies have been developed (Uysal 2014: 13). Some techniques have been designed to incorporate DfE concerns at the early design stage, while others have been designed to apply them in the last design development stages (Hauschild et al. 2004: 1).

Design for disassembly (DfD): is to create products which are capable of being easily disassembled by the end of their useful life so that the remaining components and materials may be recycled, reused or refurbished into new ones (Bogue 2007: 285). To satisfy the criteria for a successful DfD, Bogue (2007: 287) stated that there are three factors to be considered, which are, "Selection and use of materials", "Design of products" and "Selection of connectors, joinery, and fasteners".

Design for recycling (DfR): is an approach developed for products to be designed having a recycling stage at their end-of-life. For companies to achieve such an approach, they must embrace new design concepts in which the possibility to recycle a product is considered starting with the first stages of the product development process (Peters et al. 2012: 203).

2.1.1.3. Cradle to Cradle

The concept of better use of material by encouraging two definite but different cycles of material used to support sustainable design and production is known as Cradle to Cradle (C2C). It is a concept proposed by William McDonough in 2002. By completing the product loop, C2C strives to reduce negative environmental consequences. While traditional life cycle analysis takes a "cradle to grave" approach, "cradle to cradle" aims in creating an endless loop of inputs and outputs. This concept was inspired by biological metabolism, where a waste product from one natural process is utilized by another species or system as a source of energy or nutrition (Dyllick and Rost, 2017: 14).

Cradle to grave is the opposite concept of C2C and does not create a closed loop of material production. As its name indicates, the product will come to an end, resulting in waste production. Products designed based on the 'cradle-to-grave' approach are manufactured from raw materials and will enter the decay process and are lost. However, in the 'cradle-to-cradle' design, waste is minimized as there is a closed loop with the help of recycling, and therefore, the environmental impact is reduced. This cycle ensures that when the components of a product reach their end of life, they can be used as raw materials (Karaca, 2018: 25). C2C is founded on a set of fundamental concepts which are; exclusive renewable energy usage, diversity celebration, and elimination of waste (C2CPII 2014: 4).

2.1.2. Parameters of Environmental Sustainability

Environmental sustainability parameters are a set of indicators that are used to reduce or measure the negative environmental impact of a product. A set of parameters are collected from the literature review for the purpose of conducting the research and constructing a set of parameters that can be used as a guideline. The parameters of environmental sustainability are constructed into six category groups, which are: *i.*) material, *ii.*) energy efficiency, *ii.*) waste, *iv.* atmospheric emission, *v.* product feature, and *vi.*) end-of-life options.

2.1.2.1. Material

The selection and use of materials are crucial aspects to consider in the design and production of environmentally responsible furniture. The material chosen has a significant influence on a product's environmental performance, determining its energy efficiency in manufacturing and usage, as well as how readily it can be recycled and if it poses a threat when discarded. Material selection should begin early in the design phase, with consideration given to the utilization of the product, the possibility of recyclability, and required performance qualities. Designers should attempt to use a material that is suitable for the product's intended usage. There is a lot of debate about whether some materials are inherently less environmentally friendly than others. Some may use more energy or nonrenewable resources in their manufacturing, but they may last longer. Some materials are simpler to recycle, whereas others are tough to deteriorate quickly and safely (Deniz 2002: 83). Some of the things to consider in the selection and usage of materials for environmental sustainability are stated below:

1. Minimum use of materials: Using less material in the production of a product helps in the reduction of resource consumption. Additionally, the benefit of less material usage can be seen in the product lifecycle from the reduction of pollution and energy in manufacturing and use to the minimization of waste (Deniz 2002: 85).

2. Usage of recycled materials: Reduction of the product’s environmental impact can be achieved by the use of recycled and recyclable materials. Recycling reduces waste and is usually more energy efficient.

3. Biodegradable materials: Many petroleum-based products and materials have issues with resource sustainability and disposition after their useful lives are over. Biodegradable materials derived from resources that are able to be renewed can be employed in product development to tackle such issues (Fouad and Farag 2019: 39).

4. Using renewable materials: Materials that can be produced or developed fast enough to sustain their usage are considered renewable. These materials can be created naturally or can be synthetic ones. However, non-renewable materials take a longer time to be recovered.

5. Reduction of material variety: Using less variety of material helps mainly at the end life cycle stage of the product facilitating the product recyclability. Additionally, a reduced material variety means fewer manufacturing complications and steps, having an advantage in efficient energy use and cost reduction.

6. Avoiding Toxic materials: Hazardous substances and chemicals in materials used to produce a product not only impact the environment but also danger to health and cause cancerous diseases. The goal of designers is to choose materials with less toxic properties (Süzer and Yilmaz 2010: 834).

2.1.2.2. Energy Efficiency

Energy is another important parameter to take into account in the design and manufacturing of environmentally sustainable furniture. Using resources efficiently in order to make effective use of the resources and avoid waste is the primary goal of environmentally aware design (Deniz 2002: 88). The production of furniture requires a large amount of energy. Energy use and production have placed a significant negative impact on the environment, both in terms of resource usage and pollution. The usage of fossil fuels in the manufacturing process results in the emission of greenhouse gases (Krajnc and Glavic 2003: 285). Apart from the manufacturing stage, during the design stage, designers should be able to identify the better alternative energy sources available. Criteria to consider in the selection and usage of energy for environmental sustainability are stated below:

1. Reduction of energy use: The quantity of consumed energy during the manufacturing of furniture should be minimized to create efficiency. Different manufacturing procedures

might need various levels of energy consumption. By addressing the environmental effect of various production processes, furniture designers may minimize energy usage during the manufacturing phases (Okursoy 2012: 12).

2. Use of low energy content material: The energy content of material also known as embodied energy is the energy used in the extraction, processing, production, and delivery of materials. The usage of renewable resources, materials having durability, and materials transported locally with the use of low energy are some characteristics of low energy content materials (Schneider 2018).

3. Renewable energy consumption: Oil, coal, and gas-based energy sources have a great environmental impact; however, they are highly beneficial in improving countries. Renewable energy sources are believed to have a less environmental, social, and economic impact. These resources are solar, hydropower, wind, geothermal, biofuel, ocean energy, and others generating 15–25% of the energy used worldwide (Kumar 2020: 227). Exhibiting reduced or no exhaust and toxic gas emissions these energy sources cause low environmental pollution. The generation of wind energy is thought to consume the least amount of water, emit the minimum greenhouse gases, and have the finest social effects. It is regarded as one of the most environmentally friendly renewable energy sources, before geothermal, hydropower, and photovoltaics (Kumar 2020: 227).

4. Reduction of energy use during transportation: Energy use in the transportation of material or product can be minimized by reducing the distance by using locally produced materials. Additionally, the use of assembly and minimal packaging reduces energy use during transportation.

2.1.2.3. Waste

The environment and human health are in greatest danger today because of the rapid aggregation of waste over the entire globe. The furniture industry plays a great role in producing waste, especially at the manufacturing stage. Material wastage occurs during mass production and custom design furniture production (Koo et al. 2017: 2627). Waste is a result of errors in the manufacturing process and reflects a failure in the product design and the process. As the ultimate goal of sustainability, governments, various institutions, organizations, and businesses are attempting to create, promote, and implement a zero-

waste approach (Krajnc and Glavic 2003: 286). The waste indicators show how well the firm is doing in terms of waste reduction. Some of the indicators or criteria of solid waste are as follows:

1. Reduction of waste from production: Waste reduction is an issue that runs parallel to enhancing material efficiency. Production procedures, on the other hand, might generate additional waste such as pollution and production materials (Okursoy 2012: 12).

2. Generation of dangerous waste: Toxic waste materials generated during production have a serious negative effect on the environment and both consumers and employees suffer from major health problems as a result of the generation of toxic wastes. Furniture firms should give attention to these criteria to achieve environmental and social sustainability.

3. Reducing waste from packaging: The packaging of products uses a lot of resources and generates a large quantity of waste. As a result, the environmental effect of packaging is enormous (Zhang and Zhao 2012: 901). Packaging produces solid, liquid, and gaseous pollution. Glasses, plastic, paper, metals, and other materials are included as waste packaging materials. Chemical wastes that are released from the packaging will be in contact with rain and create liquid wastes that will flow into the environment and create great damage which affects health. In order to avoid such problems, green packaging can be a solution. Green packaging is characterized as environmentally friendly packaging composed entirely of natural plants that can be recycled or reused, and during the product's life cycle, it does not damage humans or the environment (Zhang and Zhao 2012: 902).

4. Waste disposal management (liquid, solid): Solid and liquid wastes generated during the production of furniture should not be just thrown into the environment and the company should implement a proper waste management system to decrease the pollution of the environment.

5. Recycling waste: Waste from production needs to be collected and recycled instead of being thrown into landfills. Recycling has an advantage in reducing the impact of waste on the environment. Furthermore, recycling helps in conserving resources and reduces pollution by minimizing the need to gather additional raw materials.

2.1.2.4. Atmospheric Emissions

Concerns on the earth's climate change have risen recently due to the concentration of pollutant gasses in the atmosphere as a result of different human activities. Due to their numerous environmental impacts (stratospheric ozone depletion, acid rain, greenhouse effect with climate change, etc.), air emissions are particularly important (Krajnc and Glavic, 2003: 287). In fact, finding a good solution to these problems is very essential for the survival of our planet Earth. The cause of global warming or climate change is the increase in greenhouse gasses in the atmosphere. The great accumulation of gasses like Co2, water vapor, chlorofluorocarbons, nitrous oxide, and methane makes the atmosphere warm. Additionally, fuels burned as a source of heat, electricity, and energy for different human activities such as manufacturing and transportation cause emissions that are toxic and pollute the environment and create a great impact on health. Atmospheric emission indicators measure firm's awareness on emissions that pollute the environment and the attention they give to complying with standards that aim to reduce pollution. Indicators to consider in reducing atmospheric emissions are listed below:

1. Comply with clean air and climate protection strategy: Nations develop clean air and climate change strategies based on UN climate action plans and UN environmental programs which aim in reducing greenhouse gasses, minimizing environmental impacts. These strategies should be implemented by governmental, public, and private sectors to minimize environmental impact and pollution.

2. Minimizing atmospheric emissions (NO2, CO2, SO2, and CH4): Manufacturing companies are responsible for the production of pollutant gasses that cause danger to human health and the environment. Using methods that are useful in reducing the amount of these pollutant gasses is critical. Nitrogen dioxide (NO2) and sulfur dioxide (SO2) are hazardous gasses that create acid rain when in contact with water in the atmosphere (Clean Air Technology Center 1999:1). Manufacturers can adapt pollution avoidance techniques and technologies to reduce this pollution. Methane (CH4) is a greenhouse gas that is an important cause of climate change and primary precursor of tropospheric Ozone. According to the UN Environmental program, over a 20-year period, methane warms the globe 86 times more than carbon dioxide (CO2) (United Nations Environmental Program

(UNEP) n.d.). Measures on the use of fossil fuel usage and waste management should be taken to minimize the emission of such gas in the environment.

2.1.2.5. Product Features

Incorporating design features of a product that help in the minimization of resources, at the early stage of the product development is crucial in achieving a more efficient product. The sustainable principle requires long-lasting items that do not take a lot of resources in the process of making them, using them, maintaining them, and fixing them (Krajnc and Glavic 2003: 286). Product indicators measure the use of some product properties to minimize the use of resource and environmental impacts. Product indicators to consider while designing and developing sustainable products are listed below:

1. The extended life span of the product (Durability): Durability is a concept of being able to use a product for a long period of time. This can be accomplished by locating and removing any potential weak areas in the design, especially for functional elements and components (Deniz 2002: 72). Designers should use durable materials and products should be made so that they can be upgraded in the future.

2. Modular product design: In a system, a module is a unit that functions independently of other units structurally while collaborating with other modules to accomplish a common objective (Tobler and Josefsson 2017: 5). The utilization of modular product design has grown due to its ability to boost manufacturing efficiency. Tobler and Josefsson (2017: 6) explained that minimizing interacting elements between the assembled parts is one objective of a product architecture based on modularity.

3. Multi-functionality: This feature allows for the diversified utilization of a product/system, as well as the optimization of use and an equalized need for energy in use (De Almeida Souza and De Barros Pereira 2006: 276). Deniz (2002: 83) stated that multi-functional products are naturally eco- efficient. Two types of multi functionality can be applied in a product; firstly, is where a single product can be used for a number of distinct purposes at once and secondly, a product can be put to use for something else after being retired from its main usage (Deniz 2002: 83).

2.1.2.6. End-of-life Options

End-of-life options are developed to increase the useful life of a product with identical amounts of energy and material use (Chang et al. 2014: 57). Given the present issues with environmental waste effect and landfill saturation, selecting an acceptable end-of-life placement for used product is developing into a significant strategy for the majority of manufactured products (Remery et al. 2012; 419). Designers should make decisions regarding this at the beginning of product development by taking into account the product's characteristics. Remery et al. (2012: 420) stated that mostly designers do not have enough knowledge on end-of-life evaluation methods of a product. End-of-life indicators to be considered at the end of product use to minimize waste are as follows:

1. Product recycling: To lessen products' impact on the environment after it has served its purpose and to get advantage, products can be recycled after components are disassembled to produce new products (Okursoy 2012: 13).

2. Reusability of a product: According to Life cycle design, reusability of a product is the potential of product's usage in various settings, or second life cycle (De Almeida Souza and De Barros Pereira 2006: 276). Reusability decreases the tendency of a product being a waste after use. Reusability of a product can be achieved by using design strategies such as modularity and durability at the beginning of the product development stages. Cooper & Gutowski (2017: 12) stated that under the correct conditions, a reused product's life cycle energy may be lesser than a new product resulting in a positive impact on energy efficiency.

3. Enhancing remanufacturing: Remanufacturing is a criterial waste reduction strategy in which includes gathering used products, disassembling, replacing defective parts, reassembling, and selling them (Deniz 2002: 106). New marketing methods are required as a result of adjustments in the customer-manufacturer relation (Östlin et al. 2008: 4). Moreover, remanufacturing companies depend on customers returning used products.

2.2. SOCIAL DIMENSION

The social dimension of sustainability focuses on human progress and the ongoing change between people and organizations. Governments, civil society, corporations, and citizens must communicate to make decisions about how the world should be and how it

might be improved (Dişli Bayrkatar & Ayyildiz 2021: 194). A lot of research has been done and written on the environmental and economical dimensions of sustainability, however not much has been done in terms of the social aspect of sustainability (Sutherland et al. 2016: 690). This dimension of sustainability is engaged with a wide range of topics, including equity, governance, safety, labor rights, diversity, justice, and human health, to name a few. As a result, understanding and implementing social sustainability is challenging due to the wide range of concepts related to this dimension (Sutherland et al. 2016: 691). Watkins (2014: 48) explains that literature on this topic is scarce and promotes two differing viewpoints on how ethical and social concerns might be addressed during the product development process. The first evaluates the broader social and ethical concerns surrounding the product's source and manufacturing, as well as the impact on the local community and employees. The second one focuses on the user's social demand, integrating features of functionality, incorporating ergonomics and other design specialties, using and creating in a socially relevant manner to address particular human needs, design for the elderly, anti-crime design, and design that is both compressive and universal (Bhamra & Lofthouse 2007, cited by Watkins 2014: 46). Some researchers such as Littig & Grießle (2005) study social sustainability in link with other concepts such as environmental sustainability and stated that sustainability arises from a desire to comprehend social processes involving the interaction of society with nature. On the other hand, McKenzie (2004: 13) states that before seeking to assess its impact on environmental parameters, social sustainability must first be described independently from economical or environmental sustainability. This will allow for the development of best practice models.

2.2.1. Approaches to Social Sustainability

In the literature, the social sustainability concept is explored from two perspectives; the first one is social design (Watkins 2014) and the second is social impact (Sutherland et al. 2016). Social design explores the possible design principles that are used in the design stage of a product that focuses on how social considerations and the use of friendly designs help in achieving social sustainability. Social impact focuses on the effects of public or private actions on culture, human interactions, relationships, and

organizations. Social impact from the product design and manufacturing point of view can be defined as the direct and indirect consequences experienced by stakeholders as a result of the design and manufacturing firm (Sutherland et al. 2016: 695).

2.2.1.1. Social Design

Social design is the concept of making society a center point when designing a product. In the literature, several areas of social design are broadly discussed, especially user-centered design methods (Watkins 2014: 54). User-centered design is a method of designing that places the user at the center of the process rather than the product. The interdisciplinary framework of product design involves the use of the user's desires, expectations, and experiences in the design process while developing the product's aesthetics, functions, and marketing (Cinoğlu & Şahin 2019: 572). User design or social design means creating designs that the society or user requires (Endsley et al. 2003: 12). By putting the user and society at the center of the product design process, the creation of more efficient and usable designs for a product can be achieved. Approaches that are used to create user-centered designs and fulfill the benefit of the society are discussed in the literature.

1. Designing for the developing world

Developing designs to fulfill the demand of developing countries is an old concept in social design, with various authors citing it (Watkins 2014: 55). Whiteley (1993) stated that design for third world countries should be both culturally and socially compatible. Additionally in this setting, designs ought to be economical, provide local jobs, utilize indigenous skills and materials, and design should be quite uncomplicated to allow for local repair and maintenance (Whiteley 1993, cited by Watkins 2014: 55).

2. Design for the other 90%

Watkins (2014: 55) states that design for the remaining 90% is a highly complicated concept that acts as an umbrella term for a variety of social design challenges. 90% of the population includes people who have restricted ability to purchase including the disabled, the elderly, and the underclass with little earnings. The wealthy ones, which get benefits from the majority of the earth’s resources, are 10%. Design should not be made only in consideration of the richest segment of the society but also considering the

remaining 90%. The other 90% are also referred to as consumers that are concerned with the existence and attempting to meet their basic physiological demands, according to Fuad-Luke (2009).

3. Participatory design

The basic premise of participatory design is that those who are impacted by a design must have a voice in the design phase (Bjögvinsson et al. 2012: 103). It is a design approach that is broad in social sustainability which explores how the user might be taken into account and incorporated into the design development process of a product (Watkins 2014: 59). This concept is also mentioned in other approaches such as design for the developing world.

4. Universal/Inclusive design

The goal of universal design is to make the built environment, products, and services more functional and serviceable by as many people as possible at little or no additional expense. As a result, Universal design serves individuals of different ages and capabilities, and the principles of universal design are sometimes referred to as "design for all" and "inclusive design" (Vavik and Keitsch 2010: 296). Design is frequently connected with the creation of aesthetically pleasing, high-priced items, however, in the Rio Declaration in 2005, it was mentioned that designers may also play a role in improving social living quality (Vavik and Keitsch 2010: 295).

"*Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design"* (The Center for Universal Design - About UD, n.d.). Additionally, The Rio Charter on Universal Design for Sustainable and Inclusive Development describes seven basic universal design (UD) principles, and these principles are cited by several studies in the literature (Watkins 2014: 57; Vavik and Keitsch 2010: 298).

- ***Equitable Use:*** None of the users will be stigmatized or disadvantaged by the design.
- ***Flexibility in Use*****:** Individual desires and abilities are met by the design.
- ***Simple Use:*** Despite the user's experience**,** expertise, or language skills the concept is simple to use.

- ***Perceptible information:*** Despite the user's sensory ability, the design successfully delivers important information.
- ***Tolerance for Error:*** Dangers and negative outcomes of unintentional activities are minimized by the design.
- ***Demanding little physical effort:*** Comfortable, efficient, and fatigue-free use design.
- ***Size and Space for Approach and Use:*** Despite the user's body posture, size, or flexibility, sufficient access, and usable space are provided.

5. Localization

Walker (2010: 25) identifies a localized type of situation in which components are manufactured locally and facilities such as design, manufacture, remanufacture, upgrade, repair, and recycling are provided locally, resulting in opportunities for local employment with acceptable wages, work environment, and environmental policies.

6. Personal Meaning

Personal meaning can be created in products by creating a culture and personal identity opportunities, chances for values related to an individual's private, biographical, and emotional existence as well as creating more emotionally durable connections with items that are customized (Watkins 2014; 60). Personal meaning was cited as sustainability's fourth pillar by Walker (2010: 11), highlighting how existing sustainability strategies lack an emotional connection.

2.2.1.2. Social Impact

The direct or indirect consequences perceived by stakeholders are referred to as a social impact. Direct effects are frequently easily recognizable, quantifiable, and physically constrained, while indirect impacts do not have to be adjacent to a corporation (Sutherland et al. 2016: 695). The social impacts of a product are mainly discussed concerning the manufacturing stage in the literature. Sutherland et al. (2016: 695) stated that a company has visible and quantitative effects on various social groupings as a result of its production operations and effects can vary from good to unquestionably negative, such as supporting slavery or enabling gender or racial discrimination. By linking the consequences of activities across the life cycle of a product, (UNEP et al. 2009: 46) offers

a complete taxonomy of social impact to stakeholders and quantitative impact groups. Cultural heritage, human rights, administration, work environment, health and safety, socioeconomic ramifications, or, more broadly well-being of humans are the groups that were examined (UNEP et al. 2009: 45).

When discussing the impacts the production of products has on society, the first things to consider are the stakeholders. It is necessary to investigate and discuss the direct and indirect stakeholder categories impacted by the product developing firm in order to comprehend social impacts on stakeholders (Sutherland et al. 2016: 295). Freeman (2010) states that a person or a group of people that are influenced by the accomplishment of a company's goals are referred to as stakeholders.

Stakeholder categories are defined by (UNEP et al. 2009: 46) as a set of stakeholders having common interests within the researched product system across the course of the life cycle of a product. Stakeholder groups are explored widely in the literature. Sutherland et al. (2016) explore stakeholder groups that are impacted by the manufacturing of a product and discuss the indicators that measure the impact on them. The explored stakeholder groups are employees or workers, owners, customers or consumers, suppliers, and the local community. However, this study focuses on the user's perspective of social sustainability and the impact on the stakeholder groups related to the user, and the indicators to measure them are discussed broadly. Two stakeholder groups related to the use of the product which are, customers/consumers and society/ local community are assessed in this study. Society is affected by the development process of the product.

2.2.2. Parameters of Social Sustainability

In this section, parameters that are used to measure a product's social sustainability from the perspective of two stockholder groups are discussed. The parameters of social sustainability are constructed into two category groups, which are: *i.*) User-centered (9 parameters), and *ii.*) Societal concerns (6 parameters).

2.2.2.1. User-Centered Parameters

The customer or user is the company's first focus, and any end-user of a service, product, or process is considered a member of this stakeholder group (Sutherland et al. 2016: 297). Sarkar et al. (2011: 947) state that customer indicators include effects of production and usage on consumers' health and safety, contentment with product and operation, and compliance with and consideration of particular customer rights. The identified components of such customer indicators represent the firm's capacity to fulfill customers' needs in terms of sustainable processes and product consumption (Sarkar et al. 2011: 947). Parameters to consider for the purpose of achieving and measuring a product's social sustainability having the user as a center point are stated below:

1. Design for elderly and disability: The aged and disabled have special requirements when it comes to using a product. Satisfying the needs of this group of people is crucial in the creation of socially sustainable products.

2. Design for user's health and safety: Toxic materials used in the development of a product not only have a negative impact on the environment but also have a negative impact on the user's health. Additionally, users' safety while using the product should be protected.

3. Design for the needs of the future: The needs and style of a product change from time to time. When products go out of trend, users will not be able to get the functions they want from the product anymore, and they will go for a new trending product. Future needs should be considered in developing a product to create long-term customer satisfaction through design for upgradability. Customer Preference trends, technological trends, and other competing product trends throughout different generations should be considered by the designers (Umemori et al. 2001: 88).

4. Participatory design: Consideration and participation of the user in the design process of a product is important in creating a design that satisfies the needs of the users**.**

5. Emotionally durable design: Emotional design focuses on creating a special emotional connection between users and products. Chapman (2005: 18) stated that creating more customized products having personal meaning can assist in the development of a more emotional long-lasting connection between the product and the user. If a user is connected

to a product, it most likely uses the product for a longer period of time with high satisfaction, having a benefit in the reduction of waste to the environment as well.

6. Customer satisfaction/ feedback mechanism: Getting feedback from customers is an important way for a firm to improve its products. In the pursuit of customer satisfaction, companies create easier ways for customers to give feedback.

7. Culturally sensitive design: The definition of culture is broad and interpreted in various forms. However, when it is examined in terms of design, it focuses on the behavior of the users. Designers should study the users in terms of product demands and be able to deliver products that are in line.

8. Transparency: Companies should be able to give clear information about their products design strategies and sustainability reports. This improves the relationships between customers and firms.

9. Quality of life: When products fulfill the demands of the users and their satisfaction of life standards are met by the products, quality of life is achieved.

2.2.2.2. Societal Concern Parameters

Addressing the demands of a particular community or society other than the user might be challenging for a firm. The needs of society can be issues related to the impact or benefits they can get from the firm, such as health and safety, localization, and ethics. The following parameters to consider for the purpose of achieving and measuring a product's social sustainability with the user as a center point are stated below:

1. Health and safety of the neighborhood: The neighborhood is highly affected by the manufacturing process of a product. Toxic emissions out of a factory go straight into the neighborhood, causing air and water pollution and having an impact on the health and safety of the people living or working around it. To avoid such harm, companies should be cautious about their waste management mechanisms.

2. Localization: As stated earlier, localization is a concept of using local materials and services for manufacturing, remanufacturing, repairing, and recycling by offering opportunities for local suppliers and employees**.** It has a greater benefit of improving the economic status of the local people.

3. Ethical design: A firm fulfilling this indicator causes no harm, satisfies human and labor rights, and takes community and worker responsibility

4. Noise complaints: Companies should meet the rules and standards of noise level for a specific area. Noise-polluting sounds from a factory can be produced by different types of machinery and can potentially harm society and the employees. Repairing machinery on a regular basis, replacing older machines with updated models, and adopting low-noise policies throughout the company can help to create a working environment that is healthy for the ears. Using noise-absorbing acoustical treatment on the walls of the factory will prevent noise pollution in the neighborhood.

5. Odor complaints: Furniture products can emit a wide range of volatile compounds that create odors. Coatings applied to products' surfaces are primarily responsible for such odor emissions (Bulian & Fragassa 2016: 357). In enclosed settings, this pollution has an impact on people's health and safety. As a result, careful consideration by firms should be paid to the composition and application of such products.

6. Dust complaints: Exposure to wood dust is a common risk in the wood furniture sector. Wood dust is produced through a variety of activities, such as the transfer of raw materials, cutting, planning, drilling, installation, and finishing.

2.3. ECONOMIC DIMENSION

The economic dimension reflects a method of generating, spreading, and consuming wealth, which is often characterized as a mechanism of fulfilling people's material demands through property, money, ownership of products, or anything else with monetary worth (Herremans and Reid 2002: 17). According to Kim et al. (2015: 184), comparing it to other dimensions of sustainability, this dimension of sustainability has attracted the most attention.

A company's activities such as financial performance improvement and adding value to the business are the main focuses of this dimension of sustainability (Bansal 2005: 200). Value is formed by firms with the services and products they provide by enhancing efficiency (Bowman and Ambrosini, 2000: 5). Additionally, Conner (1991: 132) stated that value is developed through creating unique and new products that customers need, decreasing input costs, and attaining manufacturing efficiency. It was stated by Bowman

and Ambrosini (2000: 5) that a company realizes the value it makes and improves its financial performance when it manages to sell the product for a price that at the very least outweighs the product's expense. However, strong value creation often does not indicate high financial performance. When value is formed by a corporate, it spreads it to its users in the form of products and services, in the form of profit and equity to other stakeholders, and to employees in the form of earnings.

Lin et al. (2014: 32) stated that financial performance in financial reports is commonly conflated with economic performance in sustainability reports. The profitability and future success of the cooperation are measured by its financial performance. While economic performance in sustainability reports assesses the firm's impact on the economic situation of its stakeholders along with regional, national, and global economic systems (GRI 2006: 17). The Global Reporting Initiative (GRI) guidelines explain that the indicators of economic performance represent two key concepts, which are the distribution of capital among several stakeholders and the firm's major economic impacts on society (GRI 2006: 17).

2.3.1. Approaches to Economic Sustainability

In the literature, economic sustainability is mostly considered in terms of the company and its economic effects on different stakeholders. Borga et al. (2009: 172) categorized indicators of this dimension into two groups, which are economic performance and impact. In the economic performance part, the link between sustainability report and account, which includes information regarding applicable financial resources and economic activity, must be emphasized. Enterprise resource, which is about capital for operating purposes; equity among stakeholders and assets; and financial review, which is concerned with profit/loss and turnover, are the indicators of economic performance (Borga et al. 2009: 172). Economic impact, the second category group is concerned about the influence of a business on its stakeholders' economic conditions. All of the information is compiled into two indicators, which are the total quantity of purchases and the distribution of value created (Borga et al. 2009: 172). GRI (2006: 17) proposed indicators to measure the economic sustainability of a firm, which are presence in the market, economic performance, and indirect economic impact, where

each parameter includes sub-indicators. However, it is difficult to allocate studies in the literature that focus on approaches to achieve economic sustainability from the customer's perspective and the economic impacts of a firm's economic performance on customers.

Customers today take advantage of the accessibility of higher-quality products at reduced rates on the market (Zengin and Ada 2010: 5593). Developing a cost-effective product is the main aspect to consider in the effort to achieve economic sustainability from the customer's perspective. Maxwell & Van der Vorst (2003: 892) provided a checklist including the criteria to be considered in the development of sustainable products and services in all three dimensions. Three issues to consider while optimizing economic impact are proposed, which are the cost-effectiveness of the product, consideration of environmental externality costs, and whether the cost of the product is less than or the same as the competing products. The first approach to making a product cost-efficient is to reduce the costs throughout its lifecycle. This approach can be taken by developing methods or techniques to minimize the cost from the material selection phase to the end-of-life stage of the product. An economic assessment of a product is usually done by looking at the life cycle cost and manufacturing cost of a product (Finkbeiner et al. 2010: 3313). Life cycle costs are assessed from the customer's point of view while manufacturing costs are assessed from a manufacturer's perspective. The second approach is the implementation of some design strategies that help in minimizing costs for customers in the short or long run.

2.3.2. Parameters of Economic Sustainability

Parameters of economic sustainability collected from the literature that are used in measuring a product's economic sustainability with respect to minimizing cost for the users are discussed in this section. The parameters are constructed into two category groups, which are: *i.*) Cost minimization throughout the lifecycle of a product (4 parameters), and *ii.*) Design strategies to minimize cost (5 parameters).

2.3.2.1. Minimizing Cost throughout the Product Life Cycle

Developing methods or techniques to minimize the cost from the material selection to the end-of-life stage of the product allows cost minimization for customers. Parameters

to consider for the purpose of achieving and measuring a product's economic sustainability by having cost minimization for customers throughout the product life cycle are listed below:

1. Use of cost estimating methods at an early stage of product development: Prediction of cost at the beginning of product development is known as cost estimation (Rush and Rajkumar 2000: 58). Estimating costs at an early stage helps the company not to set the price of the product too high or too low and predict a price that makes both the customer and the firm advantageous.

2. Using local materials to reduce cost: Local materials are available at lower costs when compared to imported materials. Using these materials in production will decrease the operational cost of the product, minimizing the price for customers.

3. Cost minimization by efficient energy: Energy is used in different stages of the product life cycle, but manufacturing takes a large amount. Using cost-minimizing alternative energy sources and effective energy use can help in reducing the operating cost of a product.

4. Cost-efficient packaging: Optimized packaging is advantageous in conserving resources, reducing packaging material, and minimizing waste. This method should be incorporated during the design of a product. For instance, €1.2 million is saved by IKEA every year because designers discovered how to disassemble its Ektorp couch into numerous pieces, reducing packaging size by half (Chainalytics n.d.). This allows the reduction of purchasing costs for customers.

2.3.2.2. Design Strategies to Minimize Cost

Design strategies direct product development in terms of the desired outcome. Good design considers functionality, aesthetics, and environmental advantages as well as cost-efficiency. Parameters to consider for the purpose of achieving and measuring a product's economic sustainability having cost minimization for customers in the design stage are listed below:

1. Use of multi-functionality to reduce cost: When a product is multi-functional and provides flexibility in use, it means the user will need fewer products. Instead of using a

new product for the second function, the multi-functional item will serve more than one purpose, saving the customer from additional costs.

2. Design for assembly: This is a method that focuses on minimizing a product's assembly cost in the design stage. It gives detailed methods for evaluating cost and predictability throughout the design stage and hence offers cost-minimizing options (Ma et al. 2018: 2).

3. Designing products with fewer connecting elements and components: Material and component minimization at the early stage is important to reduce the operational cost of a product. Less number of components requires simplified steps and techniques during the manufacturing process following the need for a smaller number of workers and experts. This will reduce labor costs during manufacturing in addition to the reduced material costs (Perera et al. 1999: 111). When production costs are reduced, the ultimate market price is reduced as well (Xie 2016: 10).

4. Modular design: Ma et al. (2018: 2) stated that modular product design is one of the techniques to apply Design for Assembly. By having fewer assembly components and by enhancing pre-assembly and integrating similar connectors, modularity reduces assembly costs (Ma et al. 2018: 2). Modularity contributes to lower life-cycle costs by decreasing the number of procedures and repeating operations (Gershenson et al. 1999: 14). Additionally, modularity helps in reducing separation costs by minimizing the cost of detachment for remanufacturing and recycling.

5. Durable product design: In order to promote the design and manufacturing of products in such a way as to seek resource-saving and waste reduction, the durability of products is becoming more crucial within the scope of EU regulations towards a supply chain (Iraldo et al., 2017: 1353). Durability refers to a product's capacity to last its whole lifetime. Durability is advantageous in terms of lower cost for customers and decreased environmental impact. A durable product helps customers avoid purchasing new ones in a short period of time.

2.4. TOOLS FOR SUSTAINABLE PRODUCT DESIGN

The facilitating mechanisms for the implementation of sustainable product design concepts can be referred to as sustainable product design tools. While some tools measure the environmental impact of a company and its products, others assist companies in

determining the most effective sustainable product design approaches. Some of the most widely used tools are described below.

2.4.1. Eco-design Strategy Wheel

The Netherlands' Delft University of Technology developed sustainable value software known as Eco-design Strategy Wheel, which helps to improve the environmental performance of a product (Jeganova et al. 2004: 19). The tool also assists companies in determining the most effective eco-design methods for their business structure and industry (Brezet & Van Hamel 1997, cited by Okursoy 2012: 10). The tool is a "graphical representation of all possible eco-design strategies throughout the lifetime of a product," as stated in a statement from Delft University. The tool developed by Brezet and Van Hemel uses seven environmental methodologies used to measure a product's environmental performance: *i.*) Review of product design, *ii.)* Selection of low-impact material, *iii.)* Minimization of material consumption and techniques for improving production, *iv.)* Efficient distribution mechanism, *v.)* Minimization of impact while in use, *vi.)* Initial lifetime enhancement and *vii.*) End-of-life enhancement.

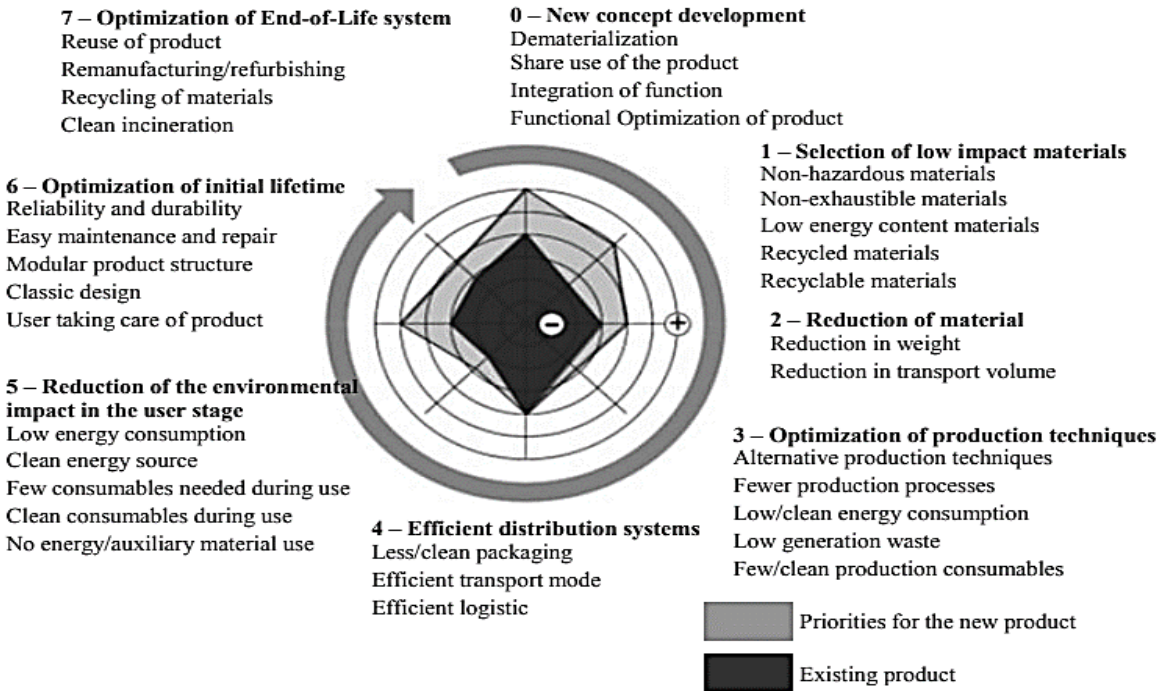


Figure 2.3: Eco-design Strategy Wheel by Brezet and Van Hemel (Hemel & Keldmana 1996, cited by Uysal 2014: 12)

This wheel was later modified, and Okala eco-design strategy wheel was designed by the American Society of Industrial Designers in 2003. This wheel contains eight environmental strategies to improve environmental performance. It is a life cycle assessment method that provides a broader view of various design strategies in order to understand the product life cycle, which helps to estimate the impact until the end of the product (White et al. 2013: 2).

Table 2.1: Strategy of Okala eco-design wheel (White et al. 2013)

Okala eco-design strategy wheel	
Design for Innovation	**Design for Reduced Material Impact**
-Reconsidering was of delivering the advantage -Providing the product as a service. -Design adaptability for new technologies -Share with a multiple user -Living organism usage in product -Meet requirements offered by similar products -Design by mimicking biological system	-Avoid usage of materials which harm human or environmental health. -Materials that degrade natural resources should be avoided. -Minimization of the amount of material -used -Use of recycled materials -Use of renewable materials -Make use of waste byproducts -Use materials from recognized certifiers
Design for manufacturing innovation	**Design for Reduced Distribution Impacts**
-Reduce production waste -Design for quality in production -Reduce production energy use -Use energy sources that are carbon neutral -The production process should have lower complexity fewer steps -Reduce number of parts/materials used -Make an effort to eliminate harmful emissions.	-Weight reduction of the product and packaging -Create reusable packaging systems -Volume reduction of the product and packaging -Using the least harmful mode of transportation -Use locally sourced material and production
Design for Reduced Behavior and Use Impact	**System Longevity**
-Design for low consumption encouragement -Reduce the amount of water consumed during use -Reduce the amount of material consumed during use -Elimination of hazardous emissions while in use -Reduce the amount of energy during use -Design for carbon neutrality or renewable energy	-Encourage emotional attachment to the product. -Durable design -Design for easy repair and maintenance -Reusable design- -Produce a timeless aesthetic appeal

Table 2.1 Continued

Design for Transitional System	Design for Optimized End-of-life
-Designing upgradable products -Component re-use -Reuse for another variety of functions	-Design for automated or manual disassembly -Design business model which is recycling -Use of non-toxic recyclable materials -Biodegradable ability -Disposal-friendly design

2.4.2. Life Cycle Sustainability Assessment

Life cycle sustainability assessment is an assessment that considers the three dimensions of sustainability: social, economic, and environmental to evaluate sustainability in the design and manufacturing of products. The LCSA plan includes the three methods of assessment, which are Social Life Cycle Assessment (SLCA), Life Cycle Costing (LCC), and Life Cycle Assessment (LCA).

LCA assesses the damage a product causes to the environment throughout its life cycle. The European Commission states that LCA is the best applicable mechanism for examining the environmental impacts of production and design (Chang et al. 2017: 223). LCA is a cradle-to-grave approach to evaluate manufacturing processes. Cradle-to-grave is a system that starts with collecting raw materials from the earth with the purpose of creating a product and, in the end, the return of all materials used to the earth. LCC assesses various costs within the life cycle of a product and design to achieve economic sustainability. This tool was found in the mid-1960s. It is the oldest of the three assessments. According to ISO, LCC is defined as a mechanism that permits comparative cost evaluations (by considering initial and future practical costs) within a specific time frame. Lastly, SLCA aims at evaluating the socioeconomic and social effects of products and production. It investigates both the positive and negative effects along with their life cycle. The impact may influence the concerned stakeholder groups: local communities, consumers, workers, and chain actors. It is proposed that SLCA relies on the ISO 14040 framework but has some adaptations added to it (Grießhammer et al. 2006: 3).

2.5. SUSTAINABLE PRODUCT CERTIFICATES

Sustainable product certification systems, mostly known as green product certifications, are meant to verify that a product complies with a set of criteria and benefits

the environment (Vierra 2018: 4). They give knowledge about some environmental issues relating to a product or service. The goal is to inform and persuade consumers and professionals to consider such concerns when selecting between products and services (Frydendal et al., 2018: 578). Certification programs are classified as multi-attribute and single-attribute depending on the parameters they depend on to certify products. Multi-attribute certification systems and labels verify products depending on the parameters of their lifecycle, such as energy use, air and water emissions from manufacturing use and disposal, as well as recycled content. Single attribute certifications focus on one environmental issue, such as energy, water, and material chemical emissions that impact the environment (Vierra 2018: 4). When a neutral third party certifies the product after undertaking a product evaluation, it is considered to be the most reputable green product certification. When the certifier is independent and does not have any relationship with the designer, contractor, product manufacturer, or specifier, it is referred to as a third party. They also provide designers, customers, and others with more confidence that a product promises its sustainable features. In addition to environmental concerns, there are labels that deal with other aspects of sustainability, such as ethical and social issues. Frydendal et al. (2018: 579) stated that most green labels are voluntary, but in rare circumstances, they are mandatory, and they gave the European Union (EU) energy label, which is governed by the EU's Energy Labeling Directive, as an example of a mandatory green label.

The international organization for standardization (ISO) has begun working on a set of standards and principles for several kinds of environmental labeling in order to assist in the development of volunteer programs. According to ISO, there are three types of green product certification labels that are defined in the ISO 14020 series. The three types of labels are explained below.

Type I (Ecolabel)

Environmental labels classified as Type I are those that are voluntary, based on several attributes, third-party validated labels, and based on ISO 14024. By using Lifecycle Analysis, they express a general preference about a service or a product within a given product group, in terms of the environment (Skinner 2015: 9). Moreover, this label helps in the stimulation of continuous improvement of the environment.

Type II (Self-declared Environmental Claims)

Environmental certifications classified as Type II are based on ISO 14021 and are also voluntary. They come in the form of claims, labels, declarations, and stamps or in a more complicated grading scheme. They are single-criteria claims focusing on issues such as emission, energy consumption, or recyclability.

Type III (Environmental Declarations)

Certifications classified as Type III are voluntary, made up of verified product data depending on life cycle impacts, and are based on ISO14025. A reasonable and informed third party determines the environmental criteria, and after that, firms collect the relevant data into a reporting format, which is then independently confirmed. Third-party certification is required for this type of ecolabel.

Apart from these three typologies, there is a fourth category known as "Type I-like" that follows the same verification and certification procedure as Type I. However, it focuses on one attribute and deals with one environmental problem, and in their applications, they only examine a single life cycle phase (Skinner 2015: 9). For governments to encourage environmental practices as well as for businesses to discover and build markets for environmentally friendly products, green product certifications, also known as labeling, are a vital tool. Many nations have adopted some sort of labeling, while others are considering the development of certification programs. Some examples of green product certifications are examined below.

2.5.1. Environmental Product Declaration (EPD)

A transparent and comparable document providing information about the environmental impact of a product across its entire life cycle is known as an Environmental Product Declaration (EPD). It is independently evaluated and registered. The EPD program is an international system derived from EN 15804 and ISO 14025 for environmental declarations (Vierra 2018: 8). EPD is a regulated document that informs consumers about a product's possible impact on the environment and human health. The certification system is voluntary, multi-aspect, environmental only, LCA based and needs a third party for verification, having a 5 year validity (Minkov et al. 2018: 14). EPDs are

prepared from data provided by the product's technical description, manufacturer details, and LCA. LCA of a product is conducted in three processes:

***Upstream process*:** Raw material extraction and production operations, as well as the creation of auxiliary materials, chemicals, and packaging materials, are all included in the upstream processes.

***Core process*:** Transportation of materials to the factory and manufacturing activities are two core processes.

***Downstream process*:** Transportation from the factory to the customer, product consumption, and product and package disposal are examples of downstream operations

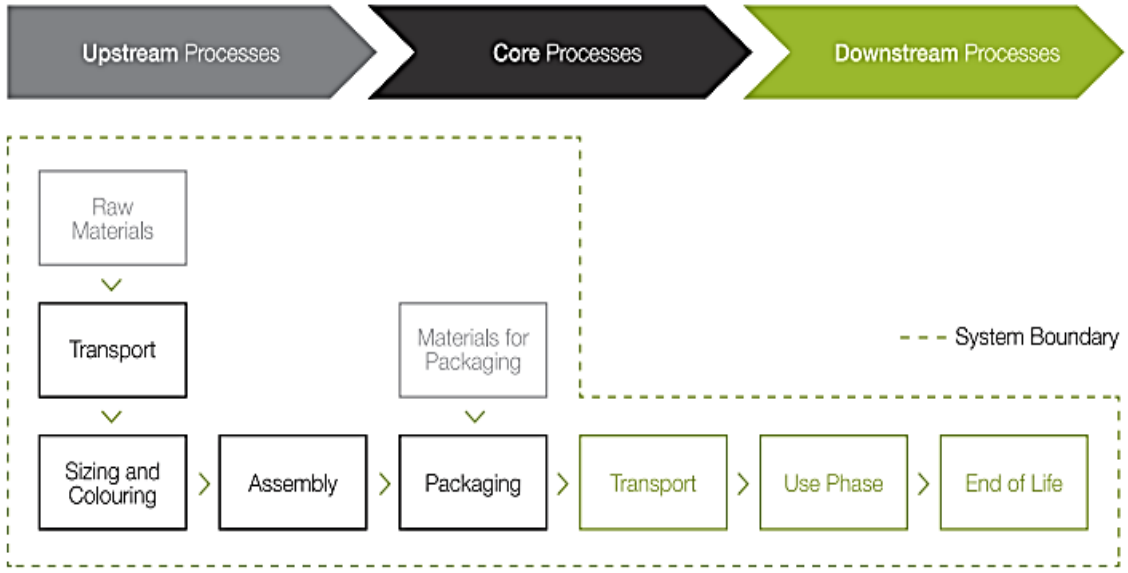


Figure 2.4: Lifecycle process of EPD certification (EPD 2018a: 6)

The life cycle of a product is assessed under environmental indicators such as resource use (non-renewable resources, renewable resources, water use), waste categories (toxic waste discharged, discharged nonhazardous waste, discharged radioactive waste), output streams (reusable components, exported energy, recyclable materials, materials for regenerating energy) and environmental impacts (EPD 2018a: 8).

2.5.2. BIFMA LEVEL

BIFMA LEVEL is a certification by the Business World and International Furniture Manufacturers Association. It is the furniture sector's sustainable standard, which is third-party certified and has multi-attributes. The goal of this voluntary standard is to develop performance requirements that include environmental and social elements across the supply network to give market-based criteria for a product that is more sustainable (BIFMA 2011: 1). It is the most comprehensive standard created for furniture. This standard applies to all commercial and institutional furniture, as well as suppliers' components and materials provided for furniture producers. LEVEL 1, 2, and 3 are the three performance tiers in the LEVEL program. The more criteria are evaluated and satisfied, the higher the number (LEVEL Certified-BIFMA, n.d.). LEVEL considers a product's environmental consequences, a company's social actions, as well as impact, health and wellness risks, to determine how a product is sustainable from several viewpoints. It evaluates products in four categories: *i.*) Materials, *ii.*) Energy and the atmosphere, *iii.)* Human and ecosystem health, and *iv.)* Social responsibility (BIFMA, 2011).

2.5.3. Cradle to Cradle Certified Products Program

McDonough Braungart Design Chemistry (MBDC) introduced C2C Certified in 2005. Cradle to Cradle Products Innovation Institute (C2CPII) was founded by William McDonough and Dr. Michael Braungart in 2010 to help grow C2C certification internationally (C2CPII 2021: 2). The certification is a multi-attribute, voluntary, generic, private, and non-LCA-based certification system that applies to materials, final products, and sub-assemblies according to the C2C Certified Products Standard (Minkov et al. 2018: 3). C2C Certified Products Standard v4 (C2CPII 2021: 3) stated that the Cradle to Cradle design concepts are the basis for the requirements of the certification. Products are evaluated in five key categories, which are listed below:

- ***Material Health*** - Materials and chemicals included in the product are chosen with human health and environmental protection in mind, resulting in a beneficial influence on the quality of resources accessible for future use and recycling.

- ***Product Reutilization-*** The intentional design of products with their next use in mind to be recycled.
- ***Climate & Clean Air Protection-*** Product production has a favorable influence on air quality, greenhouse gas balance, and renewable energy supply.
- ***Water & Soil Management-*** Water and soil are seen as valuable and communal resources. Watersheds and soil ecosystems are preserved, and humans and other species have access to clean water and soil.
- ***Social Fairness-*** Protection of human rights and the use of fair and equitable business practices should be a priority for companies.

The C2C Certified Products Program is founded on the principle of continual progress; therefore, each of the standard's five core criteria areas has four attainable degrees of achievement: Bronze, Silver, Gold, and Platinum (Minkov et al. 2018: 3). In contrast to eco-labels with a single feature, this program provides an all-inclusive approach to evaluate a product's design and production methods (Vierra 2018: 7).

2.6. INTERNATIONAL EXAMPLES OF SUSTAINABLE FURNITURE

In this section, six example products that are designed by designers and firms are presented. The products are selected based on the sustainability strategies and techniques they used.

Table 2.2: Examples of international sustainable furniture and strategies used

Products	**Sustainable Strategies used**
Spooty Chair	Recyclable materials, cost-efficient
Rocking Chair	Low-cost, recyclable, durable
Mira Chair	Recyclable, reuse, design for disassembly
X2	Recyclable materials, cost-efficient, multi-functionality, modular design
HÅG Tion	Reduction of material variety, low carbon footprint, recyclable and renewable materials, durable, design for disassembly

2.6.1. Spooty Chair by Peter Murdoch

When Peter Murdoch made furniture using materials such as Gunnar Andersen's newsprint in the 1960s, it attracted the attention of many designers. Pulp PLA (biodegradable plastic) created by combining with material thin sections has increased the

property against weight, stress, moisture, and temperature (Karaca 2018: 59). The material was useful because it was cheap and easily recyclable. Murdoch's use of paper material in furniture design, in terms of protecting ecology, has remained in mind as a very important contribution. Although the design paper is supported by mixed materials, its load bearing capacity is very low. The furniture was designed for children with paper material that is recyclable, provides more economical use, and has been effective in creating a form. However, its short life span can be seen as a drawback (Yüksel and Kiliç 2015: 362).

Figure 2.5: Spooty Chair by Peter Murdoch (Güneş and Demirarslan 2020: 89)

2.6.2. Rocking Chair by Frank Ghery

Peter Murdoch's disposable and foldable chair known as the Spooty Chair greatly inspired Frank Ghery. He designed a chair known as the Rocking Chair (Figure 2.6) by using the method of attaching paper layers to create a load-bearing capacity. He made cardboard layers opposite to each other to establish durability (Yüksel and Kiliç 2015: 362). The furniture made by this method also gave it the ability to bend. This model has taken the form of a single material that is made of thick laminate layers. Ghery's furniture was cheap, flexible, and recyclable. It was possible to obtain this furniture at a low cost for production and purchasing. Additionally, the laminate material was flexible enough to be shaped into curved or straight forms (Güneş and Demirarslan 2020: 90).

Figure 2.6: Rocking Chair by Frank Ghery (Yüksel and Kiliç 2015: 362)

Standing out with its sustainability efforts, IKEA continues to use these techniques for its furniture designs. However, compared to natural materials, this material is quite weak in terms of longevity and durability. It is accepted and preferred due to the fact that it does not spend much energy and resources on recycling (Karaca 2018: 61).

2.6.3. Mira Chair by Herman Miller

One of the first examples of sustainable product studies in furniture was carried out by Herman Miller. At the beginning of the 1990s, the company began to emphasize environmental goals as a strategy (Okursoy 2012: 17). The company collaborated with architect William McDonough to develop a tool that assesses product C2C improvement (Comacchio 2016: 41). The tool helped materials used in Herman Miller products stay in a closed loop and avoid waste that goes to landfills. Office chair Mira was designed by using the developed design tool. They have achieved a great outcome in terms of recyclability, reuse, and disassembly (Comacchio 2016: 41). Another chair, named the Aeron Chair was achieved by the company using their knowledge of materials and design for the environment. 94% of the chair's material was recyclable, and it was made of already recycled materials (Okursoy 2012: 17).

Figure 2.7: Herman Miller's Mira chair (Comacchio 2016: 41)

2.6.4. X2 by Giorgio Caporaso

The Italian architect Giorgio Caporaso uses ecological materials to design furniture. His best-known furniture is X2, which is made of totally recyclable materials. Their eco-design collection consists of 17 pieces of furniture that are ecological, recyclable, and made up of a special kind of cardboard (Şahin 2018: 58). The furniture can be easily maintained and repaired at a low cost. The designs are simple and modern, with a smooth continuous line at the surface (Güneş and Demirarslan, 2020: 91). His furniture known as "More", is a modular furniture having numerous purposes for inside and exterior settings. It is a multifunctional product that can be used as sitting, shelving or display.

Figure 2.8: Giorgio Caporaso's sustainable furniture (Güneş and Demirarslan 2020: 92)

2.6.5. HÅG Tion by Flokk

Flokk is a furniture company consisting of different brands offering a diverse selection of chairs, accessories, and tables for office environments. The firm combines nine brands with the goal of developing new designs that prioritize the health and well-being of users and the society around them. Flokk has a 40-year record of accomplishment in organized environmental attention, allowing the firm to be a pioneer in the production of sustainable furniture. Flokk aims to be an ecologically responsible leading company with resource and energy-efficient circular products, processes, and services that produce low greenhouse gas emissions, cause no threat to health and the environment, and generate minimal waste. It issued its first GRI-format sustainability report in 2011. Flokk designed and developed its furniture products in accordance with ideas they established in the 1990s, which are still used as a framework. The company called the five circular criteria 5-III and (3-III) three focus areas for their environmental strategies, which are; *i*, Climate*; ii*, Health; and *iii*, Resources. The five circular criteria stated at Flokk (2021: 111) are as follows:

- **Low weight:** Using fewer materials with optimized weight
- **Fewer components:** Allows for smarter functionality and easier production
- **Right choice of materials:** Not using materials containing toxic substances and a greater reliance on renewable and recycled materials.
- **Long lifespan:** Concept of the reduced need of furniture replacement, good quality with simplicity to reuse and adjustable for numerous uses having interchangeable wearing parts.
- **Designed for disassembly:** Maintaining materials in a closed-loop, simple to disassemble and simple to separate for recycling.

Wood, wool, steel, plastic, and aluminum are the five most important raw materials in the company's core product line. The firm uses polypropylene as the primary plastic material choice because, when compared to other plastic alternatives, it has fewer CO2 emissions, giving it a higher environmental advantage. Additionally, they use recycled post-consumer plastic. Flokk uses die-cast aluminum pieces that include 95% recycled aluminum on average, having the same quality and durability as virgin aluminum. The steel used in the products of this company is 20-40% recycled. Products are shipped to

customers completely assembled with minimal packaging or wrapped in a flat cardboard box. The firm not only gives attention to environmental sustainability but also adapts parameters for the other two dimensions of sustainability. It works for the protection of customers' and workers' health and safety and uses localization in choosing suppliers and employees. Flokk earned environmental certifications such as GREENGUARD, EPD, Cradle to Cradle, Ecolabel, and Blue Angel (Flokk 2021: 145).

Figure 2.9: HÅG Tion (Flokk n.d.)

HÅG Tion is the earliest task chair of the company, having environmental certifications such as GREENGUARD Gold and EPD. It has the lowest carbon footprint of the firm's other office chairs, with 75% renewable and recycled materials. Additionally, its lightweight but durable construction allows it to withstand the needs of everyday use (Flokk n.d.).

2.7. FURNITURE SECTOR IN TÜRKİYE

In Türkiye, the furniture industry plays a crucial role in making a significant contribution to the country's economy, helps in the employment of a large number of people, has no foreign trade imbalance, and is rapidly developing (Ersen 2021: 339). Furniture production in Türkiye started in the 19th century (Republic of Turkey-Minister of Trade 2019: 4). Furniture has first been made in small workshops by furniture experts. Since the 1990s, there has been major growth in the number of medium and large firms and it has become a fashion sector due to globalization. However, the Turkish furniture sector is primarily made up of small and midsize enterprises (Ersen 2021: 339). With an

8% increase in 2005, the furniture sector in Türkiye experienced rapid growth. The small-scale workshops have a great role in producing handcrafted furniture. Standard model furniture is produced by large-scale furniture firms using mechanized mass production techniques. Even though other materials, such as glass, metal, and plastic, have begun to be utilized for furniture production recently, wood retains its popularity (Serin et al. 2014: 147). Rapid urbanization, population, and living standards raise furniture needs, which has a direct impact on the furniture industry. Until recently, the furniture sector's manufacturing was traditional, using low technology, small resources, and labor-heavy systems, but through experience transformation, it has progressed to be a more capital and expertise-intensive sector in comparison to prior years (Serin et al. 2014: 147). According to Kesedi (2019: 19), the Turkish furniture sector is among the country's rare sectors, having a low importation amount of raw materials, making furniture export extremely profitable. Türkiye's furniture industry is centered mostly in Istanbul, Bursa (Inegöl), Ankara, Izmir, Kayseri, and Adana. The most prominent furniture-producing areas are Istanbul and the Bolu-Düzce region, which is known for its wood product manufacturing. Ankara is also home to Türkiye's well-known furniture production zone, known as "*Siteler.",* which has over 10,000 registered small and medium-sized businesses (Republic of Turkey-Minister of Trade 2019: 5). A number of studies show that the number of enterprises and the number of employees in this sector have increased over the years. TOBB (2013: 7) shows that there were about 16,915 enterprises and 116,860 employees by 2012 in Türkiye. As the number of enterprises increases, the impact this industry has on the environment and society also increases.

The Turkish Standards Institution (TSE), which is Turkey's official authority for standards and operates in a variety of fields, certifies furniture companies and manufacturers in environmental management and energy efficiency aspects. Efforts to apply sustainable strategies and produce sustainable furniture are expanding in Türkiye. However, most of the furniture that is labeled "green" is office furniture. Some products designed by applying sustainable strategies are discussed below.

Table 2.3: Turkish sustainable furniture examples and strategies used

Products	**Sustainable Strategies Used**
Furniture by Meb Rure	Recycled materials, cost-efficient, modular design, design for disassembly, low carbon footprint.
Me too Chair	Recyclable materials, waste management and recycling, minimum packaging, reduction of energy during transport, design for disassembly, renewable

2.7.1. Recycled Silk Furniture by Meb Rure

Meb Rure, an Istanbul-based furniture designer, created a furniture piece using recycled silk material. The stool, chair, and ottoman were made using waste silk fabric, showcasing innovative approaches to environmentally responsible furniture design. The designer uses recycled silk yarn from Nepal and American oak to make these fluffy furniture pieces (Laylin 2013). They are designed with modular legs that can be easily disassembled. Modularity allowed the product to be easily transported with a decreased transportation cost, have efficient packaging, and have a decreased carbon footprint during transportation.

Figure 2.10: Recycled silk furniture by Meb (Laylin, 2013)

2.7.2. Me Too Chair by Nurus Office

Nurus Office is a furniture company based in Turkey that received sustainability certifications such as GREENGUARD, Ecolabel, and recyclability certifications complying with international standards such as ISO 9001 and ISO 14001 (Aydin 2015: 47). The company aims on the reduction of environmental impact at every stage of product processing stage, from procurement to manufacture, packing, and delivery. Their task

chair, named “Me Too” is one of the company’s green-certified products. It is certified to meet Turkish standards for sustainability (TSE) and is made with 28.7% recycled material. The fabric used has received a reliability certificate. Waste chemical materials such as wet paint, powder paint, and chemical material packaging are delivered to recycling companies. To reduce energy use during transport, packaging size is kept to a minimum and the packaging is composed of recyclable materials (Nurus n.d.c). The parts of the product are renewable, replaceable, and easy to disassemble, having an end-of-life sustainability option.

Figure 2.11: Me Too Chair by Nurus Office (Nurus n.d.c)

CHAPTER 3

ANALYSES OF TURKISH FURNITURE COMPANIES REGARDING THE PARAMETERS OF SUSTAINABLE DESIGN

This chapter contains an explanation of the objective of the study and the methods used to achieve the aim. The research design is explained in terms of the selection of participant furniture firms and case products; a brief explanation of selected green-labeled and other prominent Turkish furniture firms; used data collection methods; the design and structure of the questionnaire form; and design of the parameter-based comparative analysis of the selected case products. Following an explanation of the data analysis process of collected data from the questionnaire, the findings of the comparative analysis and the survey are presented in the remaining part of the chapter.

3.1. RESEARCH APPROACH

The purpose of this research is to identify the parameters of sustainable design in furniture, as well as the level of awareness among prominent Turkish furniture companies about the implications of these parameters, and to identify the benefits and drawbacks of implementing the parameters in the Turkish furniture firms. The study focuses on the three dimensions of sustainability, which are environmental, social and economic dimensions. Moreover, analyses two groups (green-labeled and not green-labeled) of Turkish furniture firms. For the purpose of meeting the goal of the study, a questionnaire survey is conducted on related company authorities or designers working in the furniture firms. Finally, based on parameters, which were determined by the extensive literature review given in Chapter 2, parameter-based comparative analysis of the selected case products of firms was performed. The research questions of the study are stated below:

- Q1: What are the parameters of sustainable design in the furniture industry?
- Q2: What is the level of awareness of the selected firms regarding the implication of sustainable design parameters?
- Q3: Which parameters are the most and least implemented in the selected furniture firms?
- Q4: What are the possibilities and drawbacks of the production of sustainable Turkish furniture?

3.2. SELECTION OF PARTICIPANTS

This study was carried out on selected office furniture firms and case products. In this section, the process of selecting office furniture firms and the criteria used are discussed.

3.2.1. Furniture Firms

Based on the aim of the study, the participant furniture companies selected for the analyses are classified into two sections. The study aims to find out the level of awareness of the Turkish furniture companies regarding the implications of sustainable design parameters. In the study, the prominent Turkish furniture firms are compared to green-labeled firms. The number of furniture firms in Türkiye that received international green labels is quite limited. For this reason, first the firms for this category were identified and selected. Various studies on Turkish furniture and reports about the sector and its leaders in relation to sales, exports, and advancements were examined. After gathering data on companies, an extensive and in-depth literature review was done to identify if they received any certificates for the qualification of sustainability standards. As a result of the review, companies having products which are certified with green product certifications were found to be: Koleksiyon, Nurus, and Bürotime (Bürotime n.d.a; EPD 2018d; Nurus n.d.-b).

The other prominent Turkish furniture firms were selected depending on the character of the green-labeled furniture firms to have consistency among the scales of the firms and the type of their products. The three selected green-labeled furniture firms are middle-to-large-sized companies producing office furniture. Koleksiyon is a firm

producing furniture for living areas and offices. However, the certified furniture pieces are used in office environments. The other criteria for selecting the prominent furniture firms was the number of international sales and representative offices. With the literature review on green-labeled furniture firms, it was possible to identify the scale of their international marketability and competitiveness. Additionally, it was seen that they had received various local and international design awards. For the selection of the firms for his study, Aydin (2015: 43) provided Architonic, which is an international design database including designer and company portfolios from various countries in different fields of architectural and furniture design. Another database named Archiproducts was found for this study. The two databases are regarded as guiding databases for the selection criteria in the present study as they represent an international standard for design and manufacturing quality.

Case selection criteria are provided in the following sequence depending on the above statements (Figure 3.1.):

- Architonic and Archiproducts database listing
- Office furniture companies which are medium to large scale in size
- Number of international sales and representative offices
- Receiving international and local design awards

Furniture firms that fulfill at least three of the selection criteria listed above are selected. Adherence to the selection criteria of; i.) Achitonic and Archiproducts database, ii.) Size of the company, and iii.) Overseas market entrance, Ersa and Tuna Offices were selected to conduct the research. B&T Design fulfills the first three criteria; however, it does not have any award-winning product. Furthermore, Ofisline and Zivella firms were chosen by taking into account the compliance of the companies with the last three criteria mentioned above, which are, ii.) Size of the company, iii.) Overseas market entrance, and iv.) Design awards.

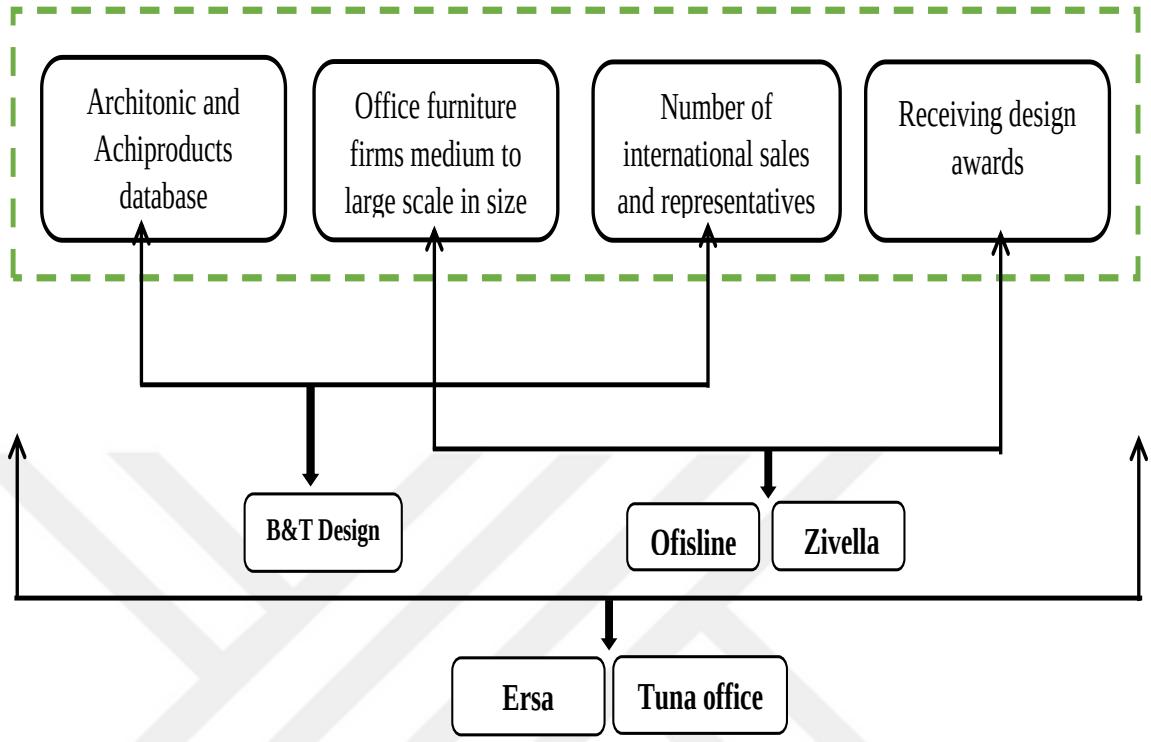


Figure 3.1: Chart representation of the case selection criteria

3.2.2.Case Products

Two products from each furniture firm were selected for the purpose of carrying out a criteria-based comparative analysis for this study. Case products are selected based on the received sustainable/green certificates or design awards. In the case of green-labeled furniture firms, most have products that are labeled as green or the company has received green certification. Case products from the prominent Turkish furniture firms, which are Ersa, Ofisline, Tuna Office, B&T Design, and Zivella, are selected based on the latest design award-winning products they have. It was not possible to find information on awarded products of B&T Design on their official website, hence, the best-selling and iconic products of this company are selected.

Table 3.1.Summary of case firms and products that have been selected for the study (B&T Design n.d.a; B&T Design n.d.b; Bürotime n.d.a; Bürotime n.d.b**;** EPD 2018b; EPD 2018c; Ersa Furniture n.d.a**;** Ersa Furniture n.d.b ; Ofisline n.d.; Nurus n.d.a; Nurus n.d.d; Tuna Ofis n.d.; Zivella n.d; Zivella 2021)

Company	**Designer**	**Selected Case Products**	**Selection Criteria**	**Function**
Green Declared Furniture Firms				
Koleksiyon	Koleksiyon Studio	Zenith Chair	EPD Certified (2018)	Workplace, educational
	Faruk Malhan	Cantata Chair	EPD Certified (2018)	Workplace, , classrooms
Nurus	Aksu-Suradi Studio	U Too Desk	Ecolabel and recyclability Certified	Office Furniture
	Stefan Brodbeck	Alava Chair	Green Good Design award & GREENGUARD Certified	Offices, lounges, accommodation, education zones and so on
Bürotime	b.design team	Comfy Chair	GREENGUARD Certified	Office Furniture
	Özge Çağla Aktaş - Duygu Aslanel	Bliss	GREENGUARD Certified	Office waiting areas
Other Prominent Turkish Furniture Firms				
Ersa	Cappelletti Architetti	Premier Chair	A'Design Award 2012	Work place, Educational
	Ece Yalım	Frame Executive	German Design Award International Design Excellence Award	Office Furniture
Ofisline	------	Teo Couch	Good Design Awarded	Office Furniture
Tuna Office	Ozan Sinan Tığlıoğlu	Poff Pouf	IF Design awarded	Dynamic office furniture
	Ozan Sinan Tığlıoğlu	Dama	Design Turkey& German Design Awarded	Common areas
B&T Design	Alp Nuhoğlu	Pera Chair	Bestselling Product	Office furniture, can be adapted
	Alp Nuhoğlu	Pi Pouf	Iconic Product	Office Waiting area
Zivella Office	Emin Ercan	Rounded Armchair	IF Design Awarded	Office Furniture
	Alp Nuhoğlu	Toy Pouf	Design Turkey & BIGSEE Product Design Awarded	Office Furniture

3.3. GENERAL INFORMATION ABOUT SELECTED FURNITURE FIRMS

3.3.1. Green Declared Furniture Firms

3.3.1.1. Koleksiyon

Koleksiyon furniture firm was founded in 1972 by architect Faruk Malhan in a tiny metal workshop in Ankara, making it one of Turkey's most important design enterprises (Can and Gürpınar 2021: 1014). The company began producing upholstered and wooden products in 1976. Koleksiyon strives to create "the architecture of furnishing" by developing the best standards, quality ideas, and design ideas. Koleksiyon now uses its factory, which has a manufacturing capacity of 400,000 square meters of timber furniture and 54,000 pieces of upholstered furniture, to place manufacturing at the service of design (Can and Gürpınar 2021: 1014). The firm currently has domestic stores in Istanbul, Ankara, Izmir, Gaziantep, Antalya, and Tekirdağ and 19 stores internationally. It creates designs and furnishings for cultural and commercial centers, lodging and entertainment facilities, workplaces, and private houses. While being competitive in the marketplace worldwide, Koleksiyon adheres to global standards and has integrated the concept of natural resource and environmental preservation and creating healthy and safe working conditions for employees. Additionally, the company is a specialist in waste management and recycling in all stages, with a dedication to ongoing progress in this field (Koleksiyon n.d.b). The company obtained several certificates for energy management, information security management, and environmental protection, complying with different international standards such as ISO 14000, SAP/3, ISO 18001, BW, ISO 9000-2000, and CRM erp (Aydin 2015: 47). Thirty products of this company received EPD in 2018.

3.3.1.1.1. Case product 1: Zenith Chair

Zenith Chair is furniture that can be used in various spaces such as offices, educational institutions, and lounge areas. By emphasizing user-centric design, the chair has a working table that can be adjusted and a basket under that can be used as a storage. The chair received EPD certification in 2018 (EPD 2018b). In addition to being a certified product, the furniture is selected based on its flexible organization design. It is designed to have four types of bases, allowing it to be adapted to different spaces and functions.

Figure 3.2: Zenith Chair (Koleksiyon n.d.c)

3.3.1.1.2. Case Product 2: Cantata Chair

Cantata Chair was designed by Faruk Malhan and received EPD certification in 2018. It is a family of chairs that come with different options. The Cantana seminar chair version received the Red Dot and Design Turkey Awards in 2015. Receiving a green certification and having a flexible organization for various space uses made the chair chosen for this study.

Figure 3.3: Cantata Chair (Koleksiyon n.d.a)

3.3.1.2. Nurus Office

Nurus was established in 1927 by Nurettin Kunurkaya in Ankara as a carpenter's workshop. In 1980, the company decided to specialize in office furniture in response to rising interest from both the public and private sectors (Can & Gürpınar 2021: 1015). The

company works with 30 external designers that are chosen based on their previous work and expertise on the issues at hand (Aydin 2015: 55). It has 15 local stores in several cities in Turkey and several stores in 30 countries internationally. Nurus furniture has received the Green Good Design Award 2015 and certifications such as GREENGUARD, Ecolabel, and recyclability certifications complying with international standards such as ISO 9001 and ISO 14001 (Aydin, 2015: 47). Nurus strives to reduce its environmental impact at every level of the process, from procurement to manufacture, packing, and delivery. Additionally, the company strives to use energy as effectively as possible (Nurus n.d.b).

3.3.1.2.1. Case product 1: U Too Desk

U too Desk is a working system designed by Aksu-Suradi Studio and received four design awards, including Good Design, Red Dot, and Design Turkey. U Too workstation enables variable workplace organization according to the number of employees in various divisions. The product holds an Ecolabel and a recyclability certificate (Nurus n.d.d). U Too workstation is selected as a case product due to its flexible organization and green certificates. It can be adapted to a working station, a single desk, a meeting desk, and an executive desk.

Figure 3.4: U Too Desk (Nurus n.d.d)

3.3.1.2.2. Case Product 2: Alava Chair

Alava Chair is furniture by Nurus, designed by Stefan Brodbeck, and received the German Design Award and Good Design Award. It is designed with a minimum use of materials and is certified with GREENGUARD Gold and Green Design sustainability awards for waste, energy conversion, and pollution efficiency (Nurus, n.d.a)**.** In addition to being a certified product, the furniture is selected based on its flexible organization design. It is designed to have three types of bases and an optional writing pad to be adapted in various spaces such as offices, lounges, accommodations, and educational zones.

Figure 3.5: Alava Chair (Nurus n.d.-a)

3.3.1.3. Bürotime

In 1994, Bürotime was established under Tosunoullar Furniture Inc. across an area of 6500 m2 in the manufacturing zone of Konya. Currently, it runs a 140,000 m2 factory in the location where it was established. It is stated on the company's website that the company is in the local and international markets. The company exports to 50 countries and has 150 sales locations (Bürotime, n.d.-c). The firm keeps the environment, humans, and design factors in mind and uses principles related to using raw materials with no harm, reducing waste mechanisms, and enhancing the recycling rate. The company used modern packaging systems that helped to decrease the amount of waste that takes place in their facility. For the purpose of minimizing its carbon footprint, the firm has been practicing organic waste or burning of biomass. In 2014, Bürotime became the number one office furniture producer company in Turkey to earn GREENGUARD Gold certification because

it was able to provide customers with surroundings that safeguard human health and promote quality of life by using sustainability strategies.

3.3.1.3.1. Case product 1: Comfy Chair

Comfy Chair is an office chair designed by the Bürotime design team. It is a GREENGUARD-certified product designed with a flexible organization for different spaces. It consists of executive, operational, and waiting seats.

Figure 3.6: Comfy Operational (Bürotime n.d.-d)

3.3.1.3.2. Case Product 2: Bliss

Bliss Chair is designed by Özge Çağla Aktaş and Duygu Aslanel and provides solutions to various usage scenarios in the lobby and waiting areas. The chair comes in different bases, providing flexibility and adaptability. Additionally, Bliss chair holds a GREENGUARD GOLD certificate.

Figure 3.7: Bliss (Bürotime n.d.-b)

3.3.2. Other Prominent Turkish Furniture Firms

3.3.2.1. Ersa

Ersa furniture firm was established in 1958 by Metin Atabey Ata and developed simple furniture from pipes and other materials because of a lack of resources (Can and Gürpınar 2021: 1010). It is stated in Aydin (2015: 65) that Ersa considers innovation as a mechanism where numerous aspects such as customer demands, competing products, and sales strategy are considered. Working with a variety of Turkish and international designers, as well as bringing designs from some of the world's most well-known through worldwide collaborations, the firm develops executive office furniture, conference hall chairs, office task chairs, metal storage, and accessories. It manufactures its product in a factory located in Ankara, covering an area of around 60,000 square meters with a simple architectural design that is in balance with the environment (Ersa, n.d.). Service to customers is provided through its stores in different cities across Turkey, such as Istanbul, Izmir, Ankara, Adana, and also Izmit, and Bursa. Moreover, the company has received more than 50 prominent national and international awards, namely Design Turkey, Red Dot, and Good Design awards (Ersa, n.d.). It is a holder of international standards such as ISO14001, ISO 9001:2008, ISO14001, Q MARK BS 476, and OHSAS 18001(Aydin 2015: 47). Two award-winning pieces of furniture have been selected as case products for this company.

3.3.2.1.1. Case product 1: Premier Chair

Premier Chair is designed by Cappelletti Architetti for seminar and meeting areas. The reasons behind the selection of this chair for analysis are: receiving a local or international design award and having alternative bases to create flexibility and space adaptability. Premier chair was a winner of the German Design Award in 2018. It has alternative base design options such as wood, sled, 4- legged metal, spider, and wheeled base.

Figure 3.8: Premier Chair (Ersa Furniture n.d.b)

Case Product 2: Frame Executive Desk

Frame is an executive desk designed by Ece Yalım design studio. The product received the A'Design Award in 2012, IF Communication Design Award in 2013, and the Red Dot Design Award honorable mention in 2012. The product is multifunctional, offering storage and lighting. Additionally, Frame has an alternative option of a meeting table and an operational desk.

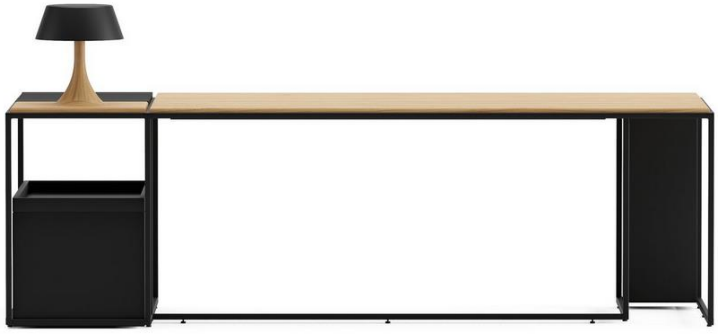


Figure 3.9: Frame Executive Desk (Ersa Furniture, n.d.-a)

3.3.2.2. Ofisline

Ofisline being a part of Gökler group has been developing hospital, office, dormitory, and training furniture with more than 20 years of experience in the field. The group is founded in the city of Sivas, Turkey, and covers a 60,000 meter square production area. Ofisline exports to 72 countries around the world. It is also stated on the company's

website that the furniture firm prioritizes utilizing the most environmentally friendly materials during the manufacturing of products. A total of 16 design awards, such as international design, Good Industrial Design, Red Dot Design, Good Design, German Design, and IF Design, have been earned by the company. Ofisline has local stores in Ankara, Istanbul, and Izmir and international stores in Qatar and Sudan.

3.3.2.2.1. Case product 1: Teo Couch

Teo Couch is a product by Ofisline that received a Good Design Award in 2014 (Ofisline n.d.). The product has two-seater and armchair versions.

Figure 3.10: Teo Couch (Ofisline, n.d.)

3.3.2.3. Tuna Office

Tuna Office was founded in 1970 to raise the quality of its products and services to a greater level by creating comfort, function, innovation, and other important parameters in the furniture sector (Archiproducts, n.d.). It offers designs that are adaptive to the demands and goals of both suppliers and users, all while maintaining universal design ideas. All the brands under Tuna: Tuna Office, Tuna Home, and Tuna Girsberger are all produced in a manufacturing factory covering a 55.000 meter square area located in Silivri, Istanbul (Tuna Office, n.d.-b). The firm provides solutions such as seating, desk systems, partition systems, and coffee tables with a design philosophy of giving attention to the interests and cultural habits of the working environment. The company has stores in Istanbul and Izmir. Tuna Office has received awards such as IF Design, Good Design, German Design, and the Red Dot Design Award.

3.3.2.3.1. Case product 1: Poff Pouf

Poff Pouf is a product by Tuna Office designed by Ozan Sinan Tığlıoğlu and received an IF Design Award in 2017. The product is designed for dynamic offices, serving as multi-functional furniture. It has a handling feature and a wheel structure. Poff Pouf can be arranged together as a modular product and create a long sitting area.

Figure 3.11: Poff Pouf (Tuna Office, n.d.-a)

3.3.2.3.2. Case Product 2: Dama

Dama is designed by Ozan Sinan Tığlıoğlu, and has the concept of "being together and enjoying the game". The furniture was a winner of the German Design Award in 2016 and the Design Turkey Award in 2014. It is a multi-functional piece of furniture having a seating, storage, and planting area.

Figure 3.12: Dama (Tuna Office n.d.a)

3.3.2.4. B&T Design

B&T Design, one of Turkey's major furniture manufacturers, was established in 1985 by Talip Aysan, integrating his metalworking knowledge with designers who could come up with new design concepts (B&T Design n.d.). To be as effective and beneficial as possible, designers and manufacturers at this firm keep users in mind. From Belgium to Australia, the United States to the United Arab Emirates, the firm exports its furniture products to over 45 nations. The manufacturing of the products from this firm takes place in a 6000-meter square factory located in Kocaeli, Turkey, and has showrooms in Istanbul and Ankara, Turkey. The company designs its products with the goal of achieving high quality, high comfort, aesthetics, and functionality. It is stated on the official website of the company that it focuses on developing designs that boost efficiency in space, time, and firm management. B&T Design also implements sustainable strategy through the product development process (B&T Design n.d.a).

3.3.2.4.1. Case product 1: Pera Chair

Pera Chair was designed by Alp Nuhoğlu in 2003 and is a best-selling product of B&T Design. The chair family is designed with flexible and alternative options. It is designed to have seven types of bases, allowing it to be adapted to different spaces and functions.

Figure 3.13: Pera Chair (B&T Design, n.d.-b)

3.3.2.4.2. Case Product 2: Pi Pouf

Pi is an iconic B&T Design product designed by Alp Nuhoğlu. While it can be used alone, many Pi Poufs can be used to create visually saturated spaces. Additionally, it can be used in waiting rooms or as a seating area, and benches can be formed by combining many Pi Poufs.

Figure 3.14: Pi Pouf (B&T Design, n.d.-c)

3.3.2.5. Zivella Office

Zivella was founded in 1999 to offer creative and human-centered answers to evolving workplace demands. The firm produces its products in a factory in Istanbul and has stores in seven locations locally and internationally, which are Istanbul, Ankara, Konya, Rize, and Antalya in Turkey and abroad in England and Azerbaijan. The company exports to 37 countries and has representative offices in eight counties including the Netherlands, Belgium, Morocco, Egypt, Sweden, UAE, Saudi Arabia, and Luxembourg. As stated on the official website of the company, they provide products that are simple and useful by using materials that are environmentally sensitive. Giving caution to the experiences of customers, the firm produces better designs and products. Design awards such as Good Design, IF Design, and BigSee product design awards have been earned by the company (Zivella, n.d.).

3.3.2.5.1. Case product 1: Rounded

Rounded is a chair by Zivella Office, designed by Emin Ercan. The chair is the owner of the 2021 IF Design Award. The chair has a plain and geometric circular form, designed with the concept of simplicity in mind.

Figure 3.15: Rounded Armchair (Zivella 2021)

3.3.2.5.2. Case Product 2: Toy Pouf

Toy Pouf is a piece of furniture designed by Alp Nuhoğlu to make a workplace more cheerful. It is a winner of the Turkey Design Award 2019 and the BIGSEE Product Design Award 2020. Toy Poufs can be used in waiting rooms or a seating area and benches can be formed when many Toy Poufs are combined.

Figure 3.16: Toy Pouf (Zivella n.d.)

3.4. DATA COLLECTION METHOD

A web-based questionnaire survey was selected as the data collection method for this study. A survey tool called Jotform is used to build online forms. Web-based surveys are a powerful communication tool because they allow the use of the internet to reach people, and they are flexible and low-cost. First, the selected companies were contacted by phone, and the questionnaire forms were sent to them by email. The questionnaires were asked to be filled out by product designers or individuals that have good knowledge of sustainability. More detailed information on the selection of the participants is given under section 3.6.1. below.

3.5. STRUCTURE OF THE SURVEY

The questionnaire is composed of two parts: the first is dedicated to finding out the level of sustainable approach taken by the furniture firms (Appendix B); the second is to collect information about the selected case products for the purpose of carrying out parameter-based analysis. The section about the case products is presented on separate sheets for each company because of the variety of the selected case products as shown in Appendix C. The questionnaire sheets are offered in both Turkish and English. The questionnaire on the firm's sustainability contains different sections with questions on: i.) The background of the participants; ii.) The firm's expertise in sustainability; iii.) Working structure; iv.) Sustainable product design parameters; and v.) Opportunities and drawbacks of using sustainable parameters. In the following section, more information on the various parts of the questionnaire is provided.

3.5.1. Background of Participants

The survey is conducted after giving a brief explanation of the study's aim at the start of the questionnaire. The first section of the questionnaire includes questions that help to get information about the participant's age, gender, educational background, profession or position in the firm, and the level of knowledge they have on sustainability. For the purpose of determining their awareness of sustainability, participants were asked if they had any education on sustainability and if they had ever participated in any sustainable design projects.

3.5.2. Firm’s Expertise in Sustainability

In the second section, the firm's sustainable product design expertise is questioned. The companies are asked if they have any certifications they have received for satisfying the standards on the three dimensions of sustainability in their product development. Additionally, questions to assess the commitment of companies to inform and train their employees about sustainability are asked in this part.

3.5.3. Firms Working Structure

The third section includes questions that help get information on the firm’s working structure on sustainability. If the company uses sustainable strategies, at what stage of the product life cycle do they integrate the strategies is asked. Additionally, the participation of product designers in the decisions made regarding sustainability and at what stage of product development they participate is asked. These questions are asked to find out about the company’s product design process and if the involvement of the experts has any influence on the implementation of sustainability.

3.5.4. Sustainable Product Design Parameters

In the fourth section, participants are asked to rate how frequently sustainable product design parameters are used in their product development process. The sustainable parameters used in this section are the parameters that are collected from the literature review in Chapter 2 of the study. These parameters are related to the three dimensions of sustainability, namely, environmental, social, and economic aspects. Environmental sustainability parameters are grouped into six categories, which are: material, energy, waste, air emission, product, and end-of-life options. The parameters of the social dimension are categorized into two groups: which are user-centered and societal concerns. Economic sustainability parameters are also grouped into two sections; one is cost minimization techniques throughout the lifecycle of a product, and the other is design strategies to minimize cost, as seen in Table 3.2.

Table 3.2: The parameters of sustainable product design derived from the literature review of the study used in the questionnaire.

Parameters of Sustainable Product Design					
Environmental Dimension		**Social Dimension**		**Economical Dimension**	
Material	**1.** Using bio degradable materials **2.** Minimum use of materials **3.** Use of recycled/recyclable materials **4.** Using renewable materials **5.** Reduction of material variety **6.** Avoiding toxic materials	**User-Centered**	**1.** Design for elderly and disability **2.** Design for user's health and safety **3.** Design for the needs of the future **4.** Participatory design **5.** Emotionally durable design **6.** Customer satisfaction/feedback mechanism **7.** Culturally sensitive design **8.** Transparency **9.** Quality of life	**Cost minimization throughout the lifecycle**	**1.** Use of cost estimating method at an early stage of product development **2.** Using local materials to reduce cost **3.** Cost minimization by efficient energy use **4.** Cost-efficient packaging
Energy Efficiency	**1.** Reduction of energy use in manufacturing **2.** Use of low-energy content material **3.** Using renewable energy source **4.** Reducing energy use during transportation.	**Societal Concerns**	**1.** Health and safety of a neighborhood **2.** Localization **3.** Ethical design **4.** Noise complaints **5.** Odor complaints **6.** Dust complaints	**Design Strategies**	**1.** Use of multi-functionality to reduce cost **2.** Design for assembly **3.** Designing products with fewer connecting elements or components **4.** Modular design for cost reduction **5.** Durable product design
Solid/ Liquid Waste	1. Reducing waste from production 2. Not generating dangerous waste 3. Reducing waste from packaging 4. Management of disposed waste 5. Recycling of waste				
Air Emission	**1.** Comply with clean air and climate protection strategy **2.** Minimizing atmospheric emissions (NO2, CO2, SO2, Ch4)				

Table 3.2 Continued

Product	**1.** The extended life span of the product (Durability) **2.** Modular product design **3.** multi-functionality				
End-of-life	**1.** Product recycling **2.** Reusability of a product **3.** Enhancing remanufacturing				

3.5.5. Opportunities and Drawbacks

The last section of the questionnaire includes questions that help to assess the opportunities and drawbacks the companies experienced from using sustainable product strategies during their product development. This section assists firms with sustainability experience in providing information about the benefits and drawbacks of their experience, as well as firms that do not implement the sustainable strategy in providing information on why they do not apply it. The opportunities and drawbacks mentioned in this section of the questionnaire are collected by analyzing studies such as (Okursoy 2012) and (Valipoor and Ujang 2011).

3.6. Parameter-Based Comparative Analysis

A parameter-based comparative analysis is applied to analyze and compare the level of implications of sustainable product parameters on the selected case products. The first group of products are furniture that has received green certification, and the second are furniture from other prominent firms that have won various local and international design awards. The study analyzes these products using the environmental, social, and economic parameters collected through a brief literature review in the upper sections. Information on the application of the parameters in the design and development of the product was obtained during the procedure of the questionnaire survey. As stated in section 3.6, a separate form was provided for participants to get detailed information on the application of the parameters on the products. Participants were asked to check the

box if the parameters stated were used in the design and development of the product (Appendix A).

Depending on the data obtained, the furniture products are evaluated and analyzed on a separate table. Each parameter is given a possible one point, and if that parameter is used in the design of the product, referring to the answers of the designers and authorities from the firm, a score point of one is given. If not, the product is given zero.

Table 3.3: Sample section of the environmental parametric analysis table with Zenith Chair and U Too Desk

	Parameters	**Point**	**K1**	**N1**
Material	Using Biodegradable materials	1		
	Minimum use of materials	1	●	●
	Use of recyclable materials	1	●	●
	Use of renewable materials	1		●
	Reduction of material variety	1	●	
	Avoiding toxic materials	1	●	●
	Total	6	4	4
KI - Zenith Chair N1- U Too Desk				

Table 3.4: Sample section of the social parametric analysis table with Zenith Chair and U Too Desk

	Parameters	Point	K1	K2
Social Concerns	Health and Safety of the neighborhood	1	●	●
	Localization (Using local resources and employment)	1	●	●
	Ethical design	1	●	●
	Noise complaints	1	●	●
	Odor complaints	1		
	Dust complaints	1		●
	Total	6	4	5
	KI - Zenith Chair N1- U Too Desk			

Table 3.3. and Table 3.4. given above describe the parameter-based environmental and social analysis on Zenith Chair from Koleksiyon and U Too Desk from Nurus. Appendix A. contains the entire set of tables from the analysis performed on all selected products. In table 3.3, the parameter group 'Material' from the environmental dimension is presented to analyze the two products. Each of the parameters under the group holds a possible score of 1. Zenith Chair scored 4 points because participants from the firm noted that the three parameters:- 'Minimum use of material', 'Use of recyclable materials', 'Reduction of material variety', and 'Avoiding toxic materials' are used in the design and development of the furniture. Based on this, U Too Desk scored 4 points as well. Table 3.4. shows the social assessment of the products in the parameter group 'Social concerns'. Zenith Chair scored 4 points, and U Too Desk scored 5 out of a total of 6 points. The parameter 'Odor complaints' was not included in the development of both products.

3.7. FINDINGS AND RESULT

The results and findings that were gathered through the questionnaire survey and through the conducted parameter-based comparative analysis are discussed broadly in this section of the study.

3.7.1. Questionnaire Survey

The purpose of conducting the questionnaire was to gather data on the level of implication of the sustainability parameters on the selected firms and to find out the opportunities and drawbacks. The corresponding results were gathered from a questionnaire survey conducted from June 14, 2022, to July 26, 2022, on 8 selected furniture firms in Turkey.

3.7.1.1. Reliability Test

In this study, the Cronbach alpha coefficient was used to assess the internal consistency between the various variables. Five reliability tests for environmental parameters, social parameters, economic parameters, opportunities and drawbacks are performed. In order for a scale to be reliable, the Cronbach alpha must be greater or equal to 0.7 (Akreim 2018: 75). This study's Cronbach alpha scores were 0.848 for the

environmental parameters, 0.764 for social parameters, 0.765 for the economic parameters, 0.563 for opportunities, and -0.714 for drawbacks. The value for opportunities and drawbacks indicates a poor internal consistency between the answers of the respondents in these sections. The results for the other three show good internal consistency.

Table 3.5: Reliability test of scales

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	N of items
Environmental Parameters	0.848	0.854	23
Social parameters	0.764	0.754	15
Economic Parameters	0.765	0.777	9
Opportunities	0.563	0.527	5
Drawbacks	-0.714	-0.868	9

3.7.1.2. The Demographic Background of Respondents

Descriptive data for demographic variables is generated using descriptive statistical analysis. The results show that 37% of the participants are product designers, 25% are R&D directors, and 12.5% are integrated system managers. The following Table 3.6. demonstrates the distribution of sample participants according to their position in the firms.

Table 3.6: Sample distribution according to respondent's position on a firm

	Frequency	Percent
Integrated System Manager	1	12.5
Interior Architect	1	12.5
Product Designer	3	37.5
Quality and Sustainability Responsible	1	12.5
R&D Director	2	25.0
Total	8	100.0

The survey indicates that 75% of participants have a bachelor's degree, followed by 25% of them having a master's degree. Moreover, participants were asked if they had taken any education on sustainability and if they had participated in any sustainable projects. 62% of the participants did not take education on sustainability and 25% of the participants took such an education. Additionally, the survey indicates that 25% of the respondents did not participate in sustainable projects and 75% have participated. The participants from Ersa, Tuna Office, and Zivella did not take any education on sustainability but they have participated in sustainable design projects. Participants from Koleksiyon, Nurus, and Bürotime have education and experience in sustainable projects. The participant from Nurus elaborated that she has education on sustainability from training given by the managers within the company, and the participant from B&T Design has done his final project on life cycle analysis and has received Corporate Carbon Footprint training. Table 3.7. shows the allocation of respondents based on their educational background and experience with sustainability.

Table 3.7: Sample distribution according to participants' educational background and knowledge and experience on sustainability.

		Frequency	Percent
Valid	Bachelor's degree	6	75.0
	Master's degree	2	25.0
	Total	8	100.0
Taking education on sustainability			
		Frequency	Percent
Valid	No	5	62.5
	Yes	3	37.5
	Total	8	100.0
Participation in sustainable projects			
		Frequency	Percent
Valid	No	2	25.0
	Yes	6	75.0
	Total	8	100.0

3.7.1.3. Firm's Expertise in Sustainability

Descriptive data for the sustainability certification variables are generated using descriptive analysis. Participants from the selected firms were asked if they had received any environmental, social, or economic sustainability certification. The results show that 87% of the selected firms received environmental sustainability certificates, and 12% did not receive any environmental certification. Green-labeled furniture firms received TSE environmental management and energy management certifications. They are certifications given by the Turkish Standards Institution (TSE), which is Turkey's official authority for standards and operates in a variety of fields. It has full membership in international standard organizations such as ISO. Additionally, Zivella and Tuna Office are holders of TSE environmental management certification. Koleksiyon received EPD certification, while Nurus and Bürotime are holders of GREENGUARD certification. Moreover, none of the selected companies received any social or economic sustainability certificates. The following Table 3.8. demonstrates the distribution of sample firms according to the sustainability certification.

Table 3.8: Sample firm distribution according to received sustainability certification

Environmental sustainability certification			
		Frequency	Percent
Valid	Yes	7	87.5
	No	1	12.5
	Total	8	100.0
Social sustainability certification			
		Frequency	Percent
Valid	No	8	100.0
Economic sustainability certification			
		Frequency	Percent
Valid	No	8	100.0

Furthermore, participants were asked at what life cycle stage of a product they implemented sustainable thinking. As shown in Figure 3.17, raw material extraction and component manufacturing stages received 100% of cases. Product design and assembly 71.4% and distribution 41%. The rarely used stages in the implementation of sustainability are use and end-of-life receiving 28.6% of cases.

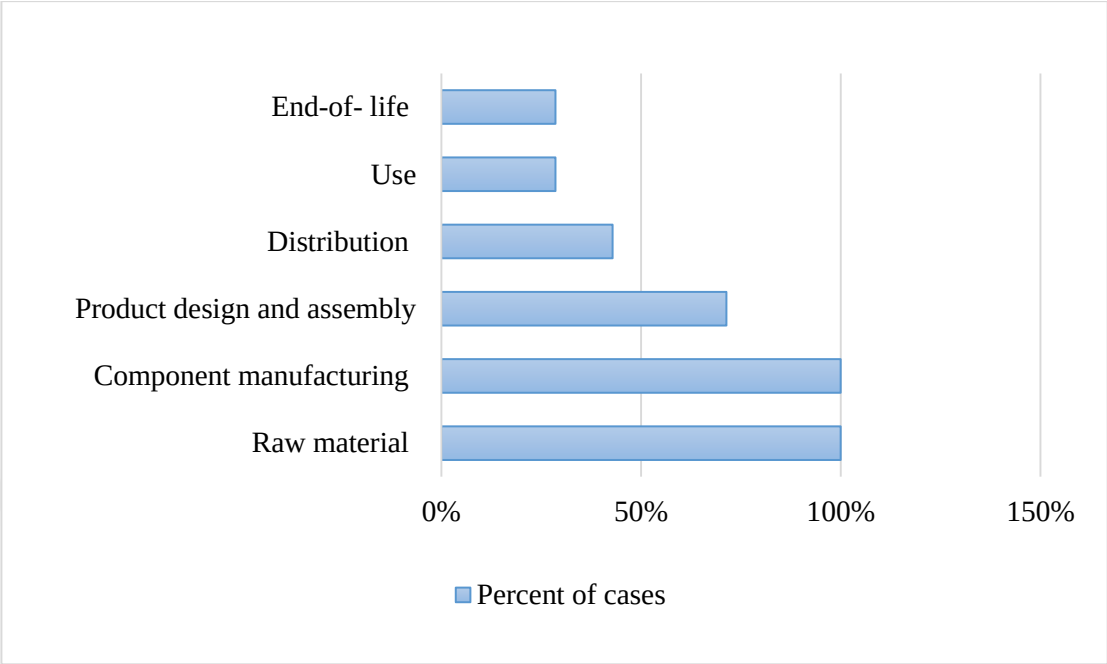


Figure 3.17: Sample firm distribution according to the life cycle stage of implementing sustainability

3.7.1.4. Results on the Use of Sustainable Product Design Parameters

In this section of questionnaire data, one sample t test has been utilized to assess the most and least used sustainable parameters in the selected furniture firms. This test is used in this study to evaluate the amount of influence on the score's average mean value recorded for every subgroup of parameters; environmental, social, and economic parameters.

Environmental Parameters

Participants were asked to rate the environmental parameters as to how often they are used in the design and development process of products in their firm. To assess whether their mean differed substantially from the average mean value of scores provided for each parameter construct category within the environmental dimension, a one-sample t-test was utilized. A ranking of the mean differences is done to identify the most and least used parameters in the selected furniture firms. As seen in Table 3.9, mean difference is calculated based on the average mean value calculated for the material subcategory (3.1250) and energy subcategory (2.312).

According to the results, the most effective parameter in the material category is 'Avoiding toxic materials', with the highest mean difference (0.6250). The lowest used parameter is 'Using biodegradable materials', with a negative mean difference (-1.000). The findings corroborate the conclusion that, 'Avoiding toxic materials' is an important environmental parameter used in the selected furniture firms.

Table 3.9: Ranking of material and energy parameter categories

Material	**Test Value =3.1250**				
	Mean	Mean Difference	t	Sig.	Rank
Using bio-degradable materials	2.1250	-1.00000	-8.000	.000	**5**
Minimum use of material	3.5000	.37500	1.984	.088	**2**
Use of recyclable materials	3.0000	-.12500	-.661	.529	**3**
Using renewable materials	2.8750	-.25000	-2.000	.086	**4**
Reduction of material variety	3.5000	.37500	1.403	.203	**2**
Avoiding toxic materials	3.7500	.62500	3.819	.007	**1**
Energy	Test Value = 2.312				
	Mean	Mean Difference	t	Sig.	Rank
Reduction of energy use in manufacturing	3.0000	.68800	2.574	.037	**1**
Use of low energy content materials	1.6250	-.68700	-3.754	.007	**4**
Using renewable energy source	2.2500	-.06200	-.248	.811	**3**
Reducing energy used during transport	2.3750	.06300	.239	.818	**2**

The results for the energy category show that the most effective parameter is 'Reduction of energy use in manufacturing' with the highest mean difference (0.6880). The least effective parameter is 'Use of low energy content materials' having a negative mean difference (-0.6870). The findings corroborate the conclusion that 'Reduction of energy use in manufacturing' is an important environmental parameter used in the selected furniture firms.

Table 3.10. shows the mean difference calculated based on the average mean value calculated for the material subcategory (3.050) and energy subcategory (3.250). According to the results, the most effective parameter in the waste category is 'Waste

disposal management' with the highest mean difference (0.450). The least effective parameter is 'Waste recycling', with a negative mean difference (-0.425). The data back up the conclusion that 'Waste disposal management' is an important waste parameter used in the selected furniture firms.

Table 3.10: Ranking of waste and atmospheric emission parameter categories

Waste	Test Value = 3.050				
	Mean	Mean Difference	t	Sig.	Rank
Reducing waste from production	3.1250	.07500	.600	.567	3
Not generating dangerous waste	3.2500	.20000	1.222	.261	2
Reducing waste from packaging	2.7500	-.30000	-1.200	.269	4
Waste disposal management	3.5000	.45000	1.684	.136	1
Waste recycling	2.6250	-.42500	-1.616	.150	5
Atmospheric Emission	Test Value = 3.250				
	Mean	Mean Difference	t	Sig.	Rank
Comply with clean air and climate protection	3.2500	.00000	.000	1.000	1
Minimizing atmospheric emissions NO2 CO2	3.2500	.00000	.000	1.000	1

In the atmospheric emission category, both parameters 'Comply with clean air and climate' and 'Minimizing atmospheric emission' scored an equal mean difference (0.00). This supports the conclusion that both parameters are equally used in the selected furniture firms.

Lastly, the mean difference is calculated based on the average mean value calculated for the product feature subcategory (3.166) and end-of-life (2.328). The most used parameter in the product feature with the highest mean difference is the 'Extended life span of a product'. The parameter 'Modular product design', which had a negative mean difference (-0.416), was the least used parameter in the product features category. Moreover, the parameter 'Reusability of a product' had the greatest mean difference in end-of-life category (0.375). The least used parameter is 'Enhancing remanufacturing' with a negative mean difference (-0.250).

Table 3.11: Ranking of product features and atmospheric emission parameter categories

Product Features	Test Value = 3.166				
	Mean	Mean Difference	t	Sig.	Rank
Extended life span of a product	3.8750	.70900	5.672	.001	**1**
Modular product design	2.7500	-.41600	-2.542	.039	**3**
Multi-Functional product	2.8750	-.29100	-2.328	.053	**2**
End-of-life	Test Value = 2.375				
	Mean	Mean Difference	t	Sig.	Rank
Product Recycling	2.2500	-.12500	-.764	.470	**2**
Reusability of a product	2.7500	.37500	1.197	.270	**1**
Enhancing remanufacturing	2.1250	-.25000	-2.000	.086	**3**

Social Parameters

Participants were asked to rate the social parameters according to how often they are used in the design and development process of products in their firm. To assess whether their mean differed substantially from the average mean value of scores provided for each parameter construct category within the social dimension, a one-sample t-test was used. A ranking of the mean differences is done in this section also to identify the most and least used parameters in the selected furniture firms. As seen in Table 3.12, the mean difference is calculated based on the average mean value calculated for the user-centered subcategory (3.041). The most used parameter in the user-centered category with the highest mean difference is the 'Customer satisfaction feedback mechanism'. The least used parameter is 'Design for elderly and disability', having a negative mean difference (-1.166).

Table 3.12: Ranking of user-centered parameter category

User-centered	Test Value = 3.041				
	Mean	Mean Difference	t	Sig.	Rank
Design for elderly and disability	1.8750	-1.16600	-5.146	.001	8
Design for user's health and safety	3.2500	.20900	1.277	.242	4
Design for the needs of the future	3.6250	.58400	3.192	.015	2
User participatory design	2.8750	-.16600	-.733	.488	5
Emotionally durable design	2.2500	-.79100	-4.833	.002	7

Table 3.12. Continued

Customer satisfaction feedback mechanism	3.8750	.83400	6.672	.000	1
Culturally sensitive design	2.6250	-.41600	-2.273	.057	6
Transparency	3.3750	.33400	1.825	.111	**3**
Quality of life	3.6250	.58400	3.192	.015	**2**

Table 3.13. shows the mean difference calculated for the social concerns parameter category based on the average mean value (2.812). The most effective and widely used parameters are 'Localization' and 'Ethical design' having a mean difference (1.063). The least effective parameter is 'Odor complaint' with a negative mean difference (-0.937). The data corroborate the conclusion that 'Localization' and 'Ethical design' are important social concern parameters used in the selected furniture firms.

Table 3.13: Ranking of social concerns parameter category

Social concerns	Test Value = 2.812				
	Mean	Mean Difference	t	Sig.	Rank
Health and safety of a neighborhood	3.0000	.18800	.497	.634	**2**
Localization	3.8750	1.06300	8.504	.000	**1**
Ethical design	3.8750	1.06300	8.504	.000	**1**
Noise complaints	2.2500	-.56200	-1.793	.116	**3**
Odor complaints	1.8750	-.93700	-2.674	.032	**5**
Dust complaints	2.0000	-.81200	-2.481	.042	**4**

Economic Parameters

Participants were asked to rate the Economic parameter according to how often they are used in the design and development process of products in their firm. To assess whether their mean differed substantially from the average mean value of scores provided for each parameter construct category within the social dimension, a one-sample t-test was used. A ranking of the mean differences is done in this section also to identify the most and least used parameters in the selected furniture firms. As seen in Table 3.14, the mean

difference is calculated based on the average mean value calculated for the economic parameters (3.166). According to the results in Table 3.14, the most effective parameter in the economic parameter is 'Durable product design' having the highest mean difference (0.709). The least used parameters are 'Cost-efficient packaging' and 'Modular product design' with a negative mean difference value (-0.541). The data corroborate the conclusion that 'Durable product design is an important economic parameter used to reduce cost in the selected furniture firms.

Table 3.14: Ranking of economic parameters

Economic	Test Value = 3.166				
	Mean	Mean Difference	t	Sig.	Rank
Use of cost estimating methods at an early stage	3.2500	.08400	.513	.624	**4**
Using local material to reduce cost	3.7500	.58400	3.568	.009	**2**
Cost minimization by efficient energy	2.7500	-.41600	-1.327	.226	**6**
Cost efficient packaging	2.6250	-.54100	-2.057	.079	**7**
Use of multi-functionality to reduce cost	3.0000	-.16600	-.878	.409	**5**
Design for assembly	3.1250	-.04100	-.139	.893	**4**
Designing products with fewer connecting elements	3.3750	.20900	.645	.539	**3**
Modular design for cost reduction	2.7500	-.41600	-2.542	.039	**6**
Durable product design	3.8750	.70900	5.672	.001	**1**

3.7.1.5.Opportunities and Drawbacks

The questions in this section were asked to assess the opportunities and drawbacks the companies experienced by using sustainable product strategies during their product development. Descriptive analysis was used to generate descriptive data. The highest rated opportunities by the selected firms are 'Enhanced brand image' and 'Decreased environmental impact', each having eight responses (100%) of cases. They are followed by 'Enhanced Product Quality', 'Cost Reduction and Profitability', 'Market competitiveness', and 'Enhanced Product Design and Innovation', making seven

responses (87%), six responses (75.0%), and five responses (62.5%), respectively. The lowest rated value by the selected firms is 'Increased Customer Satisfaction'. In other words, increased customer satisfaction is the least influential opportunity when using sustainability in selected furniture firms.

Table 3.15: Sample firm distribution according to opportunities created in the selected furniture firms

		Responses		Percent of Cases
		N	Percent	
Sustainability use opportunity	Cost reduction and profitability	6	14.0%	75.0%
	Market competitiveness	6	14.0%	75.0%
	Enhanced brand image	8	18.6%	100.0%
	Enhanced product quality	7	16.3%	87.5%
	Enhanced product design and Innovation	5	11.6%	62.5%
	Increased customer satisfaction	3	7.0%	37.5%
	Decreased environmental impact	8	18.6%	100.0%
Total		43	100.0%	537.5%

The participants were also asked about the drawbacks that limit the use of sustainable design strategies. The highest rated drawback values by the selected firms are 'Lack of used tools to take experience from' and 'Lack of harmony of sustainability with product features' having seven responses (87.5%). In other words, they are the most influential drawback of not using sustainability. It is followed by 'High Financial Demand', 'Sustainability not being a priority for furniture firms', 'Existence of various standard systems', 'Standards are only based on raw material extraction', 'Complexity of sustainability tool' and 'Time-consuming', making six responses (75%), five responses (62.5%), four responses (50%), three responses (37.5%), and two responses (25%) respectively. The lowest rated drawback value is 'Lack of used tools to take experience from'. It is the least influential value of not using sustainability in furniture firms.

Table 3.16: Sample firm distribution according to drawbacks of not using sustainability

		Responses		Percent of Cases
		N	Percent	
Drawbacks	Standards are only based on raw material extraction	3	8.1%	37.5%
	Existence of various standard systems	4	10.8%	50.0%
	Lack of defined strategy	7	18.9%	87.5%
	Sustainability not being a priority for furniture firms	5	13.5%	62.5%
	Lack of used tools to take experience from	1	2.7%	12.5%
	Complexity of sustainability tool	2	5.4%	25.0%
	High financial demand	6	16.2%	75.0%
	Time-consuming	2	5.4%	25.0%
	Lack of harmony of sustainability with product features	7	18.9%	87.5%
Total		37	100.0%	462.5%

3.7.2. Parameter-Based Comparative Analysis

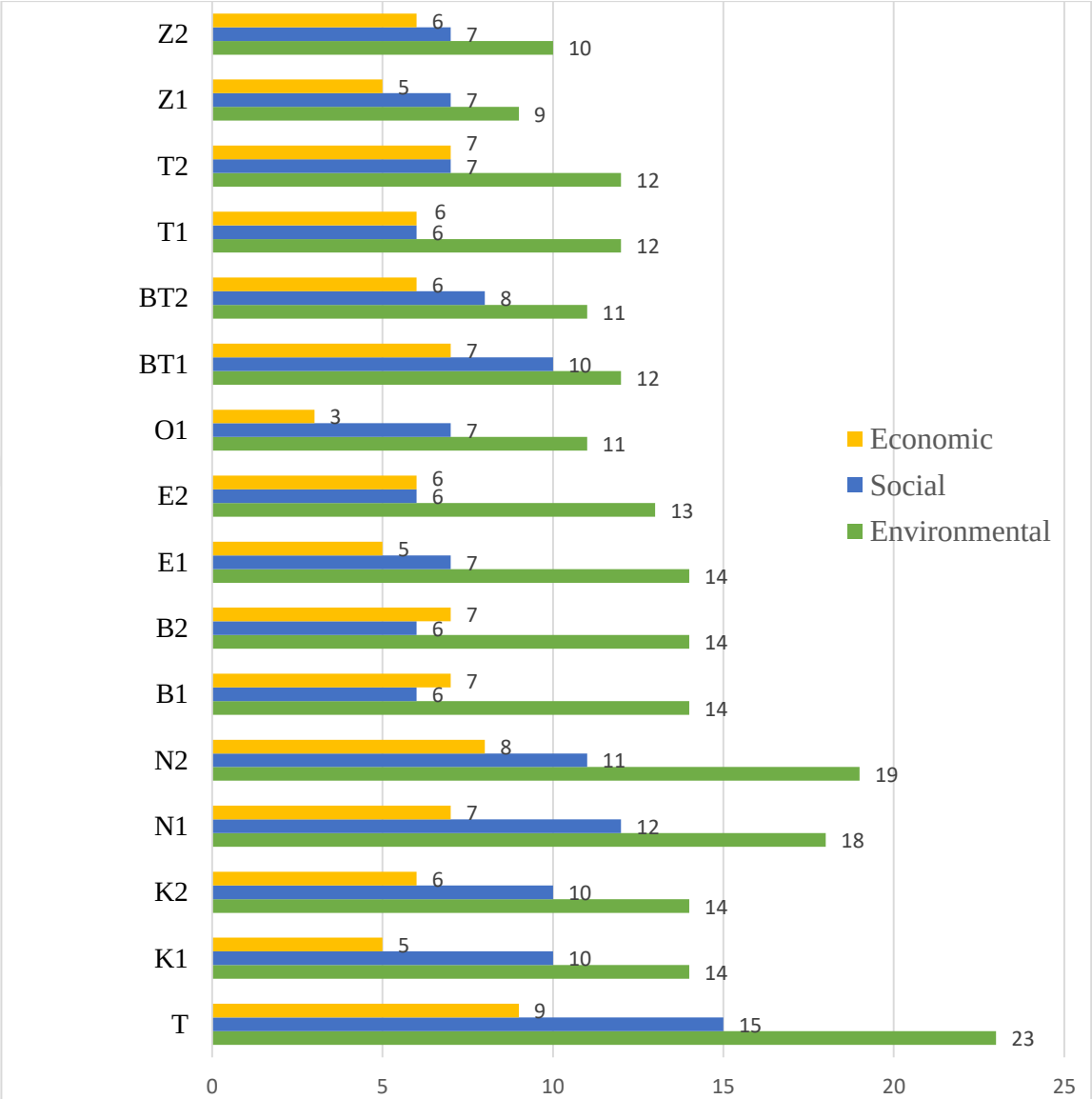
The results of the parameter-based comparative analysis, best summarized in Table 3.17, show that all of the selected case products do not use 100% sustainable product parameters during their design and development. They account for a maximum of 80.8% and a minimum of 44.6% of the total points available. According to the data collected on the implication of the parameters on the products, the results scored by the products on the analysis are Zenith Chair (63.8%), Cantata Chair (65.9%), U Too Desk (78.7%), Alava Chair (80.8%), Comfy Operational (57.4%), Bliss Chair (57.4%), Premier Chair (55.3%), Frame Executive (57.4%), Teo Couch (44.6%), Pera Chair (61.7%), Pi Pouf (53.1%), Poff Pouf (51%), Dama (53.3%), Rounded Armchair (44.6%), and Toy Pouf (48.9%). In terms of total points acquired, the lowest point was scored by Round Armchair and Teo Couch (21/47), while Alava Chair scored the highest point (38/37).

Table 3.17: Summary table of the finding of parameter-based comparative analysis

		Point	K1	K2	N1	N2	B1	B2	E1	E2	O1	BT1	BT2	T1	T2	Z1	Z2
Environmental	**Material**	**6**	4	4	4	5	4	4	4	4	3	4	3	3	3	3	3
	Energy	**4**	2	2	3	3	2	2	1	1	2	2	2	1	1	1	1
	Waste	**5**	3	3	5	5	3	3	4	4	3	3	2	3	3	3	3
	Air Emissions	**2**	2	2	2	2	2	2	2	2	2	1	1	1	1	0	0
	Product	**3**	2	2	2	2	2	2	1	3	1	1	2	3	3	1	2
	End of life	**3**	1	1	2	2	1	1	2	1	0	1	1	1	1	1	1
	Total required=23		**14**	**4**	**18**	**19**	**14**	**14**	**14**	**13**	**11**	**12**	**11**	**12**	**12**	**9**	**10**
Social	**User-centered**	**9**	6	6	7	6	4	4	5	4	4	7	5	4	5	5	5
	Social concerns	**6**	4	4	5	5	2	2	2	2	3	3	3	2	2	2	2
	Total required=15		**10**	**10**	**12**	**11**	**6**	**6**	**7**	**6**	**7**	**10**	**8**	**6**	**7**	**7**	**7**
Economic	**Product Life cycle**	**4**	3	3	4	4	3	3	3	2	2	4	3	2	2	3	3
	Design strategies	**5**	2	3	3	4	4	4	2	4	1	3	3	4	5	2	3
Total required=9			**5**	**6**	**7**	**8**	**7**	**7**	**5**	**6**	**3**	**7**	**6**	**6**	**7**	**5**	**6**
Total		**47**	**30**	**31**	**37**	**38**	**27**	**27**	**26**	**27**	**21**	**29**	**25**	**24**	**26**	**21**	**23**
%		**100 %**	**63.8**	**65.9**	**78.7**	**80.8**	**57.4**	**57.4**	**55.3**	**57.4**	**44.6**	**61.7**	**53.1**	**51**	**55.3**	**44.6**	**48.9**

K1 - Zenith Chai N1- U Too Desk B1 - Comfy Operational E1- Premier Chair
K2- Cantata Chair N2- Alava Chair B2 - Bliss E2- Frame Executive
O1 -Teo Couch BT1- Pera Chair T1- Poff Pouf Z1- Rounded Armchair
BT2- Pi Pouf T2- Dama Z2- Toy Pouf

The following Figure 3.18 shows a chart representation of the acquired scores in terms of the three sustainable dimensions. The Parameters of the environmental dimension make up 23 points, the social 15 points, and the economic 9 points of the total 47 required points.



	T	K1	K2	N1	N2	B1	B2	E1	E2	O1	BT1	BT2	T1	T2	Z1	Z2
Economic	9	5	6	7	8	7	7	5	6	3	7	6	6	7	5	6
Social	15	10	10	12	11	6	6	7	6	7	10	8	6	7	7	7
Environmental	23	14	14	18	19	14	14	14	13	11	12	11	12	12	9	10

Figure 3.18: Chart representation of the results obtained through parameter-based analysis

3.7.2.1. Environmental Parameters

The environmental parameters have six group categories, making a total of 23 points. Material is the largest constructed category, comprising six parameters and making a total of 6 points. It is followed by Waste, Energy, Product features, End of life, and

lastly, Atmospheric emissions, comprising five parameters (5 points), four parameters (4 points), both Product features and End of life three parameters (3 points) and two parameters (2 points) respectively.

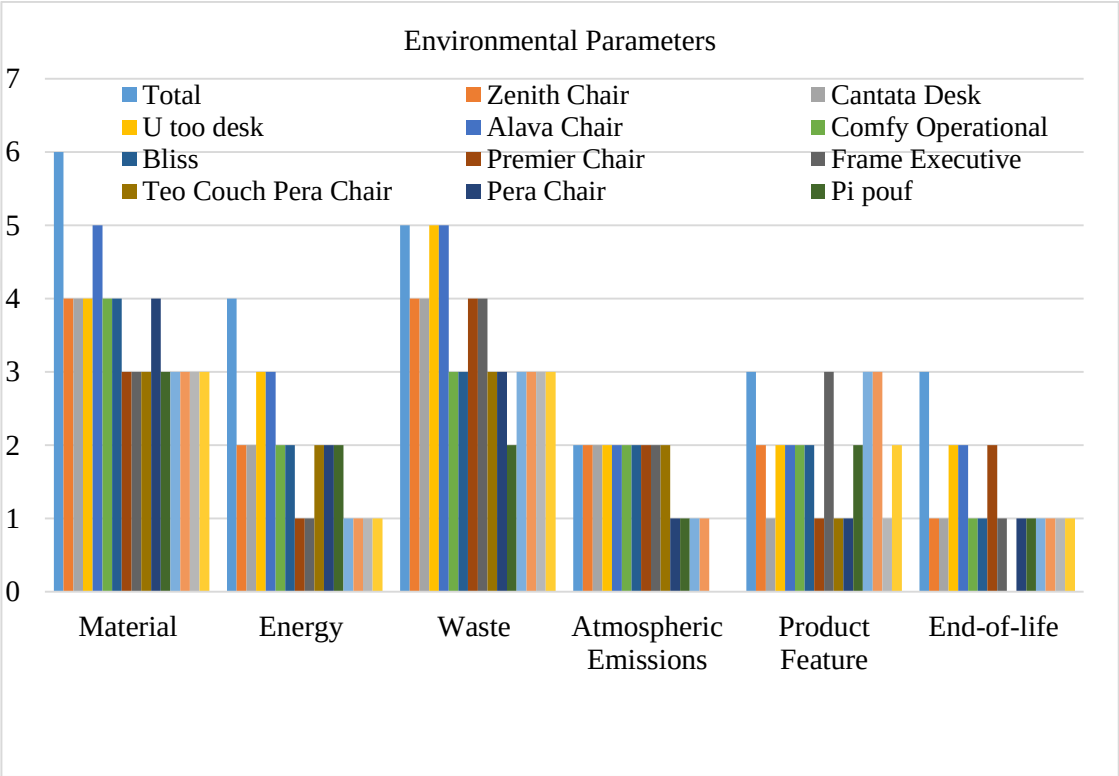


Figure 3.19: Comparison of the 15 products by environmental parameters

3.7.2.1.1. Material

The highest required point in the material category is scored by the Alava Chair by Nurus (5/6). Zenith Chair, Cantata Chair, U Too Desk, Comfy Operational, Bliss Chair, Premier Chair, Frame Executive, and Pera Chair achieved an equal 4 points (4/6). Moreover, the other case products, Pi Pouf, Poff Pouf, Dama, Rounded Armchair, Toy Pouf, and Teo Couch achieved an equal 3 points (3/6). The parameters ‘Minimum use of materials’, ‘Avoiding toxic materials’ and 'Reduction of material variety' are used during the design and development of all case products. ‘Use of renewable materials’ is the less used parameter, which is used in the design and development of U too Desk, Alava Chair, and Teo Couch. Lastly, ‘Using biodegradable materials’ was not used in the design and development of any of the products.

3.7.2.1.2. Energy

U Too Desk and Alava Chair received the highest points in this construct category, earning 3 out of a possible 4 points. Zenith Chair, Cantata Chair, Comfy Operational, Bliss Chair, Teo Couch, Pera Chair, and Pi Pouf achieved equal 2 points (2/4). Lastly, Premier Chair, Frame Executive, Poff Pouf, Dama, Rounded Armchair, and Toy Pouf achieved 1 out of 4 points. The parameter ‘Reducing energy use in manufacturing’ is used in the development of all of the case products. Furthermore, ‘Use of low-energy content material’ and 'Using renewable energy source' are the least used parameters.

3.7.2.1.3. Waste

The highest achieved points in this construct category are achieved by U Too Desk and Alava Chair (5/5). Premier Chair and Frame Executive acquired 4 points (4/5). The other case products, except Pi Pouf, attained three points (3/5). Pi Pouf acquired the least points (2/5). The parameters ‘Reduction of energy use in manufacturing’ and ‘Not generating dangerous waste’ are the most commonly used in the design and development of the case product. Moreover, ‘Reducing waste from packaging’ and 'Recycling of waste’ are the least used.

3.7.2.1.4. Atmospheric Emission

In this construct category, case products from Koleksiyon, Nurus, Bürotime, Ersa, and Ofisline achieved a required point of two (2/2). Pera Chair, Pi Pouf, Poff Pouf, and Dama achieved (1/2). The parameters under this category group were not used in the design and development of Rounded Armchair and Toy Pouf.

3.7.2.1.5. Product Features

The parameter ‘Extended life span of the product’ is used during the design and development of all 15 case products. The highest point in this category (3/3) is achieved by Frame Executive, Poff Pouf, and Dama, having multifunctional and modular product features. Premier Chair, Teo Couch, Pera Chair, and Rounder Armchair achieved the lowest point (1/3). ‘Multi-Functional product’ is used in Zenith Chair, Cantata Chair, U

Too Desk, Frame Executive, Poff Pouf, and Dama. Lastly, the parameter 'Modular product design' is used in Alava Chair, Comfy Operational, Bliss Chair, Frame Executive, Pi Pouf, and Toy Pouf.

3.7.2.1.6. End-of-life Options

U Too Desk, Alava Chair, and Premier Chair received the most points in this construct category, earning 2 out of a possible 3 points. The parameters in this category group are not used in the design and development of the Teo Couch. The rest of the case products received a required point of one (1/3). 'Product reusability' is the most used parameter in this category. Finally, the only product that uses the parameter 'Enhancing remanufacturing' is Frame Executive.

3.7.2.2. Social Parameters

The social parameters have two group categories, making a total of 15 points. The construct category 'User-centered' comprises nine parameters and makes a total of nine points. It is followed by 'Social concerns', which have six parameters and make a total of six points.

3.7.2.2.1. User-centered

U Too Desk and Pera Chair achieved the highest acquired points in this construct category, which is 7 points out of a total of 9 points. Zenith Chair, Cantata Chair, and Alava Chair achieved an equal 6 points (6/9). Premier Chair, Pi Pouf, Dama, Rounded Armchair, and Toy Pouf achieved 5 points (5/9). Lastly, Comfy Operational, Bliss Chair, Frame Executive, and Poff Pouf scored 4 points (4/7) in the user-centered construct category. The parameters 'Design for the user's health and safety', 'Customer satisfaction/feedback mechanism', 'Transparency', and 'Quality of life' are used during the design and development of all 14 case products. 'Culturally sensitive design' and 'Emotionally durable design' are the less used parameters in the selected products. 'Emotional durable design' is only used in the two products from Koleksiyon, and 'Culturally sensitive design' is used on U Too Desk and Pera Chair. 'Design for the elderly and disabled' was not used in the design and development of any of the products.

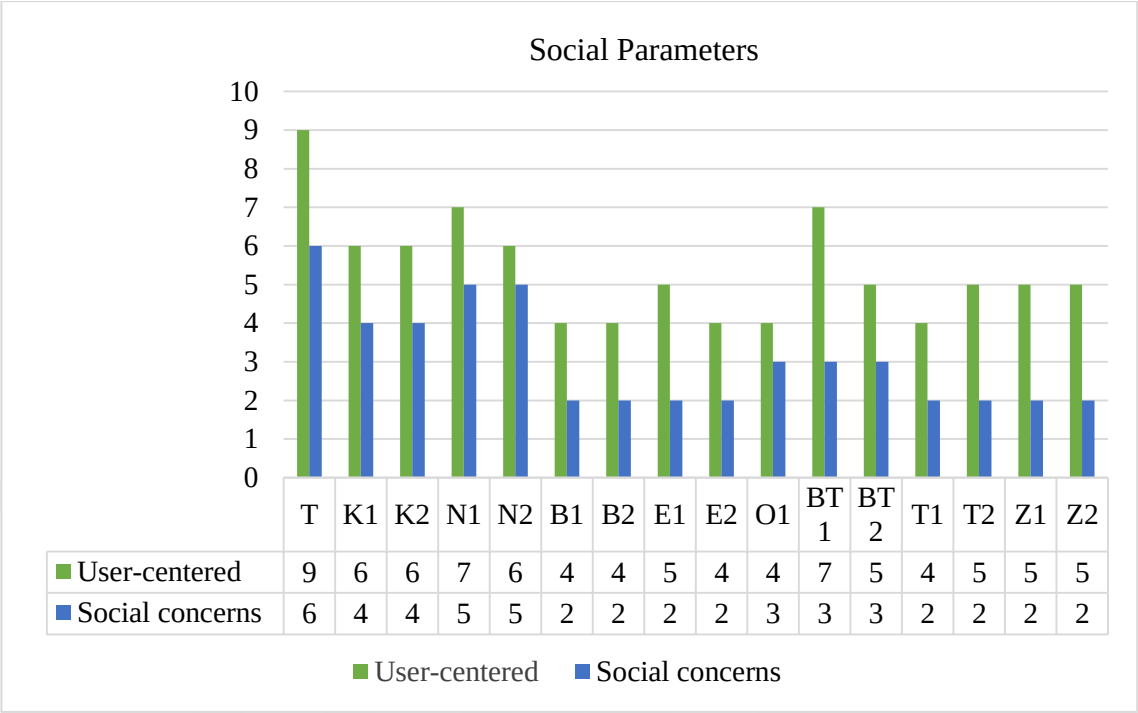


Figure 3.20: Comparison of the 15 products by social parameters

3.7.2.2.2. Societal Concerns

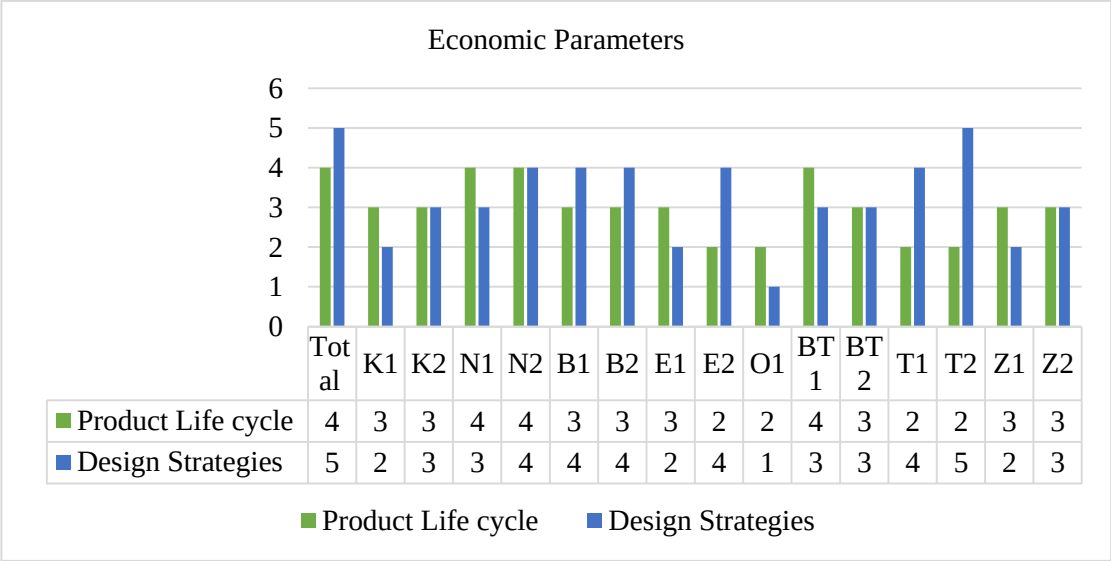
In this construct category, U Too Desk and Alava Chair achieved the highest points, which is 5 points out of a total of 6 points. Zenith Chair and Cantata Chair (4/6), Pera Chair and Pi Pouf (3/6), and the other eight furniture products scored 2 out of 6 points. The parameters 'Localization' and 'Ethical design' are used during the design and development of all 15 case products. The parameter 'Health and safety of a neighborhood' is used in the design of furniture from Koleksiyon, Nurus, and B&T Design. 'Dust complaints' and 'Noise complaints' are the less considered parameters during the development of the products. 'Odor complaint' did not get any points on any of the selected products.

3.7.2.3. Economic Parameters

As shown in figure 3.21, the economic parameters have two group categories, making a total point of required 9 points. 'Product life cycle' construct category comprises four parameters, making a total of four points. It is followed by 'Design strategies', which have five parameters and make a total of five points.

3.7.2.3.1. Product Lifecycle

In the cost reduction by product life cycle category group, the highest points are achieved by U Too desk, Alava Chair and Pera Chair, each achieving an equal point of four (4/4). Zenith Chair, Cantata Chair, Comfy Operational, Bliss Chair, Premier Chair, Rounded Armchair, and Toy Pouf scored an equal 3 points (3/4). Lastly, 2 acquired points were scored by Frame Executive, Pi Pouf, Poff Pouf, and Dama. 'Use of cost estimating methods at an early stage of product development' is used in all products except the Premier Chair. Furthermore, only Frame Executive did not use the parameter 'Using local materials to reduce cost'. 'Cost minimization by efficient energy use' is used in the design and development of all the selected products except furniture from Tuna Office (Poff Pouf and Dama). Lastly, 'Cost-efficient packaging' is the least used parameter under the category group 'Product life cycle' obtaining points only on U Too Desk, Alava Chair, and Premier Chair.



	Total	K1	K2	N1	N2	B1	B2	E1	E2	O1	BT 1	BT 2	T1	T2	Z1	Z2
Product Life cycle	4	3	3	4	4	3	3	3	2	2	4	3	2	2	3	3
Design Strategies	5	2	3	3	4	4	4	2	4	1	3	3	4	5	2	3

Figure 3.21: Comparison of the 15 products by economic parameters

3.7.2.3.2. Design Strategies

The highest required point in using design strategies to reduce cost was scored by Dama from Tuna Office (5/5). Alava Chair, Comfy Operational, Bliss Chair, Frame, and Puff Pouf achieved equal four points (4/5). Three points (3/5) are achieved by U Too Desk, Cantata Chair, Pera Chair, Pi Pouf and Toy Pouf. Finally, the lowest acquired points (2/5)

are achieved by Zenith Chair, Premier Chair, and Rounded Armchair. Among the five design strategies for reducing cost, 'Durable product design' had the highest frequency of being used by all of the selected case products. 'Designing products with fewer connecting elements or components' is used in most of the products, except the U Too Desk and Zenith Chair. The strategy 'Use of multi-functionality to reduce cost' is used by Zenith Chair, Cantata Chair, U Too Desk, Frame Executive, Poff Pouf, and Dama. Products from Nurus, Burotime, Frame Executive by Ersa, Pera Chair by B&T Design, and Dama by Tuna Office use the strategy 'Design for assembly' in their design and development. Lastly, 'Modular design for cost reduction' is used in case products including Alava Chair, Comfy Operational, Bliss, Pi Pouf, Poff Pouf, Dama, and Toy Pouf.

3.8. DISCUSSION

Based on the results in Table 3.8 on certification received by the firms, most of the firms received environmental certification on environmental sustainability, except B&T Design. The green-labeled furniture firms (Koleksiyon, Nurus, and Bürotime) received TSE environmental management and energy management certifications in addition to international green certifications such as EPD, GREENGUARD, Ecolabel, and zero waste certifications. Based on the literature review on firms and the participant's elaboration on the questionnaire form, the other prominent firms, except for B&T Design and Ofisline received TSE environmental management certification. Ofisline received LEED Gold for the industry. This shows that most of the selected firms are familiar with the practice of environmental sustainability. However, all of them did not receive certification for social and economic sustainability.

According to the listed mean value in the analysis Table 3.9 for the environmental parameters in the material category, the results indicate that 'Avoiding toxic materials', with a mean value =3.750 ranked first. 'Reduction of material variety' and 'Minimum use of material', with a value =3.500 ranked second, has been identified as the most used parameters in the selected firms. 'Using biodegradable' materials and 'Using renewable materials' are the least used parameters. In the energy construct category, the results indicate that 'Reducing of energy use in manufacturing', with a mean value =3.000 ranked first. The least used energy parameter is 'Use of low energy content material', with a mean

value =1625. Moreover, ‘Waste disposal management’ is the most used parameter in the waste construct category. The least used waste parameter is ‘Waste recycling’, with a mean value =1625. The two parameters in the atmospheric emission category have an equal mean value, being equally used parameters. ‘Extended life span of a product’ and ‘Reusability of a product’ are the most used parameters in product feature and end-of-life option categories. It is believed that the parameters listed on material, energy and atmospheric emission are the most used due to the attention given to these issues in the international environmental standards. Companies should research and experiment on the usage of biodegradable and renewable materials to minimize environmental impact of products and achieve sustainability. Moreover, the use of product features and end-of-life options should be considered at the early stage of the product design. Making sustainability a priority and giving training and workshops on the parameters to the designers and employees can help in improving the use of the parameters, which are stated as the least used in this study.

With a mean = 3.875, ‘Customer satisfaction’, ‘Localization’, and ‘Ethical design’ are ranked the highest among the social parameters. They are followed by ‘Quality of life’ and ‘Design for the need of the future’ having a mean point =3.625. ‘Odor compliant’ and ‘Design for elderly and disability’ are ranked the least used, having a mean value=1.875. This parameter is not used as a design strategy, due to the fact that most of the products are office furniture. Firms when designing a product for a working environment, elderly are less considered. Parameters in the user-centered category group ranked the highest since firms prioritize the needs of their users and customers more than society. Furthermore, in the economic parameter section, the most used parameter is ‘Durable product design’ with a mean value= 3.875, followed by ‘Using local material to reduce cost’ having a mean value = 3750. Finally, the least used parameters are ‘Cost-efficient packaging’ and ‘Modular product design’ with a negative mean difference value = 2.750. Durability is considered as an attribute of a good quality product. The ability to withstand damage and be used for a longer time is the customer’s priority when choosing a product to purchase. Therefore, companies work continuously to provide durable products, and for this reason, this parameter received the most used parameter in the economic parameter. In contrast, modular product design is rarely used due to lack of

knowledge on modularity, and participants stated in section 3.8.1.5. that one of the drawbacks of using sustainability parameters is the difficulty of integrating them to the product features. However, firms should consider using this parameter in the design of products more since it is useful in achieving other parameters as well. Modularity helps in material efficiency, energy efficiency due to the use of fewer components and fewer steps while manufacturing, and helps minimize cost.

As a result of the parameter based comparative analysis on selected case products, U Too Desk and Alava Chair by Nurus scored the highest point 18/23 and 19/23 respectively on environmental parameter analysis. The smallest point (9/23) was scored by Rounded Armchair from Zivella. In the analysis of social parameters, U Too Desk scored the highest point (12/15). The smallest point (6/15) was scored by Comfy Operational, Bliss, Frame Executive and Poff Pouf. Furthermore, Alava Chair scored the highest point (8/9) for the economic parameters and the smallest point (3/9) is scored by Teo Couch. Products from the prominent firms did not show a significant difference on the usage of economical parameters except Teo Couch, when compared to products from green certified firms. The products having the highest scores in all the three dimensions belong to Nurus. This shows that the firm pays attention to environmental, social, and economic parameters more than the other firms.

There is a considerable difference in the use of environmental parameters on the products than the other two dimensions of sustainability. Products from Koleksiyon, Nurus, and Bürotime use the environmental parameters more than other prominent firms. It is believed that their high performance is linked to their sensitivity to sustainable education and environmental certifications, since the participants from these firms received education on sustainability. In fact, the participant from Nurus received training on sustainability given by the managers with in the company. They also received TSE environmental management certification and other international certifications such as EPD and GREENGUARD. The low performance of the other prominent firms on the environmental dimension can be linked to the drawbacks stated in section 3.8.1.5. The highly rated drawbacks: the need for high financial demand to implement sustainability; lack of harmony with the product design; and sustainability not being a priority created low performance on the use of the parameters. Moreover, low performance in category

groups such as "product features" and "end-of-life" is linked to the use of lifecycle thinking more in the raw material and component manufacturing life cycle stages of products, as stated in section 3.8.1.3.

CHAPTER 4

CONCLUSION

It is a well-known fact that sustainability is a fundamental approach to consider for the purpose of minimizing the environmental crises occurring globally. However, considering only the environmental dimension does not create a significant change. The other two dimensions (social and economic) should be considered in studying and applying a sustainable approach. In the furniture sector, applying this approach is important because it has a big role and potential in decreasing environmental impact and improving health and social comfort.

This study examines the use of parameters under the three sustainable dimensions in the selected middle to high scale furniture firms in Turkey. A wide range of parameters are first identified through a thorough literature review. The identified parameters are used to examine and assess furniture firms and selected case products with a combination of research methods that include a questionnaire survey and a parameter-based comparative analysis. Eight firms, three that have received green product certification (Koleksiyon, Nurus, and Bürotime) and five other prominent furniture firms (Ersa, Ofisline, B&T Design, Tuna, and Zivella) are selected to conduct the study. The study examines the use of 23 environmental, 15 social, and 9 economic parameters obtained through the literature review, on the selected firms and case products.

The results show that ‘Avoiding toxic materials’, ‘Reduction of energy use in manufacturing’, ‘Waste disposal management’, ‘Comply with clean air and climate protection strategy’, ‘Minimizing atmospheric emissions’, ‘Extended life span of a product’ and ‘Reusability of a product’ are identified as the most used environmental parameters through the survey and analysis of the products. With respect to social

parameters, ‘Customer satisfaction’, ‘Localization’, and ‘Ethical design’ are recognized as the highly used social parameters.

Furthermore, ‘Durable product design’ and ‘Using local material to reduce cost’ are the most used economic parameters according to the data from the survey and analysis of the case products. On the other hand, parameters related to materials such as ‘Using biodegradable materials’, ‘Using renewable materials’, ‘Use of low energy content material’, and ‘Waste recycling’ are identified as the least used parameters, which shows the lack of eligibility of Turkish market for green materials. Additionally, ‘Enhancing remanufacturing’, ‘Odor compliant’, ‘Design for elderly and disability’, ‘Cost-efficient packaging’ and ‘Modular product design’ are the least used parameters in the design and development process of products in the selected firms.

As a result of the parameter-based comparative analysis of selected case products, furniture from Nurus scored the highest points in all three dimensions. The lowest points are scored by Zivella in the environmental dimension; products from Bürotime, Ersa, and Tuna Office in the social dimension; and products from Ofisline in the economic dimension. The high performance of Nurus is believed to be a result of their sensitivity to sustainable education and environmental certifications, since the participants from this firm received education on sustainability and received training on sustainability given by the managers in the company. Additionally, the firm implements sustainability concepts in every lifecycle stage and received different sustainability certifications, which are believed to have a great contribution to the highest performance the firm scored in this study. Based on the results of the survey, ‘Enhancing brand image’, ‘Decreased environmental impact’, ‘Cost reduction and profitability’, ‘Market competitiveness’, and ‘Enhanced product design and innovation’ are opportunities created by using sustainability approach in furniture firms. Moreover, drawbacks that limit the furniture firms from using sustainable strategies are ‘Lack of defined strategy’, ‘Lack of harmony of sustainability with product features’, ‘High financial demand to implement the strategy’, ‘Sustainability not being a priority for furniture firms’, and ‘The existence of various standard systems’. Sustainable and green approaches have much higher initial investment costs when compared to traditional approaches. Therefore, firms should use long-term financial planning to redeem these costs and focus on the public welfare,

beyond the economic aspects. Governments and responsible bodies should work on revising and defining sustainable strategies and standards. Additionally, creating awareness and laws that force firms to implement sustainability practices helps in making sustainability a priority for furniture firms.

Finally, the study contributed a set of parameters that were constructed and used in the analysis based on the extensive literature review as seen in table 3.2. The set of parameters can serve as a guideline for the designer or firm authorities in the furniture industry. The selected furniture firms are concerned with sustainability, particularly in the environmental dimension, considering the fact that they aim to receive the TSE certification in order to achieve market competitiveness and enhance their brand image. Green certifications in the building industry, such as LEED, BREEM, etc are highly popular and implemented highly in the building sector. While green product labels are mostly used for marketing and brand-enhancing purposes, their demand in the furniture sector is rather low. Therefore, increasing the number of such green labels and awareness of their importance in measuring sustainability will motivate firms to adopt them. Product features and end-of-life option categories in the environmental dimension, societal concerns category in social dimension and design strategies to minimize cost category in economic dimension are issues where low performance of the firms are recorded. Therefore, more attention should be given to these parameter groups. Using design strategies such as modular design, design for assembly, and design for waste minimization at the early life cycle stage of a product will help firms achieve sustainability in all three dimensions at the later life cycle stages of products.

Table 4.1: Conclusion remarks

• Firms should organize training and workshops for employees to create awareness.
• Firms should have a sustainability specialist.
• Certifications such as TSE should be encouraged since they act as motivators.
• Social and economic dimensions of sustainability should be promoted.

• Firms should give more attention to the parameters in the following category groups:
  • Product features and end-of-life option
  • Societal concerns category
  • Design strategies to minimize cost category

Table 4.1 Continued

• Companies should practice integrating sustainable thinking throughout the life cycle of a product.
• Low performance in materials category was found due to the lack of eligibility in the Turkish green materials market
• Companies should use the following design strategies at the early life cycle stages: • Modular design • Design for assembly • Design for waste minimization
• Firms should use the set of parameters derived in this study (Table 3.2.) as a guideline to achieve sustainability.
Opportunities created by using a sustainability approach in furniture firms; • Enhanced brand image • Decreased environmental impact • Cost reduction and profitability • Market competitiveness • Enhanced product design and innovation
Drawbacks that limit firms from using sustainable strategies are: • Lack of defined strategy • Lack of harmony sustainability with product features • High financial demand • Sustainability not being a priority • Existence of various standard systems

3.9. FURTHER RESEARCH

This thesis study begins by determining the parameters of sustainable design in the furniture sector and analyses its implication in the Turkish furniture industry. There is further work to be done to overcome the drawbacks of the research and make the study effective. It would be advantageous to continue this study in the following areas:

- The validity of the answers from the questionnaires should be investigated by conducting semi-structured interviews with the selected product designers and authorities of furniture firms. This can be beneficial in supporting the data obtained in this study with facts and getting detailed information about products to carry out an in-depth comparative analysis while avoiding some uncertainties mentioned as the limitation of the present study.
- Research can be carried out with different respondents such as the users or customers of the products on the comfort or satisfaction of the users on the

implication of sustainability parameters. For additional validation, the findings might be compared to the results of the present study.

- Further research can be done by including other stakeholders including employees and the company when determining and assessing parameters of social and economic sustainability in the furniture sector.
- Further research can be done by conducting the questionnaire surrey on large sample size.

3.10. LIMITATIONS OF THE STUDY

This research achieved its aim of studying the level of awareness and implications of parameters of sustainable design in prominent Turkish furniture firms by conducting a questionnaire survey and a parameter-based comparative analysis on selected case products from the firms. However, this study has limitations. The study's primary drawback is that it depends on self-claims of the participants. Participants were given open-ended options to elaborate more on their answers to some questions to get more solid and well-established answers. However, it was difficult to get a solid explanation from participants through that. Follow-up work of semi-structured interviews with participants or firm authorities' would be a better solution to support the data obtained. Getting responses from the firms was a difficulty encountered while conducting the research due to the busy schedules of authorities and designers. The research was conducted on 8 firms because of the limited number of firms found in Türkiye that satisfy the selection criteria stated in section 3.2.1. and limited access to firms due to their busy schedules. The small number of firms is seen as a drawback of the study, and further research can be done by increasing the number of sample firms.

The questionnaire sheets for this study were constructed both in Turkish and English due to the need of carrying out the study in the native language of the participants (Turkish) for a better understanding. However, participants may not be familiar with some sustainability terms and the translation may have brought a certain amount of confusion. Lastly, the participants are believed to give a positive answer to the questions provided to maintain the positive brand image of their products and their company. To avoid such unnecessary biases the study attempted to cross-check and investigate the facts behind

their answers, through the literature review on products and the company. However, difficulty was encountered in finding such broad information on the firm's web pages. As stated earlier, semi-structured interviews with participants would be a better option to avoid such uncertainty.

REFERENCES

Akreim Mohamed (2018), *Strategies and Policy of Green Design Implementation in Building Projects of Libya* (Doctoral Thesis) Çankaya University Graduate School of Natural and Applied Sciences Ankara.

ARCHIPRODUCTS (n.d.), *Tuna Ofis: Office Furniture*, https://www.archiproducts.com/en/tuna-ofis; AD. 30.05.2022.

AYDIN Mahmut Ferit (2015), *Analysis of Design-Driven Innovation Practices in Turkish and Swedish Furniture Firms* (Doctoral Thesis) Izmir Institute of Technology, İzmir.

AZIZ Arnis, TAHIR Mohd Osman and JA'AFAR Fakri Zaky Mohamad (2012), "Significances of Sustainability Street Furniture Design in Malaysia", *In Proceedings of the 2nd. International Conference on Arts, Social Sciences & Technology Penang*, No. I2112, pp. 1-9, Malaysia.

B&T DESIGN (n.d.), *About Us*, https://bt.design/about-us/, AD. 29.05.2022.

B&T DESIGN (n.d.a), *Design Hub*, https://bt.design/design-hub-en/, AD. 30.05.2022.

B&T DESIGN (n.d.b), *Pera 4 Prong Swivel Base Castors Chair*, https://bt.design/pera-4-prong-swivel-base-castors-chair.html, AD. 01.06.2022.

B&T DESIGN (n.d.c), *Pi Pouf*, https://bt.design/pi-pouf.html, AD. 01.06.2022,

BANSAL Pratima (2005), "Evolving Sustainably: A Longitudinal Study of Corporate Sustainable Development", *Strategic Management Journal*, Volume 26, Issues 3, pp. 197–218.

Bhamra Tracy, Lofthouse Vicky (2007), Design for Sustainability: A Practical Approach. 1st ed., Gower, London.

BIFMA (2011), Business World and International Furniture Manufacturers, *Association ANSI / BIFMA e3-2014e Furniture Sustainability Standard*, Michigan.

BJÖGVINSSON Erling, EHN Pelle and HILLGREN Per-Anders (2012). "Design Things and Design Thinking: Contemporary Participatory Design Challenges", Design Issues, Volume 28, Issue 3, pp. 101–116.

BOGUE Robert (2007), "Design for Disassembly: A Critical Twenty-First-Century Discipline", *Assembly Automation*, Volume 27, Issue 4, pp.285–289.

BORGA Francesca, CITTERIO Annalisa, NOCI Giuliano and PIZZURNO Emanuele (2009), "Sustainability Report in Small Enterprises: Case Studies in Italian Furniture Companies",*Business Strategy and the Environment*, Volume 18, Issue 3, pp.162–176.

BOWMAN Cliff and AMBROSINI Véronique (2000), "Introduction to Value Creation Versus Value Capture: Towards a Coherent Definition of Value in Strategy", *British Journal of Management*, Volume 11, Issue 1, pp. 1–15.

BULIAN Franco and FRAGASSA Cristiano (2016), "VOC Emissions From Wood Products and Furniture: A Survey About Legislation, Standards and Measures Referred to Different Materials", *FmeTransactions*, Volume 44, Issue 4, pp. 358-364.

BÜROTIME (n.d.a), *Awards*, https://www.burotime.com/en/awards, AD. 17.07.2022.

BÜROTIME (n.d.b), *Bliss*, https://www.burotime.com/en/bliss, AD. 31.05.2022.

BÜROTIME (n.d.c), *Corporate*, https://www.burotime.com/en/about-us, AD. 23.05.2022.

BÜROTIME (n.d.d), *Cozy Operational*, https://www.burotime.com/en/cozy-operational, AD. 31.05.2022.

C2CPII (2014), Cradle to Cradle Product Innovation Institute, *Cradle to Cradle Certified Product Standard*, Version 3.1, California.

C2CPII (2021), Cradle to Cradle Product Innovation Institute, *Cradle to Cradle Certified Product Standard*, Version 4, California.

CAN Aslı and GÜRPINAR Avşar (2021), "Türkiye'nin Mobilya Tasarım Tarihi,1800-2000" *The Turkish Online Journal of Design Art and Communication*, Volume 11, Issue 3, pp. 1004–1018.

CHAINALYTICS (n.d.), "How IKEA Saves Millions Through Packaging Optimization" https://www.chainalytics.com/ikea-save-millions-packaging-optimization/, AD. 08.06.2022.

CHANG Danni, LEE CKM, and CHEN Chun-Hsien (2014), "Review of Lifecycle Assessment Towards Sustainable Product Development", *Journal of Cleaner Production*, Volume 83, pp. 48-60.

CHANG Ya-Ju., NEUGEBAUER Sabrina, LEHMANN Annekatrin, SCHEUMANN

Rene and FINKBEINER Matthias (2017), "Life Cycle Sustainability Assessment Approaches for Manufacturing", *Inside, Sustainable Manufacturing:Challenges, Solutions and Implementation Perspectives*, Ed. Rainer Stark, Jeremy Bonvoisin, pp. 221–237, Springer Open, Switzerland.

CHAPMAN Jonathan (2005). *Emotionally Durable Design: Objects, Experiences and Empathy*. In Earthscan. https://doi.org/10.4324/9781849771092

CINOĞLU Ceren & ŞAHIN İsmail (2019), "A Study on Usability and User-Centered Design in Industrial Design", *The XXIXTH International Conference Research for Furniture Industry*, pp. 571–579, Poznan, Poland.

Clean Air Technology Center (1999), *Nitrogen Oxides (NOx) Why and How They Are Controlled*. Diane Publishing. https://books.google.com.tr/books?hl=en&lr=&id=kSJY-

COMACCHIO Zeno (2016), *Designing Sustainable Innovations: Opportunities for New Life Cycles Within The Furniture Industry* (Master's of Fine Arts) Linnaeus University, Sweden.

CONNER Kathleen R. (1991), "A Historical Comparison of Resource-Based Theory and Five Schools of Thought Within Industrial Organization Economics: Do We Have a New Theory of The Firm?", *Journal of Management*, Volume 17, Issue 1, pp. 121–154.

COOPER Daniel R and Gutowski Timothy G (2017), "The Environmental Impacts of Reuse: A Review", *Journal of Industrial Ecology*, Volume 21, Issue 1, pp. 38–56.

DE ALMEIDA SOUZA Paulo Fernando, & DE BARROS PEREIRA Hemane Borges (2006). "Towards Indicators of Sustainable Product Design", *IEEE International Engineering Management Conference*, pp. 274–277, IEEE, Salvador, Brazil.

DENIZ Deniz (2002), *Sustainability and Environmental Issues in Industrial Product Design* (Masters Dissertation) Izmir Institute of Technology Izmir.

DIŞLI Bayrkatar Eda & AYYILDIZ Hasan (2021), "İnovasy Stratejilerinin Kurums Sürdürülebilirlik Performansinetkisi", *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, Volume 60, pp. 189–214.

DYLLICK Thomas and ROST Zoe (2017), "Towards True Product Sustainability", *Journal of Cleaner Production*, Volume 162, pp. 346–360.

EASTMAN Charles (2012), *Design for X: Concurrent Engineering Imperatives*, Springer Science & Business Media.

EMAS Rachel (2015), The Concept of Sustainable Development : Definition and Defining Principles. Brief for GSDR 2015, United Nations, NewYork.

ENDSLEY Mica R, BOLTE Betty and JONES Debra G (2003), *Designing for Situation Awareness : An Approach to User-Centered Design*, Taylor & Francis, SA Technologies, Georgia, USA. https://doi.org/10.1201/9780203485088

EPD (2018a), Environmntal Product Declaration, *Helen Chair*, Istanbul. https://portal.environdec.com/api/api/v1/EPDLibrary/Files/8a5b645b-298b-4243-b8f6-08d8d1855218/Data

EPD (2018b), Environmntal Product Declaration, *Zenith Chairs*. Istanbul.

EPD (2018c), Environmntal Product Declaration, *Cantata Chair*, Istanbul.

Ersen Nadir (2021), "Analysis of Furniture Products' Contribution to Turkey's Economy with a Hybrid Multi-Criteria Decision Making Method", *BioResources*, Volume 16, Issue 1, pp. 339–353.

ERSA (n.d.), *Our Story*, https://www.ersamobilya.com/en/our-story, AD. 27.05.2022.

ERSA FURNITURE (n.d.a), *Frame Executive Desk System*, https://www.ersamobilya.com/en/products/frame-executive-desk?q=frame, AD. 20.08.2022.

ERSA FURNITURE (n.d.b), *Premier Chair*, https://www.ersamobilya.com/en/products/premier-dining-chair, AD. 20.08.2022.

FINKBEINER Matthias, SCHAU Erwin. M, LEHMANN Annekatrin, and TRAVERSO Marzia (2010), "Towards Life Cycle Sustainability Assessment" *Sustainability*, Volume 2, Issue 10, pp. 3309–3322.

FLOKK (n.d.), "HÅG Tion", https://store.flokk.com/global/en-gb/products/hag-tion?model=2100-STD&code=07MTEX, ET. 15.06.2022

FLOKK (2021), *Corporate Sustainability Report*,Oslo.

FOUAD Dina and Farag Mahmoud (2019), "Design for Sustainability with Biodegradable Composites", In, *Design and Manufacturing*, Ed, Evren Yasa, Mohsen Mhadhbi, Eleonora Santecchia, pp. 39–55, IntechOpen. https://doi.org/10.5772/INTECHOPEN.88425

FREEMAN R Edward (2010), *Strategic Management: A Stakeholder Approach*. Cambridge University Press.

FRYDENDAL Jeppe, HANSEN Lisbeth Engel and BONOU Alexandra (2018), "Environmental Labels and Declarations", *Inside, Life Cycle Assessment*, pp. 577–604, Springer International Publishing. https://doi.org/10.1007/978-3-319-56475-3

FUAD-LUKE Alastair (2009), *Design Activism: Beautiful Strangeness for a Sustainable World*. Taylor and Francis. https://doi.org/10.4324/9781849770941

GERSHENSON John K, PRASAD G. Jagannath and ALLAMNENI Sharada (1999), "Modular Product Design: A Life-cycle View", *Journal of Integrated Design and Process Science*, Volume 3, Issue 4, pp. 13–26.

GRI (2006), Global Reporting Initiative, *G3 Version for Public Comment Sustainability Reporting Guidelines [DRAFT]*. www.globalreporting.org.

GRIEßHAMMER Rainer, BENOÎT Catherine, DREYER Louise Camilla, FLYSJÖ Anna, MANHART Andreas, MAZIJN Bernard and WEIDEMA BO (2006), "Feasibility Study: Integration of Social Aspects into LCA".

GÜNEŞ Sinem and DEMIRARSLAN Deniz (2020), "Sürdürülebilirlik ve Mobilya Tasarımında Çevreci Yaklaşımlar", *Uluslararası İnsan ve Sanat Araştırmaları Dergisi*, Volume 5, Issue 6, pp. 81–99.

Hemel Carolien G., Keldmann, Troels. (1996), "Applying DFX Experiences in Design for Environment" *Inside, Design for X: Concurrent Engineering Imperatives*, Ed. Eastman Charles M, pp. 72-95, Chapmann & Hall, London.

HAUSCHILD Michael Zwicky, JESWIET Jacob, and ALTING Leo (2004), "Design for Environment- Do We Get the Focus Right?", *CIRP Annals*, Volume 53, Issue 1, pp.1-4.

HERREMANS Irene M and REID Robine E (2002), "Developing Awareness of The Sustainability Concept", *Journal of Environmental Education*, Volume 34. Issue 1, pp. 16–20.

IRALDO Fabio, FACHERIS Camilla and NUCCI Benedetta (2017), "Is Product Durability Better for Environment and for Economic Efficiency? A Comparative Assessment Applying LCA and LCC to Two Energy-Intensive Products", *Journal of Cleaner Production*, Volume 140, pp. 1353–1364.

IRITANI Diego Rodrigues, LOPES SILVA, Diogo Aparecido, SAAVEDRA Yovana María Barrera, GRAEL Paulo Fernando Fuzer and OMETTO Aldo Roberto (2015), "Sustainable Strategies Analysis Through Life Cycle Assessment: A case Study in a Furniture Industry" *Journal of Cleaner Production*, Volume 48, pp. 308-318.

JEGANOVA Julija (2004), Product Life Cycle Design: Integrating Environmental Aspects into Product Design and Development Process at Alfa Laval (Master's Thesis) Lund University, Sweden. https://www.lumes.lu.se/sites/lumes.lu.se/files/jeganova_julija, AD. 28.11.2022.

KARACA Betül (2018), *Sürdürülebilir Mobilya Üretiminde Tasarimci Bilinci Üzerine Bir Araştirma Yüksek Lisans Tezi* (Yüksek Lisans Tezi) Başkent Üniversitesi, Ankara.

KESEDI Nimet Başar (2019), *New Product Development in the Tukish Furniture Industry: Experiances of In-House Industrial Designers* (Master's Thesis) Middle East Technical University, Ankara.

KIM Juran, TAYLOR Charles R, KIM Kyung Hoon and LEE Ki Hoon (2015), "Measures of Perceived Sustainability", *Journal of Global Scholars of Marketing Science*, Volume 25, Issue 2, pp. 182–193.

KOLEKSIYON (n.d.a), *Cantata Chair*, https://koleksiyon.com.tr/urun/cantata/, AD.31.05.2022.

KOLEKSIYON (n.d.b), *Quality and Environment*, https://koleksiyon.com.tr/about/quality-and-environment/, AD. 23.05.2022.

KOLEKSIYON (n.d.c), *Zenith Chair*, https://koleksiyon.com.tr/product/zenith/, AD.31.05.2022.

KOO Bongjin, HERGEL Jean, LEFEBVRE Sylvain and MITRA Niloy J. (2017), "Towards Zero-Waste Furniture Design", *IEEE Transactions on Visualization and Computer Graphics*, Volume 23, Issue 12, pp. 2627–2640.

KRAJNC Damjan and GLAVIC Peter (2003), "Indicators of Sustainable Production", *Clean Technologies and Environmental Policy*, Volume 5, pp. 279–288.

KUMAR Mahesh (2020), "Social, Economic, and Environmental Impacts of Renewable Energy Resources", In, *Wind Solar Hybrid Renewable Energy System*, Ed, Kenneth Eloghene Okedu, Ahmed Tahour, Abdel Ghani Aissaou, pp. 227-237, IntechOpen. https://www.intechopen.com/chapters/70874Livestock , AD. 03.07.2022.

LAYLIN Tafline (2013), *Gorgeous Recycled Silk Furniture from Turkey's Meb Rure*. Green Prophet. https://www.greenprophet.com/2013/10/gorgeous-recycled-silk-furniture-from-turkeys-meb-rure/ , AD. 13.10.2022.

LEVEL CERTIFIED - BIFMA (n.d.), "Furniture Sustainability Standard", https://www.bifma.org/general/custom.asp?page=level-certified, ET. 12.03.2021.

LIN I-Hsiang (Hank), CHANG Otto H. and CHANG Chunchia (Amy) (2014), "Importance of Sustainability Performance Indicators as Perceived by the Users and Preparers", *Journal of Management and Sustainability*, Volume 4, Issue 1, pp.29–41.

LITTIG Beate and GRIESSLER Erich (2005), "Social Sustainability: A Catchword Between Political Pragmatism and Social Theory", *International Journal of Sustainable Development*, Volume 8, Issue 1/2, pp. 65–79.

MA Junfeng, KREMER Gul E.Okudan and LI Mian (2018), "A Key Components-Based Heuristic Modular Product Design Approach to Reduce Product Assembly Cost", *International Journal on Interactive Design and Manufacturing (IJIDeM)*, Volume 12, Issue 3, pp. 865–875.

MAXWELL Dorothy and VAN DER VORST Rita (2003), "Developing Sustainable Products and Services", *Journal of Cleaner Production*,Volume 11, Issue 8, pp. 883–895.

MCDONOUGH William and BRAUNGART Michael (2002), "Design for the Triple Top Line: New Tools for Sustainable Commerce", *Corporate Environmental Strategy*, Volume 9, Issue 3, pp. 251-258.

MCKENZIE Stephen (2004), "Social Sustainability : Towards Some Definitions", *In Hawke Research Institute, Working paper series*, Issue 27. https://www.unisa.edu.au/siteassets/episerver-6-files/documents/eass/hri/working-papers/wp27.pdf

Minkov, N., Bach, V., & Finkbeiner, M. (2018). Characterization of the Cradle to Cradle Certified ™ Products Program in the Context of Eco-labels and Environmental Declarations. *Sustainability*, *10*(3), 738. https://doi.org/10.3390/su10030738

NURUS (n.d.a), *Alava Chair*, https://www.nurus.com/tr/calisma-koltuklari/alava, AD. 31.05. 2022.

NURUS (n.d.b), *DNA*, https://www.nurus.com/en/dna, AD. 23.05.2022.

NURUS (n.d.c), *Me Too Chair*, https://www.nurus.com/en/performance-task-chairs/me-too, AD. 09.10.2022.

NURUS (n.d.d), *U Too Chair*, https://www.nurus.com/tr/calisma-sistemleri/u-too, AD. 31.05.2022.

OFISLINE (n.d.), *Teo Cauch*, https://www.ofisline.com.tr/en/couches/teo/, AD. 01.06.2022.

OKURSOY Mehmet Erçin (2012), *Barriers and Opportunities for Integrating Sustainable Product Design into Ankara Small and Medium-Sized Furniture Enterprises* (Master's Thesis) Middle East Technical University, Ankara, Turkey. https://open.metu.edu.tr/handle/11511/21375

ÖSTLIN Johan, SUNDIN Erik and BJÖRKMAN Mats (2008), "Importance of Closed Loop Supply Chain Relationships for Product Remanufacturing", *International Journal of Production Economics*, Volume 115, Issue 2, pp. 336-348.

OTTMAN Jacquelyn, STAFFORD Edwin and HARTMAN Cathy (2006), "Avoiding Green Marketing Myopia: Ways to Improve Consumer Appeal for Environmentally Preferable Products", *Environment: Science and Policy for Sustainable Development*, Volume 48, Issue 5, pp. 22-36.

PERERA H. S, NAGARUR Nagen and TABUCANON Mario T (1999), "Component Part Standardization: A Way to Reduce the Life-cycle Costs of Products", *International Journal of Production Economics*, Volume 60, pp. 109–116.

PETERS Harm, TOXOPEUS Marten, JAUREGUI-BECKER Juan and DIRKSEN Mark-Olof (2012), "Prioritizing 'Design for Recyclability' Guidelines, Bridging the Gap Between Recyclers and Product Developers", *Leveraging Technology for a Sustainable World*, pp. 203-208.

PRENDEVILLE Sharon (2014), *Ecodesign and Material Selection for Eco-innovation in Office Furniture Products* (Doctoral dissertation) Cardiff Metropolitan University.

REMERY Marie, MASCLE Christian, and AGARD Bruno (2012), "A New Method for Evaluating the Best Product End-of-life Strategy During the Early Design Phase", *Journal of Engineering Design*, Volume 23, Issue 6, pp. 419–441.

REPUBLIC OF TURKEY - MINISTER OF TRADE (2019), *Furniture Industry in Turkey*, Ankara.

RUSH Christopher and ROY Rajkumar (2000), "Analysis of Cost Estimating Processes Used Within a Concurrent Engineering Environment Throughout a Product Life Cycle", *In 7th ISPE International Conference on Concurrent Engineering: Research and Applications*, pp. 58–67.

ŞAHIN Sana (2018), "Mobilya Tasarımında Ekolojik Malzeme Açısından Kağıt Kullanımı", *Kocaeli Üniversitesi Mimarlık ve Yaşam Dergisi*, Volume 3, Issue 1, pp.87.

SARKAR Prabir, CARRELL John, JOUNG Che Bong and FENG Shaw C (2011), "Sustainable Manufacturing Indicator Repository", *In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, Volume 54792, pp. 943-950, Washington

SCHNEIDER Rob (2018), *Low Embodied Energy Building Materials*. https://hipages.com.au/article/low_embodied_energy_building_materials, AD. 30.07.2022.

SERIN Hasan, DURGUN Muhammet and ŞAHIN Yunus (2014), "Furniture Sector of Turkey", *European Journal of Research on Education*, Volume 2, Issue 6, pp. 147–151.

SEYAJAH Norhisham (2016), *Development of an Integrated Sustainable Design Approach for Furniture Design and Its Implementation and Application Perspectives* (Doctoral Dissertation), Brunel University, London. https://doi.org/10.14809/faim.2014.0999 page 21

SKINNER Julia M. and BRILHANTE Ogenis (2015), *Promoting Sustainable Construction in the EU: Green Labels, Certification Systems and Green Procurement*, Institute for housing and urban development studies (IHS), Rotterdam. http://www.ihs.nl/en/media/2017-11-greenlabels

SUTHERLAND John, RICHTER Justin, HUTCHINS Margot, DORNFELD David, DZOMBAK Rachel, MANGOLD Jennifer, ROBINSON Stefanie, HAUSCHILD Michael, BONOUE Alexandra, SCHÖNSLEBEN Paul and FRIEMANN Felix (2016), "The Role of Manufacturing in Affecting the Social Dimension of Sustainability", *CIRP Annals*, Volume 6, Issue 2, pp. 689-712.

SÜZER Özge and YILMAZ Meltem (2010), "An Innovative Waste Management System,

‘Cierra Recycling’, and Its Product as a Sustainable Building Material”. *Proceedings of the International Sustainable Buildings Symposium (Isbs)*, pp. 833–836.

THE CENTER FOR UNIVERSAL DESIGN (n.d.), *About UD*, https://projects.ncsu.edu/ncsu/design/cud/about_ud/about_ud.htm, AD. 04.05.2022.

TOBB (2013), *The Turkish Furniture Products Assembly Sector Report*, Ankara.

TOBLER Gabriel and JOSEFSSON Simon (2017), *Product Modularity and its Effect on Resource Efficiency* (Bachelor Thesis) KTH Royal Institute of Technology, Stockholm.

TUNA OFFICE (n.d.a), “Ergonomik ve Tasarım Ofis Mobilyaları”, https://www.tunaofis.com/en-US/awards, A.D. 31.05.2022.

TUNA OFFICE (n.d.b), “Manifacture”, https://www.tunaofis.com/en-US/manifacture, A.D. 30.05.2022.

UMEMORI Yoshimasa, KONDOH Shinsuke, UMEDA Yasushi, SHIMOMURA Yoshiki and YOSHIOKA Masaharu (2001), “Design for Upgradable Products Considering Future Uncertainty”, *Proceedings Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing*, pp. 87–92.

UNEP, SETAC & LC Initiative (2009), United Nations Environment Program, Society of Environmental Toxicology and Chemistry and Lifecycle Initiative, *Guidelines for Social Life Cycle Assessment of Products*, Kenya.

United Nations Environmental Program (UNEP) (n.d.), “Methane | Climate & Clean Air Coalition”, https://www.ccacoalition.org/en/slcps/methane, A.D. 13.07.2022.

UYSAL Mesut (2014), *Furniture Design and Product Development Principles Considering End-of-life Options and Design for Environment Strategies* (Doctoral Dissertation) Purdue University, Indiana.

VALIPOOR Shabboo and UJANG Baharudin (2011), “Challenges of Sustainable Design in Malaysian Furniture Industry”, *In 2011 International Conference on Environment and Industria Innovation, IACSIT Press*, Volume 12, pp. 60–64, *Singapore*.

VAVIK Tom and KEITSCH Martina Maria (2010), “Exploring Relationships Between Universal Design and Social Sustainable Development: Some Methodological Aspects to the Debate on the Sciences of Sustainability”, *Sustainable Development*, Volume 18, Issue 5, pp. 295–305.

VIERRA Stephanie (2016), "Green Building Standards and Certification Systems", *National Institute of Building Sciences, Washington, DC.*

WALKER Stuart (2010), "The Chimera Reified: Design, Meaning and the Post-Consumerism Object", *Design Journal*, Volume 13, Issue 1, pp. 9–30.

WATKINS Matthew Alan (2014), *An Investigation into Effective Methods for Teaching Social Sustainability within Product Design in British and Irish Universities* (Doctoral dissertation), Loughborough University. https://dspace.lboro.ac.uk/2134/14155

WCED (1987), World Commission on Environment and Development, *Our Common Future*, NY:Oxford University Press.

WHITE Philip, ST. PIERRE Louise and BELLETIRE Steve (2013), "Ecodesign Strategy Wheel", *Inside, Okala Practitioner Integrating Ecological Design*, Okala Team. http://www.okala.net/presentations.html, A.D. 28.11.2021.

WHITELEY Nigel (1993), *Design for Society*. Reaktion Books.

XIE Yi (2016), *Chinese Bench: A Research on Multi-function Furniture Design* (Master's Thesis) University of Iowa. https://doi.org/10.17077/etd.ekwntjpa

YÜKSEL Emine and Kiliç Murat (2015), "Eco-Friendly Approach in Furniture Design", *Proceedings of the 27th International Conference*, pp. 357–368, Ankara.

ZAMAGNI Alessandra, PESONEN Hanna-Leena and SWARR Thomas (2013), "From LCA to Life Cycle Sustainability Assessment: Concept,Ppractice and Future Directions", *International Journal of Life Cycle Assessment*, Volume 18, Issue 9, pp.1637–1641.

ZENGIN Yasemin and ADA Erhan (2010), "Cost Management Through Product Design: Target Costing Approach", *International Journal of Production Research*, Volume 48, Issue 19, pp. 5593–5611.

ZHANG Guirong and ZHAO Zongjian (2012), "Green Packaging Management of Logistics Enterprises", *Physics Procedia*, Volume *24*, pp. 900–905.

Zivella (n.d.), https://www.zivella.com/en/zivella/, A.D. 30.05.2022.

Zivella (2021), IF Design Award for Zivella Rounded, https://www.zivella.com/en/if-design-award-for-zivella-rounded/, A.D. 30.05.2022.

APPENDIXES

Appendix - 1. Parameter based Comparative Analysis Table

	Criterion	K1	K2	N1	N2	B1	B2	E1	E2	O1	BT1	BT2	T1	T2	Z1	Z2
Material	Using Biodegradable materials															
	Minimum use of materials	●	●	●	●	●	●	●	●		●	●	●	●	●	●
	Use of recyclable materials	●	●	●	●	●	●	●	●	●	●					
	Use of renewable materials			●	●					●						
	Reduction of material variety	●	●		●	●	●	●	●		●	●	●	●	●	●
	Avoiding toxic material	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Energy	Reducing energy use in manufacturing	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Use of low-energy content materials															
	Use of Renewable energy source	●	●	●	●											
	Reducing energy use during transportation			●		●	●			●	●	●				
	Reducing waste from production	●	●	●	●	●	●	●	●		●	●	●	●	●	●

Waste	No generation of dangerous waste	●	●	●	●	●	●	●	●	●			●	●	●	●
	Reducing waste from packaging			●	●						●				●	●
	Waste disposal management	●	●	●	●			●	●	●	●	●	●	●		
	Waste recycling			●	●	●	●	●	●	●						
Atmospheric Emission	Minimizing atmospheric emissions (NO2, CO2, SO2, Ch4)	●	●	●	●	●	●	●	●	●			●	●		
	Comply with clean air and climate protection strategy	●	●	●	●			●	●	●	●	●				
Product	Extended life span of the product (Durability)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Modular product design				●	●	●		●			●	●	●		●
	Multi-Functional Product	●	●	●					●				●	●		
End of life	Product recycling			●	●			●								
	Product re-usability	●	●	●	●				●		●	●	●	●		
	Enhancing Re-manufacturing								●							
	Design for elderly and disability															
	Design for User's health and safety	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Design for the needs of the future	●	●	●	●					●	●	●		●	●	●

User- Centered	User participatory design			●	●			●			●					
	Emotionally durable design	●	●													
	Customer satisfaction/feedback mechanism	●	●	●	●			●	●	●	●	●	●	●	●	●
	Culturally sensitive design			●							●					
	Transparency	●	●	●	●	●	●	●	●		●	●	●	●	●	●
	Quality of life	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Social concerns	Health & safety of the neighborhood	●	●	●	●					●	●	●				
	Localization	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Ethical design	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Noise complaints	●	●	●	●											
	Odor complaints															
	Dust complaints			●	●											
Product Life cycle	Use of cost estimating methods at an early stage of product development	●	●	●	●	●	●		●	●	●	●	●	●	●	●
	Using local materials to reduce cost	●	●	●	●	●	●	●		●	●	●	●	●	●	●
	Cost minimization by efficient energy use	●	●	●	●	●	●	●	●		●	●			●	●
	Cost-efficient packaging			●	●						●					
Design Strategies	Use of multi-functionality to reduce cost	●	●	●					●				●	●		
	Design for assembly			●	●	●	●		●		●			●		
	Designing products with		●		●	●	●	●	●		●	●	●	●	●	●

	fewer connecting elements and components															
	Modular design for cost reduction				•	•	•					•	•	•		•
	Durable product design	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Total Acquired point = 46	**30**	**31**	**37**	**38**	**27**	**27**	**26**	**27**	**21**	**29**	**25**	**24**	**26**	**21**	**23**

K1 - Zenith Chair N1- U Too B1 – Comfy Operational E1- Premier Chair
K2- Cantata Chair N2- Alava Chair B2 – BlissE2 – Frame executive
O1 – Teo Couch BT1- Pera Cahir T1- Poff Pouf Z1- Rounded Armchair
BT2- Pi Pouf T2- Dama Z2- Toy Pouf

Environmental Dimension
Social Dimension
Economical Dimension

Appendix - 2. Questionnaire Survey Form

This survey is prepared for the fulfillment of a master's thesis in the interior architecture graduate program at Cankaya University.

Section I: Q1- Q7 includes questions about general information about the furniture firm. Please read the questions and answer in the provided space.

1. Name of the firm _____
2. Your position in the firm or Profession _____
3. Gender?
   - ☐ Male
   - ☐ Female
4. Age?
   - ☐ 18 - 25
   - ☐ 25 – 30
   - ☐ 31- 40
   - ☐ 41- 50
   - ☐ 51- 60
   - ☐ Above 60
5. Educational Background?
   - ☐ Primary school
   - ☐ Secondary school
   - ☐ High school
   - ☐ Bachelor's degree
   - ☐ Master's degree
   - ☐ Doctorate
6. Did you take any education on sustainable design? If yes, please elaborate
   - Yes ☐
   - No ☐
7. Have you ever participated in sustainable design projects or product development?
   - Yes ☐
   - No ☐

Section II: Q8-Q13 includes questions about the firm's expertise in sustainability. Please read the questions and answer in the provided space

8. Did your company receive any certificate concerning environmental sustainability? If yes please elaborate certificates it received.

Yes ☐ No ☐

---

9. Did your company receive any certificate concerning social sustainability? If yes please elaborate certificates it received.

Yes ☐ No ☐

---

10. Did your company receive any certificate concerning economic sustainability? If yes please elaborate certificates it received.

Yes ☐ No ☐

---

11. Did your company get any training related to sustainable strategies? If yes please elaborate

Yes ☐ No ☐

---

12. Do you consider employee sustainability knowledge while recruiting for a job in your company?

Yes ☐ No ☐

13. Have you ever held any sustainable product development workshops at your company?

Yes ☐ No ☐

Section III: Q14- Q16 includes questions about the firm's working structure. Please read the questions and answer them in the provided space

14. At which stage of the product life cycle does your company integrate sustainable thinking?

- ☐ Raw material extraction
- ☐ Component manufacturing
- ☐ Product design and assembly
- ☐ Distribution and retail
- ☐ Use
- ☐ End-of-life disposal
- ☐ None

15. Do the designers in your firm have an impact on decisions made regarding sustainability?

Yes ☐ No ☐

16. In what stage of product development do the designers participate?

- ☐ Identifying the market need
- ☐ Generation of concepts
- ☐ Product design
- ☐ Creating prototypes
- ☐ Manufacturing of product

Section IV: Q17-Q19 includes parameters of sustainable product design that can be adapted to create a sustainable product

17. **If your firm uses any of the environmental sustainability strategies listed below, how often are they used?** If there are parameters that are not mentioned in the table, please specify in the given space below

		Never	Rarely	Often	Always
Environmental	**Material**				
	Using bio-degradable materials				
	Minimum use of materials				
	Use of recycled/recyclable materials				
	Using renewable materials				
	Reduction of material variety				
	Avoiding toxic materials				
	Energy Efficiency				
	Reduction of energy use in manufacturing				
	Use of low-energy content material				
	Using renewable energy source				
	Reducing energy use during transportation				
	Solid/ liquid Waste				
	Reducing waste from production				
	Not generating dangerous waste				
	Reducing waste from packaging				
	Management of disposed waste				
	Recycling of waste				
	Air Emission				
	Comply with clean air and climate protection strategy				
	Minimizing atmospheric emissions (NO2, CO2, SO2, Ch4)				
	Product				
	Extended life span of the product (Durability)				
	Modular product design				
	Multi-functionality				
	End of life options				
	Product recycling				
	Reusability of product				
	Enhancing remanufacturing				

18. **If your firm uses any of the social sustainability strategies listed below, how often are they used?** If there are parameters that are not mentioned in the table, please specify in the given space below.

		Never	Rarely	Often	Always
Social	**User-centered**				
	Design for elderly and disability				
	Design for user's health and safety				
	Design for the needs of the future				
	Participatory design				
	Emotionally durable design				
	Customer satisfaction/feedback mechanism				
	Culturally sensitive design				
	Transparency				
	Quality of life				
	Societal concerns				
	Health and safety of a neighborhood				
	Localization				
	Ethical design				
	Noise complaints				
	Odor complaints				
	Dust complaints				

19. **If your firm uses any of the economic sustainability strategies listed below, how often are they used?** If there are parameters that are not mentioned in the table, please specify in the given space below.

		Never	Rarely	Often	Always
Economic	**Cost minimization throughout the lifecycle of a product**				
	Use of cost estimating method at an early stage of product development				
	Using local materials to reduce cost				
	Cost minimization by efficient energy use				
	Cost-efficient packaging				
	Design strategies to minimize cost				
	Use of multi-functionality to reduce cost				
	Design for assembly				
	Designing products with fewer connecting elements or components				
	Modular design for cost reduction				
	Durable product design				

Section V: Q20-Q21 includes questions about the opportunities and drawbacks of using sustainable strategies in the furniture industry.

20. If your furniture firm uses sustainable product design strategies in product development, which one of the following opportunities do sustainable design strategies create

- ☐ Cost reduction and company profitability
- ☐ Serve competitiveness in the market
- ☐ Enhanced brand image
- ☐ Enhanced the quality of products
- ☐ Enhanced product design and innovation
- ☐ Increased customer satisfaction
- ☐ Decreased environmental damage
- ☐ Other

21. Which of the following drawbacks do you think limit the use of sustainable design strategies in the Turkish furniture sector?

- ☐ Standards are only concerned with raw materials, not with the design and production of the product
- ☐ The existence of various standard systems
- ☐ In the furniture sector, there is a lack of defined strategy for sustainability
- ☐ Sustainability not being a priority for furniture firms
- ☐ Lack of previously used tools to take experience from
- ☐ The complexity of sustainability tool
- ☐ High financial demand to implement sustainability
- ☐ Time-consuming
- ☐ Lack of harmony of sustainability with product features
- ☐ Other

Appendix - 3. Section Two of the Questionnaire Survey

Two products from your company (Zenith Chair and Cantata Chair) are selected to be analyzed by sustainable parameters. Please check the boxes if the parameters stated are used in the design and development of the products.

		Zenith Chair	**Cantata Chair**
Environmental	**Material**		
	Using bio-degradable materials		
	Minimum use of materials		
	Use of recycled/recyclable materials		
	Using renewable materials		
	Reduction of material variety		
	Avoiding toxic materials		
	Energy		
	Reduction of energy use in manufacturing		
	Use of low energy content material		
	Using renewable energy source		
	Reducing energy use during transportation		
	Solid/Liquid Waste		
	Reducing waste from production		
	Not generating dangerous waste		
	Reducing waste from packaging		
	Management of disposed waste		
	Recycling of waste		
	Air Emission		
	Comply with clean air and climate protection strategy		
	Minimizing atmospheric emissions (NO2, CO2, SO2, Ch4)		
	Product Feature		
	Extended life span of the product (Durability)		
	Modular product design		
	Multi-functionality		

	End-of-life Options		
	Extended life span of the product (Durability)		
	Modular product design		
	Enhancing remanufacturing		
Social	**User-centered**		
	Design for elderly and disability:		
	Design for user's health and safety		
	Design for needs of the future		
	Participatory design		
	Emotionally durable design		
	Customer satisfaction/feedback mechanism		
	Culturally sensitive design		
	Transparency		
	Quality of life		
	Societal Concerns		
	Health and safety of a neighborhood		
	Localization		
	Ethical design		
	Noise complaints		
	Odor complaints		
	Dust complaints		
Economic	**Cost minimization throughout the lifecycle of a product**		
	Use of cost estimating method at an early stage of product development		
	Using local materials to reduce cost		
	Cost minimization by efficient energy use		
	Cost-efficient packaging		
	Design strategies to minimize cost		
	Use of multi-functionality to reduce cost		
	Design for assembly		
	Designing products with fewer connecting elements or components		
	Modular design for cost reduction		
	Durable product design		