

**ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL**

**GREEN SUPPLY CHAIN MANAGEMENT PRACTICES' EFFECT ON THE  
SUSTAINABILITY PERFORMANCE:  
A CASE STUDY IN THE TURKISH SHIPYARDS**



**Ph.D. THESIS**

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**Management Engineering Programme**

**MAY 2023**



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**İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ**

**YEŞİL TEDARİK ZİNCİRİ YÖNETİM UYGULAMALARININ  
SÜRDÜRÜLEBİLİRLİK PERFORMANSINA ETKİSİ:  
TÜRK TERSANELERİNDE BİR VAKA ÇALIŞMASI**

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*To my parents, my wife, and children,*



## FOREWORD

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May 2023

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## **ABBREVIATIONS**

<b>CB-SEM</b>	: Covariance-based Structural Equation Modeling
<b>GSCM</b>	: Green Supply Chain Management
<b>PLS-SEM</b>	: Partial least squares Structural Equation Modeling
<b>SCM</b>	: Supply Chain Management
<b>SEM</b>	: Structural Equation Modeling





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# **GREEN SUPPLY CHAIN MANAGEMENT PRACTICES' EFFECT ON THE SUSTAINABILITY PERFORMANCE: A CASE STUDY IN THE TURKISH SHIPYARDS**

## **SUMMARY**

The study in this Ph.D.thesis concerns the green supply chain management practices, their impacts on sustainability performance; environmental, economic, and social performance by conducting a case study in Turkish shipyards. The more detailed objectives are; to select the optimum green supply chain management practices to fit in shipyards, to examine the impact of green supply chain management practices on the sustainability performance of shipyards, the moderator effect of environmental uncertainty on the relationship between green supply chain and sustainability performance, the mediator effect of environmental uncertainty between green supply chain and sustainability performance and the determine the penetration level of green supply chain management practices on the Turkish shipyards.

Sustainability is an essential issue in the twenty-first century regarding the environmental consequences of climate change. Green supply chain management progressively emerged to improve environmental performance. Although environmental, sustainability, green supply chain areas are popular study subjects, shipbuilding and shipyards were not examined in detail. A systematic literature review between 1980 and 2020 unveiled rare studies concerning green supply chain management sustainability in shipyards and shipbuilding. The filtered articles were categorized into shipbreaking, shipbuilding, maritime, and various. China and South Korea emerged as leading areas for research in Asia since shipbuilding is seen as a driving factor for development and growth in those economies. In Europe, Spain, Turkey, and Holland emerged as research areas. The main focus areas in the shipbuilding category are shipyard layout design according to the greenfield project, sustainable growth directions for small and medium shipyards, the ways to improve the sustainability in the shipbuilding supply chain, green shipping, and green manufacturing in the shipyard. Therefore, this thesis is the first study of the impact of green supply chain management practices on shipyards' sustainability performance.

Green supply chain management is challenging to describe because of the broad concept. Many academicians reached different definitions. An increasing number of studies about the relationship between Green supply chain management practices and companies' performance have existed in the literature since 2014. These studies have categorized sustainability performance as environmental, economic, social, and operational performance. In contrast, various GSCM practices such as green purchasing, green packaging, recycling, eco-design, internal environmental management, reverse logistic, green production, green marketing, environmental

collaboration with suppliers and customers have been questioned in these studies. The researchers found both negative and positive, primarily partial, relationships between GSCM practices and the company's performances. The authors reviewed all practices in the literature and considered practices directly related to the shipbuilding industry. For example, environmental training is a part of internal environmental management, and therefore these two applications converged as environmental management. Practices like green packaging and green transportation have little effect on the shipbuilding process and are omitted from the study.

Consequently, green design, green purchasing, green production, green marketing, environmental management, recycling are selected as exogenous latent variables for the research model. Economic, environmental, and social performances are entered as endogenous latent variables for the research model. The environmental uncertainty (ENVR-UNCER) is embedded in the research model as either a moderator or a mediator variable. Environmental uncertainty is measured as demand, supply, and technology uncertainty.

The shipbuilding industry creates substantial economic value but causes many environmental and social issues. Sustainability, environmentally driven regulations, and voluntary standards adopted in the sector have impacted shipbuilding and shipyards in the case of new design and construction standards. Major international shipbuilding companies publish yearly sustainability reports indicating sustainable development goal achievements.

The survey is based on academic studies in Turkish chemical, electrical, automotive, food packaging industries. The survey consists of three main parts. The first part contains an introduction letter with a brief explanation of the study. The second part is the demographic questions like general information about the company and the quality and environmental certificates. In the third part, the survey questions are grouped to green supply chain management practices, environmental uncertainty, and sustainable performance. The understanding of scales by the applicant and time constraints were two main obstacles to accomplishing the survey completion rate. Therefore, the author summarized the scales into expressed sentences and limited them to 33 questions. The survey filling time is a critical factor. It is arranged for around 15 minutes on average because most executives claim the intense work environment and use it as an excuse not to fill the survey. The survey used a 5-Likert type, the most preferred scale in the literature. A pilot test with shipyard executives and shipyards' owners enabled improved scales and corrected the expression failures. The final survey is applied among the GISBIR members by email. The responses are stored in the VETI system and downloaded for analysis.

A favorable finding of the survey is the certification outcome. All shipyards have a minimum of two certificates (ISO 9001 and ISO 14001, 30% of the answers). Only two small shipyards have a single certification, ISO 9001. A high portion of the shipyards has all three certificates (ISO 9001, ISO 14001, and ISO 45001). Those findings proved that Turkish shipyards embraced environmental issues and took necessary internal and external actions to improve their business competence.

Since the Turkish shipyard quantities are limited to 67, partial least square structural equation modeling (PLS-SEM) is selected to eliminate the sample size constraint. The research model is defined in the SmartPLS software. To decrease the number of relationships and make the model more parsimonious and simple, authors preferred to form a hierarchical-order model, ease the calculation and simplify the research model.

The disjoint two-stage approach is implemented. Green design, green purchasing, green production, green marketing, environmental management, and recycling formed the higher-order construct named GSCM. Demand uncertainty, technology uncertainty, and supply uncertainty formed the higher-order construct named ENVR-UNCER. Demand uncertainty indicator is omitted to obtain HOC reliability convergent and discriminant validity during the assessment of the measurement model. All other indicators satisfied the criteria and were kept in the model. After the structural model assessment, GSCM practices have been found to impact positively on economic and social performance, but not environmental performance. The environmental uncertainty did not have a moderating effect but mediates only the relationship between GSCM practices and social performance.





# YEŞİL TEDARİK ZİNCİRİ YÖNETİM UYGULAMALARININ SÜRDÜRÜLEBİLİRLİK PERFORMANSINA ETKİSİ: TÜRK TERSANELERİNDE BİR VAKA ÇALIŞMASI

## ÖZET

Bu doktora tezi, yeşil tedarik zinciri yönetimi uygulamaların, sürdürülebilirlik performansının çevre, ekonomik ve sosyal boyutları üzerindeki etkilerini ve Türk tersanelerinde bir vaka çalışmasını ele almaktadır. Tersanelere uygun optimum yeşil tedarik zinciri yönetimi uygulamalarını seçmek, yeşil tedarik zinciri yönetimi uygulamalarının tersanelerin sürdürülebilirlik performansı üzerindeki etkisini incelemek, çevresel belirsizliğin yeşil tedarik zinciri ve sürdürülebilirlik performansı arasındaki ilişkide moderatör etkisini incelemek, yine çevresel belirsizliğin yeşil tedarik zinciri ve sürdürülebilirlik performansı arasındaki ilişkide aracı (mediator) etkiyi araştırmak tezin kapsamındadır.

Sürdürülebilirlik, iklim değişikliğinin çevresel sonuçları açısından yirmi birinci yüzyılda önemli bir kavram olarak önem kazanmıştır. Yeşil tedarik zinciri yönetimi ise, çevresel performansı iyileştirmek için aşamalı olarak ortaya çıkmış bir ve gelişmekte olan bir kavramdır. Çevre, sürdürülebilirlik, yeşil tedarik zinciri alanları popüler çalışma konuları olmasına rağmen, gemi inşa ve tersaneler ayrıntılı olarak şimdiye kadar incelenmemiştir. 1980 ve 2020 yılları arasında yapılan sistematik bir literatür taraması, tersanelerde ve gemi inşasında yeşil tedarik zinciri yönetiminin sürdürülebilirliği ile ilgili yapılan çalışmaların azlığını göstermiştir. Anahtar kelimeler esas alınarak elektronik arama makale indekslerinden bulunan makaleler, çeşitli analiz filtrelerinden süzülerek, gemi söküm, gemi inşa, denizcilik ve çeşitli başlık altındaki kategorilerde toplanmıştır. Çin ve Güney Kore, gemi inşasının bu ekonomilerde kalkınma ve büyüme için itici bir faktör olarak görülmesi nedeniyle Asya'da öne çıkan araştırma yapılan ülkeler olarak gözükmektedir. Avrupa'da İspanya, Türkiye ve Hollanda araştırma yapılan başlıca ülkelerdir. Gemi inşa kategorisinde bulunan makalelerin konuları yeşilalan projesinne göre tersane yerleşim planlaması, küçük ve orta boy tersaneler için sürdürülebilir büyüme direktifleri geliştirilmesi, gemi inşa tedarik zincirinde sürdürülebilirliğin geliştirilmesi, yeşil taşımacılık, ve tersanede yeşil üretimdir. Bu nedenle bu tez, yeşil tedarik zinciri yönetimi uygulamalarının tersanelerin sürdürülebilirlik performansı üzerindeki etkisinin ilk çalışmasıdır.

Yeşil tedarik zinciri yönetimi, geniş konsepti nedeniyle bir çok akademisyen tarafından değişik şekildedirde tanımlanmıştır. Tanımlamalardaki çeşitlilik uygulama tanımlamalarına da yansımıştır. Tanım ve uygulamaları bütünleştirme çalışmaları da devam etmektedir. Yeşil tedarik zinciri yönetimi uygulamaları ile şirketlerin performansı arasındaki ilişkiye dair literatürde 2014 yılından bu yana giderek artan

sayıda çalışma vardır. Bu çalışmalarda sürdürülebilirlik performansını çevresel, ekonomik, sosyal ve operasyonel performans olarak sınıflandırmıştır. Yeşil tedarik zinciri çalışmalarında ise, yeşil satın alma, yeşil ambalajlama, geri dönüşüm, ekotasarım, iç çevre yönetimi, tersine lojistik, yeşil üretim, yeşil pazarlama, tedarikçiler ve müşterilerle çevresel işbirliği gibi çeşitli uygulamalar incelenmiştir. Bunlarda çıkan sonuçlara göre yeşil tedarik zinciri uygulamaları ile şirketlerin performansları arasında istatistiksel olarak anlamlı ve anlamsız ilişkiler tespit ettiler. Yazarlar literatürdeki tüm yeşil tedarik zinciri uygulamalarını gözden geçirerek, doğrudan gemi inşa endüstrisi ile ilgili uygulamaları dikkate çalışma kapsamına aldı. Örneğin çevre eğitimi, iç çevre yönetiminin bir parçasıdır ve bu nedenle bu iki uygulama çevre yönetimi olarak birleşmiştir. Yeşil paketleme ve yeşil ulaşım gibi uygulamaların gemi inşa süreci üzerinde çok az etkisi vardır ve çalışmadan çıkarılmıştır.

Sonuç olarak, araştırma modeli için yeşil tasarım, yeşil satın alma, yeşil üretim, yeşil pazarlama, çevre yönetimi, geri dönüşüm araştırmada kullanılacak yeşil tedarik zinciri uygulamaları olarak seçilmiştir. Sürdürülebilirliğin ekonomik, çevresel ve sosyal performansı, araştırma modeline içsel gizli değişkenler olarak alındı.. Çevresel belirsizlik (ENVR-UNCER), araştırma modeline bir moderatör veya bir aracı değişken olarak yerleştirilmiştir. Çevresel belirsizlik, talep, arz ve teknoloji belirsizliği olarak üç ayrı bileşende ele alınmıştır.

Dünyanın en eski sektörlerinden olan gemi inşaatı faaliyetleri bulunduğu ülkeler için önemli bir ekonomik katma değer yaratmakla beraber, gelişen teknolojinin, uygulanan üretim tekniklerinin de etkisiyle birçok istenmeyen çevresel ve sosyal soruna neden olur. İklim değişikliğinin getirdiği yeni koşullar, sürdürülebilirlik, çevre odaklı düzenlemeler ve sektördeki paydaşlar tarafından geliştirilen kurallar ve yükümlülükler, yeni tasarım ve inşaat standartlarında gemi inşasını ve tersaneleri etkilemektedir. Bunlara uyum sağlamak ve bu konularda öncülük rolünü üstlenmek isteyen uluslararası gemi inşa şirketleri, sürdürülebilir kalkınma hedef başarılarını gösteren yıllık sürdürülebilirlik raporları yayınlamaktadır.

Araştırmada kullanılan anket hazırlanırken, Türkiye’de kimya, elektronik, otomotiv, gıda ambalaj sektörlerindeki akademik çalışmalar gözden geçirilmiştir. Bu çalışmaların konusu tezin konusuna benzer, yeşil tedarik zinciri uygulamalarının şirketlerin sürdürülebilirlik performansına etkisi üzerinedir. Anket üç bölüme ayrılmıştır. Birinci bölümde, çalışmanın kısa bir açıklamasını içeren bir giriş yazısı bulunmaktadır. İkinci bölüm, firma hakkında genel bilgiler, kalite ve çevre sertifikaları gibi demografik soruları içermektedir. Üçüncü bölümde ise araştırmaya veri oluşturulacak şekilde 5’li likert ölçeği kullanan anket soruları üç alt gruba ayrılmıştır. yeşil tedarik zinciri yönetimi uygulamaları alt grubunda yeşil tasarım, yeşil üretim, yeşil satın alma, yeşil pazarlama ve geri dönüşüm soru grupları vardır. Çevresel belirsizlik alt grubunda da tedarik, arz ve teknoloji soru grupları ayrılmıştır. Anketin en sonunda da sürdürülebilirlik performansı adı altında çevresel, ekonomik ve sosyal soruları bulunmaktadır. Anket soruları basit ifade edilmiş cümleler halinde özetlenmiş ve soru sayısı 33 ile sınırlandırılmıştır. Anketin internet tabanlı uygulanmasına karar verilmiştir. Anket doldurma süresi kritik bir faktördür. Yöneticilerin çoğu yoğun çalışma ortamını ileri sürüp anketi doldurmamak için bahane olarak kullandığı için ortalama 15 dakikada cevaplanacak şekilde anket düzenlenmiştir. Tersane yöneticileri ve tersane sahipleri ile yapılan bir pilot test, ölçeklerin iyileştirilmesini sağladı ve ifade hatalarını düzeltilmiştir. Son anket ise, GİSBİR sektreterleri tarafından, email yolu ile üyelerine ulaştırılmıştır ve ayrıca tersaneler telefon anketçiliği yöntemi ile aranarak, anketi doldurmaları rica edilmiştir.

Cevaplar, İstanbul Teknik Üniversitesi'nin internet tabanlı VETİ sisteminde saklanmıştır.

Bulguların analizinde, demografik verilerin ortaya çıkardığı olumlu bir sonuç tüm tersanelerin kalite, çevre ve güvenlik sertifikaları konusunda bilinçli ve karar olduğunu göstermektedir. Tersanelerin %30'unun en az iki adet sertifikaya (ISO 9001 ve ISO 14001) sahip bulunmuştur. Tersanelerin %65i üç sertifikaya (ISO 9001, ISO 14001 ve ISO 45001) sahiptir. Yalnızca iki küçük tersanenin tek bir sertifikası (ISO 9001) bulunmaktadır. Bu bulgular, Türk tersanelerinin çevre konularını benimsediğini ve iş yetkinliklerini geliştirmek için gerekli iç ve dış önlemleri aldığını kanıtlamaktadır.

GİSBİR'e kayıtlı 67 tersane vardır. Anketi cevaplama oranının %100 olsa bile örneklem sayısının düşük, yani kovaryans temelli yapısal eşitlik modeli için yeterli veri sağlayamayacaktır. Örneklem kısıdını aşmak için, tezdeki analiz metodunun kısmi en küçük kareler yönteminin kullanan yapısal eşitlik modeli (PLS-SEM) seçilmesine karar verilmiştir. Araştırma modeli SmartPLS yazılımında tanımlanmıştır. Modeldeki bağımsız ve bağımlı değişkenler arasındaki bağlantı sayısını azaltmak, modeli daha tutarlı ve basit hale getirmek için üst düzey model oluşturulmayı ve araştırma modelini basitleştirmeyi tercih etmişlerdir. Ayrık iki aşamalı yaklaşım yöntemi uygulanarak, üst düzey modelin yeni yapıları test edilerek onaylanmıştır. Özet olarak, yeşil tasarım, yeşil satın alma, yeşil üretim, yeşil pazarlama, çevre yönetimi ve geri dönüşüm, ilk modelde 3 ayrı indikatörü içeren bir yapı iken, her biri GSCM adlı üst düzey yapıyı oluşturan bir indikatör olmuştur. Talep belirsizliği, teknoloji belirsizliği ve arz belirsizliği, aynı şekilde ENVR-UNCER adlı üst düzey yapıyı oluşturmuştur. Model değerlendirmesindeki ilk aşamada ölçüm modelinin değerlendirilene gerekli yeterlilikleri sağlaması gerekmektedir. Bu işlemler sırasında üst düzey yapının güvenilirlik yakınsaması ve ayırt edici geçerliliği elde etmek için talep belirsizliği indikatörü modelden gerekli değerleri karşılamadığı için çıkartılmıştır. Diğer indikatörler kriterleri karşılayarak modelde tutulmasına karar verildi. İkinci aşamada olan yapısal model değerlendirmesi sonucunda, yeşil tedarik zinciri uygulamalarının ekonomik ve sosyal performansı olumlu etkilediği, ancak çevresel performansı etkilemediği bulunmuştur. Çevresel belirsizliğin düzenleyici bir etkisi bulunamamıştır, ancak yalnızca yeşil tedarik zinciri uygulamaları ile sosyal performans arasındaki ilişkiye aracılık etmekte olduğu ortaya çıkmıştır.



## 1. INTRODUCTION

The dictionary definition of sustainability is “relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged” and “relating to a lifestyle involving the use of sustainable methods.” With the growing concern about depleting natural resources and increasing environmental problems, the sustainability concept emerged as a critical and crucial set of development approaches to maintain and develop the mean quality of life in contemporary societies.

The sustainability concept first emerged in Germany in 1713 through Hans Carl von Carlowitz, a German tax accountant and mining administrator in Freiburg. One of his responsibilities was to supply enough timber to the mining industry. The process of melting ores had consumed whole nearby forests. Although the surrounding rivers co-engineered and made it possible to transport timber from a great distance, the timber crisis was postponed for a while. Scarcity of wood and increasing transport costs caused bankruptcy in the mining sector. Under these circumstances, Carlowitz formulated the first concept of sustainability in the forestry sector (“Nachhaltigkeit”) in his book *Sylvicultura oeconomica or Haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht* in 1713, (Grober, 1999).

The Industrial Revolution started in the late eighteenth century in Europe. The extraordinary technological developments and new inventions dramatically changed lifestyles throughout the world. The 19th century was a transition period from agriculture-based to industrial economies. In the twentieth century, with the critical shift from coal-driven engines to engines fueled by petroleum-based products, the increase in production led to a spike in population and thus to a rapid rise in the consumption of finished products and natural resources. Waste and the depleting of natural resources became two of the undesirable effects of modern civilization. Subsequent improvements in the mid-20th century included environmental preservation and corrective actions, defining efficiency as using fewer inputs for more output, producing less waste, and inventing new, eco-friendly processes.

Consequently, the United Nations introduced in 1987 the Brundtland Report to the public to draw attention to the need for sustainable development. In this report, sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). Since the leading cause of the problems above were the effects of industrial activities, the report’s primary focus is on bringing the power of civil, public, and governmental stakeholders to bear on companies to force them to apply environmental and sustainability approaches. This inevitably led to two questions: First, which policies should the companies pursue to achieve the desired and needed sustainability level? Second, how should we define and measure a company’s sustainability performance? Sustainability performance came to be defined as quantifying an organization's total performance based on several indicators, including its policies, decisions, and actions creating economic, social, and environmental results, (Buyukozkan & Karabulut, 2018).

Green Supply Chain Management (GSCM) is a concept that emerged during the 1990s to eliminate environmental concerns under the idea of supply chain management, (Srivastava, 2007). Many organizations were starting to go green in their business out of respect for environmental sustainability, and the concept of GSCM arose as a new systematic approach and became an essential factor in business activities, (Abu Seman, 2012). In addition, GSCM can be considered a relatively advanced management practice for manufacturers to improve their environmental performance (Qinghua Zhu, Gollagher, Geng, Fujita, & Hashimoto, 2010).

Green supply chain answers both questions, determines indicators for performance evaluation, and arranges the relations between the company with its suppliers and customer under a sustainability concept. Since environmental issues and scarcity of resources hinder achieving sustainable performance, GSCM is the philosophy to optimize the performance in unfavorable conditions. This generates an advance toward sustainable development and leads to considerable cost reduction for some or even all enterprises involved, (Mardani et al., 2020), and (Green, Zelbst, Meacham, & Bhadauria, 2012) found that the adoption of GSCM practices by manufacturing organizations leads to improved environmental performance and economic performance, which positively impact operational performance and, consequently, organizational performance. In addition, (Rao & Holt, 2005) stated that many

organizations in South East Asia recognize GSCM as a way to demonstrate their sincere commitment to sustainability. The analysis identified that greening the different phases of the supply chain leads to an integrated green supply chain, ultimately leading to competitiveness and economic performance. Yildiz Çankaya and Sezen (2019) examined the impact of eight GSCM practices on economic, environmental, and social performance, the three dimensions of corporate sustainability. The study was conducted on 281 manufacturing firms in Turkey. The eight practices studied were green purchasing, green manufacturing, green distribution, green packaging, green marketing, environmental education, internal environmental management, and investment recovery. Except for green purchasing, all GSCM dimensions are related to at least one of the sustainability performance dimensions. As a result, GSCM has gradually become the new concept for the sustainable development of enterprises.

In a supply chain, the interaction between the stakeholders consists of exchanging information and goods. The goods exchange includes transportation. Maritime transport remains the backbone of global supply chains, as more than four-fifths of world merchandise trade, by volume is, carried by sea. Around 95,000 ships transported 11 billion tons of goods in 2019. Since environmental sustainability has become a significant policy concern in global maritime transport, regulations increasingly affect shipping market dynamics, impacting shipbuilding and shipyards. They are responsible for incorporating new standards into the design and construction of ships, (UNCTAD, 2020). Concerns about the need to construct more green and sustainable ships to achieve desired sustainability performance goals became interesting to stakeholders in the maritime industry and the shipyards that are a subsector of the marine industry. In the case of shipyards, green supply chain management can assist the maritime sector in complying with IMO regulation and achieving the sustainability goals that benefit society and future generations, (Lister, Poulsen, & Ponte, 2015).

The general objective of this study is to investigate the impact of green supply chain management practices on three sustainability performances by conducting a case study in Turkish shipyards. The environmental uncertainty will be in the scope and be evaluated either as a moderator or mediator. The detailed objectives will be presented in the research methodology section.

## 1.1. Literature Review

The research phases are described in Table 1.1. Research Phases. The search assumptions, limits, and coverage have been determined in the first phase. Scopus and Web of Science databases have been selected for the research. The search variables were the following: the time interval was between 1980 and 2020, and documents were limited to articles and reviews written in English. The keywords were determined as “sustain\*, green, shipyard, shipbuilding” in the article title, abstract, and keywords areas of the searched documents. The keyword sustain\* is expressly used to cover different versions of “sustain”, such as sustain, sustainability, sustainable, sustained, sustaining, etc. The term “green” may cover the literature for several green supply chain studies, and therefore, it is selected as a keyword. “Shipyard” and “shipbuilding” are two words related to each other and were used alone or together in the searched documents.

**Table 1.1 : Research Phases**

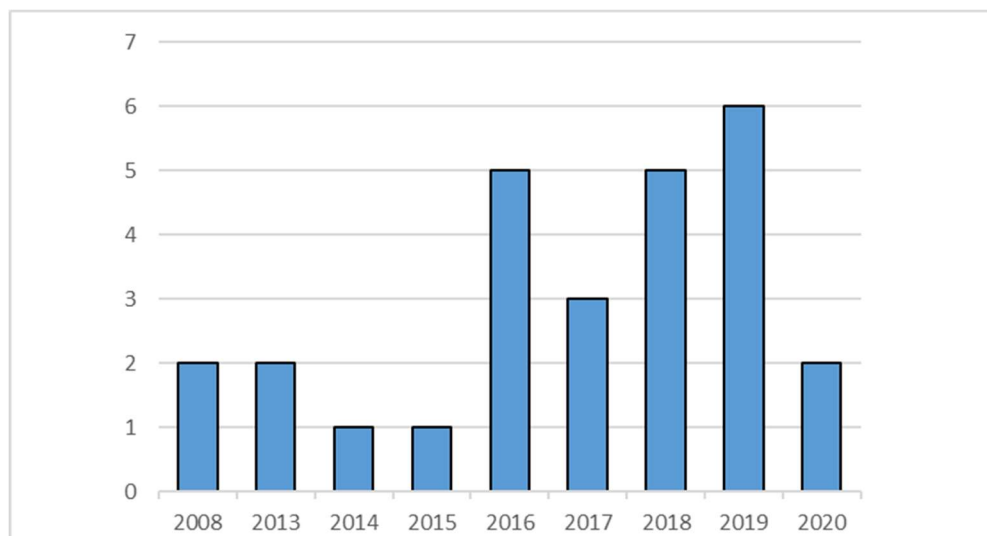
Phases and Descriptions	Details
Phase 1 Defining the keywords and search criteria	Keywords: sustain*, green, shipyard, shipbuilding Fields: Topics (article title, abstract, keywords) Databases: Scopus & WoS Period: 1980-2020 Document Type: Article & Review Language: English Scopus Search 1: "sustain* or green and shipyard" n = 151 Search 2: "sustain* or green and shipbuilding" n = 287 Combining #1 & #2; n = 362
Phase 2 Executing the search	WoS Search 1: "sustain* or green" n = 1.011.669 Search 2: refining "shipyard or shipbuilding" n = 96 Total n = 458 Screens Duplicates x = 84 excluded Eligibility check via title and abstract x = 307 excluded Available to download full text x = 40 excluded Remained full text n = 27 Reading the available full text
Phase 3 Screening the results	Creating excel datasheet Simultaneous data analyses Reporting elaboration Conceptual framework
Phase 4 Reporting and dissemination	

The second phase includes the search execution. The Boolean operators “and” and “or” were used to combine searches. Two searches have been done in each database. The first search in the Scopus database was with the keywords “sustain\* or “green” and “shipyard” and resulted in 151 articles. Using similar keywords but with “shipbuilding” resulted in 287 articles. When the Scopus search combined two searches, the total number of articles was 362. On the other hand, the first search in

the Web of Sciences database resulted in over one million results with keywords “sustain\* or “green” This result shows how the subject is popular in the research area. However, refining the existing search with “shipyard” or “shipbuilding” decreased the number of relevant articles to 96, which is a definitive proof that there is a gap in this area. Endnote software combined the two subtotal searches, and 458 articles remained. The deeper analysis started in the third phase. Endnote excluded 84 duplicated articles, and the titles and abstracts of all the remaining articles were checked for eligibility concerning their subject areas. Arts & Humanities, Agricultural and Biological Sciences, Chemistry, Medicine, Chemical Engineering and Biochemistry, Genetics and Molecular Biology were excluded. There remained 27 articles after eliminating articles without full contents.

## 1.2. Analyses of the Results

China and South Korea emerged as leading areas for research in Asia since shipbuilding is seen as a driving factor for development and growth in those economies. In Europe, Spain, Turkey, and Holland emerged as research areas. Since there are few studies on the American region, it can be stated that the shipbuilding sector is mainly located in Asian and European countries. The search started from 1980, but the first two findings are dated to 2008, followed by a slight increase in publications, Figure 1.1.



**Figure 1.1 :** Annually published articles

The articles are summarized in four categories: shipbuilding, maritime, shipbreaking, and various. The field is vast, and there are many related but discrete areas of possible inquiry. Shipyards are the production facilities where shipbuilding operations are performed. Ships coming out of shipyards sail naval routes, visit ports, transport human and trade goods, catch fish, and purchase consumables, spare parts, and carburants – and, as a result, create a substantial economic activity area, which we can define as the maritime industry. Some unlucky ships sink and stay on the seafloor. Very few ships continue their life as a museum or school ship, but most ships wind up at the shipbreaking facility where the ship is completely broken into small parts for resale and recycling. There remained two articles, in different subjects and not related to any of the above ones, and they are summed up in the category named “various.” The focus area and methodology of each article are summarized in Table 1.2.

The main focus areas in the shipbuilding category are shipyard layout design according to the greenfield project, sustainable growth directions for small and medium shipyards, the ways to improve the sustainability in the shipbuilding supply chain, green shipping, and green manufacturing in the shipyard. Articles in the maritime category focus on customer required sustainable maritime supply chains, noise effects of a few ports in the Mediterranean, a review and analysis of the green maritime environmental program in North America, the relationship between drivers and practices of the green maritime supply chain, using fiber reinforced polymers from the circular economy perspective, and potential collaborations around the sustainable development goals in the maritime industry. The shipbreaking articles reviewed the environmental, economic, social, legal, and technical aspects of shipbreaking and the sector’s greening.

Authors of the articles studied used methodologies such as literature review, case study, hypothesis testing via survey, data development analysis, establishing a framework, Artificial Neural Network, Monte Carlo analysis, Delphi method, Quality Function Deployment, and empirical study. Findings are explained below.

Sanderson (2008) determined that the dichotomy of deciding between the lean or agile approach is less useful in a shipbuilding supply chain environment and stated that the design and build process used in the shipyard introduces radical unpredictability into the demand for “functional” components of naval vessels. Song and Woo (2013) used the greenfield project for an efficient and assembly-oriented shipyard layout design,

followed by S. J. Lee, Woo, and Shin (2014). J.-s. Lee (2013) proposed directions for small- and medium-sized shipyards such as merger and acquisition, switching activity from building to repair and maintenance, penetrating the shipbreaking sector, and establishing subcontractor links with the major shipyards sustainable development. Babur, Cevikcan, and Durmusoglu (2016) designed a lean-oriented, axiomatic occupational health and safety system and applied it in a shipyard. Green supply chain readiness, competitive advantage, and social responsibility are significant drivers in supplier participation, while governmental involvement and customer requirements are not substantial, Caniels, Cleophas, and Semeijn (2016). T. Lee and Nam (2017) proposed four countermeasures to enhance strategic plans for green shipping in South Korea: the establishment of a shipping–shipbuilding collaborative network, information sharing and joint cost reduction for the shipping and shipbuilding industries, investment in R&D in eco-friendly vessels, and support for LNG fueled ship. Technological innovations should be cost-effective for any improvement in the energy efficiency of main engines and a sustainable improvement, Xie, Yue, and Wang (2017). Solar panels are considered the most suitable, appropriate, and sustainable technology, Hadžić, Kozmar, and Tomić (2018). Gaining wood durability and adopting alternative native wood or wood cored sandwich composites may be a solution to enhance the artisanal boatyard’s sustainability, Walter, Junior, and da Silva (2018). Rafael Diaz (2019) proposed a framework to quantify benefits and risks per project, considering the constraints within the project. Dust pollution, noise pollution, and harmful gas pollution are the primary pollutant sources in the shipyard workshop environment, Zhou, Wang, and Zhu (2019). Ramirez-Pena, Abad Fraga, Sanchez Sotano, and Batista (2019) and Ramirez-Peña, Sánchez Sotano, Pérez-Fernandez, Abad, and Batista (2020) found lean and green paradigms the most commonly implemented in the supply chain. That green supply chains connect the social aspects required by the I4.0 performance model.

Lam (2015) found that green design ships, engines, and machinery were the most critical design requirement in sustainable maritime supply chains. Schenone, Pittaluga, Borelli, Kamali, and El Moghrabi (2016) studied the impact of environmental noise generated from ports. Since noise reduction is not possible in the port of Patras, installing soundproof windows in nearby buildings is preferred. In contrast, in the port of Tripoli, necessary improvements have been undertaken to decrease noise levels.

The maritime companies in North America developed the Green Maritime Environmental Program that proposed a framework to establish and reduce environmental impact. Participants demonstrate an annual improvement of specific environmental performance indicators, Walker (2016). Jasmi and Fernando (2018) determined that the support of top management is significantly related to the green supply chain solutions, whereas regulations, green initiatives, and security are partially related. Zapelloni, Garcia Rellan, and Bello Bugallo (2019) analyzed the marine equipment manufacturing sector's use of reinforced fiber from the circular economic perspective to identify sustainable solutions for the manufacturing process stage. Sustainable development goals number 8 (Decent work and economic growth), 9 (Industry, innovation, and infrastructure), 12 (Responsible consumption and production), and 14 (Life below water) are found to be the most aligned with the core business of the maritime industry, representing its core responsibility towards sustainability, (Wang, Yuen, Wong, & Li, 2020).

Neşer, Ünsalan, Tekoğul, and Stuer-Lauridsen (2008) studied the Turkish shipbuilding sector's environmental, safety, and health problems. The paper examined the differences in regulation between developed and developing countries. M. S. Hossain, Fakhruddin, Chowdhury, and Gan (2016) reviewed severe environmental pollution. They found that its impacts on marine ecosystems, biodiversity, forestry, fisheries, and human health are the main obstacles to developing a sustainable ship-breaking industry. Jain, Pruyun, and Hopman (2017) proposed material flow analysis to manage waste and resources better, thereby attracting green ship recycling. Abrasive water jet cutting is a green technology that increases the economic value of scrap metal and decreases environmental and labor health problems. However, it carries a high initial investment cost, (Yan, Wu, & Yu, 2018). Brazil shipyards need to acquire expertise and expand feasibility studies into developing a sustainable ship recycling industry, (Ocampo & Pereira, 2019).

S. Lee, Noh, and Oh (2018) found the efficiency of total emissions is higher than that of direct emissions except for the shipbuilding industry. Almeida and Terra (2019) posited that the innovation context influences the development of enterprises through a variety of factors, such as the institutional environment, the characteristics of the economic sector, sustainability management, and established networks that affect the decision-making in and growth of the companies.

**Table 1.2 : Articles by Categories**

Activity/Sector	Reference	Focus Area	Methodologies
Shipbuilding	Sanderson (2008), Song and Woo (2013), S. J. Lee et al. (2014), J.-s. Lee (2013), Babur et al. (2016), Caniels et al. (2016), T. Lee and Nam (2017), Xie et al. (2017), Hadžić et al. (2018), Walter et al. (2018), Rafael Diaz (2019), Zhou et al. (2019), Ramirez-Pena et al. (2019), Ramirez-Peña et al. (2020)	<ul style="list-style-type: none"> <li>●to test the decision for selecting lean or agile approach in shipbuilding;</li> <li>●shipyard layout design; ●green field project in a shipyard layout; ●analyze of the Korean small medium sized shipyards in aspect of efficiency, growth and stability; ●a systematic approach design of lean oriented occupational health and safety by using axiomatic design principles; ●empirical study analyses of drivers for supply chain suppliers in the shipbuilding; ●to define green shipping and eco-friendly vessels and identify the regulations and current market situation in major countries; ●how to improve sustainability in a shipbuilding supply chain in the energy efficient primary engine selection decision process; ●application of sustainable renewable energy systems in Croatian shipyards; ●a materials' selection process comparing technically between available and manufacturing processes; ●to illustrate cost-benefit tradeoffs stemming from assessing digitalization program investment risks in the military shipbuilding sector; ●to introduce green manufacturing into a workshop in the shipyard; ●to develop of an index that indicates the current situation considering that supply chain is a critical factor type of change; ●the relation of the key enabling I4.0 technologies with Lean, Agile, Resilience and Green paradigms within the shipbuilding supply chain</li> <li>●customer requirement based on a sustainable maritime supply chain design; <ul style="list-style-type: none"> <li>●analyzing noise effects in three ports according to Managing the Environmental Sustainability of Ports for a durable development; ●discussing green maritime environmental programs in North America regarding current framework with benefits, limitations, and recommendations; ●to investigate the relationship between drivers and practices of green maritime supply chain management; ●to analyze the marine equipment manufacturing sector using fiber reinforced polymers from the circular economy perspective; ●to examine extended responsibilities and the potential collaborations within the value chain concerning the sustainable development goals in the maritime industry</li> </ul> </li> <li>●to study the legal, technical, economic, social, and environmental aspects of the green shipbreaking activities in Bangladesh, Brazil, and Turkey; ●to analyze the multidisciplinary scientific tools and techniques that can be used to make green ship recycling; ●to introduce abrasive water cutting technology as a green application</li> <li>●to measure and decompose green productivity growth of Korean manufacturing industries between 2004 and 2010 using the Malmquist-Luenberger productivity index; ●to study the technological strategies and sustainable management of innovative small businesses in the biotechnology, oil, pharmaceutical, and shipbuilding sectors of Brazil</li> </ul>	<ul style="list-style-type: none"> <li>●a case study focusing on the supply chain of a significant UK shipyard; ●review of previous research on shipyard layout; ●case study in a shipyard; ●data development analysis and Malmquist index; axiomatic design-oriented methodology; ●hypotheses testing via survey with companies in the supply chain of shipyards; ●review of green shipping literature and cases in major countries; ●to develop objective functions for the portfolio selection of main engines according to different supply chain strategies; ●calculation energy demand and selection based on the shortest payback ratio; ●a sustainability environmental evaluation framework using parameters like boats seakeeping, service life, price, CO2, footprint, embodied energy; ●artificial neural network and Monte Carlo model to generate data samples that support the execution of the neural network; ●environmental assessment model using neural network model; ●Delphi method and survey to identify the significance of the lean and agile paradigms; ●a performance model defined by I4.0 including twelve enabling technologies</li> <li>●an analytical approach using Quality Function Deployment and Analytical Network Process; ●network for cooperation with new procedures and methodologies; review and appraisal of the program; ●online survey-based institutional theory; ●Material and Energy Flow Analysis; ●review and content analysis of the published sustainability reports, documents</li> <li>●An empirical study on management policies regarding sustainable shipbreaking activities, review, and discussion of the analytical tools on both operations management and environmental engineering domains; ●interviews with the sector professionals; ●definition and application of Abrasive Water Cutting system</li> <li>●Empirical analyzes were set for 17 industrial manufacturing sectors in Korea from 2004 to 2010; ●qualitative research with interviews via questionnaire,</li> </ul>
Maritime	Lam (2015), Schenone et al. (2016), Walker (2016), Jasmi and Fernando (2018), Zapelloni et al. (2019), Wang et al. (2020),		
Shipbreaking	Neşer et al. (2008),M. S. Hossain et al. (2016), Jain et al. (2017), Yan et al. (2018) Ocampo and Pereira (2019)		
Various	S. Lee et al. (2018) Almeida and Terra (2019)		

### **1.3. Green Supply Chain Practices**

Green supply chain management is challenging to describe because of the broad concept. Many academicians reached different definitions. Pinto (2020) defined as approaches addressing environmental issues in organizations and their supply chains stem from the intersection of green management and supply chain management research. Srivastava (2007) wrote that GSCM is integrating environmental thinking into supply chain management and includes product design, material sourcing, selection, manufacturing process, delivery of the final product, product life management. GSCM covers the product's life cycle management during the supply chain phases until the end and focuses on environmental aspects of each process within other relevant organizations by integrating all stakeholders (Rao & Holt, 2005). The GSCM incorporates environmental concerns into SC activities (Qinghua Zhu & Sarkis, 2004). The GSCM network encompasses the suppliers through manufacturers, and then to customers, would finally close the loop (reverse logistics) by the logistics service provider with the help of a customer (Tseng, Islam, Karia, Fauzi, & Afrin, 2019).

Different conceptualizations of GSCM practices exist in the literature. While some researchers classify greening inbound, greening production, greening outbound, others classify internal and external actions. Pinto (2020) summarized all of these in Table 1.3.

**Table 1.3 : GSCM practices.**

GSCM practices	Description	Sources
Green design	Design of products for reduced consumption of materials /energy, Intend to reduce products' adverse effects on the environment during its entire life cycle, Design of products for reuse, recycling, recovery of materials, parts, Design the products to be easily set up for the users in the most energy-saving ways, Design for reduction of environmentally hazardous substances, Design for recycling waste and design for remanufacturing aimed at returning it to a better condition	Arena, Mastellone, and Perugini (2003), Beamon (1999), Zhu, Sarkis, and Lai (2007), Eltayeb et al. (2011), Lin (2013), Sarkis (1998), Tseng and Chiu (2012), Fiksel and Fiksel (1996), Gungor and Gupta (1999), Oiko, Saavedra, Amaral, and Ometto (2009), Zhu et al. (2008a), Zhu et al. (2007), Chien and Shih (2007), Younis et al. (2016), Miroshnychenko, Barontini, and Testa (2017), Balon (2019).
Green purchasing	Choice of suppliers by considering the environmental criteria, Buying environment-friendly raw materials, Pressuring supplier(s) to take environmental actions	Carter and Ellram (1998), Yang, Lin, Krumwiede, Stickel, and Sheu (2013), Kannan, de Sousa Jabbour, and Jabbour (2014), Zhu et al. (2008a), Zhu et al. (2007), Zhu and Sarkis (2006, 2004), Azevedo et al. (2011), Younis et al. (2016), Islam et al. (2017), Balon (2019).
Green production	Generate minimum waste and reduce environmental pollution, Re-manufacturing and lean production, Cleaner production, Improved capacity utilization, Lower raw material costs, gain production efficiency, and improve their corporate image, Increase amount of goods delivered on time, do not use hazardous or restricted materials during manufacturing and minimize waste during production, Substituting toxic inputs with environmentally friendly ones	Van Hoek (1999), Tseng and Chiu (2012, 2013), Zhu and Sarkis (2007), Lee (2011) Srivastava (2007), Pusavec, Krajnik, and Kopac (2010), Santos and Vanalle (2010), Zhu et al. (2007), Zhu et al. (2007), Srivastava (2007), Chien and Shih (2007), Green et al. (2012), Sarkis (2003), Islam et al. (2017), Balon (2019).
Customer environmental collaboration	Collaborate with customers to develop environmental management solutions, Collaborate with customers to manage, reverse flows of materials and packaging	Lin (2013), Azevedo et al. (2011), Zhu et al. (2008a), Zhu and Sarkis (2006, 2004), Younis et al. (2016), Santos et al. (2019), Tseng et al. (2019).
Internal green management Environmental management	Environmental compliance monitoring and Auditing, Total quality environment management, Pollution prevention plans, Environmental manager, and training for employees. Employee incentive programs for environmental suggestions	Olugu, Wong, and Shaharoun (2011), Rao and Holt (2005), Tsoufias and Pappis (2008), Zhu and Sarkis (2004), Zhu et al. (2008a), Zhu et al. (2007), Miroshnychenko et al. (2017), Islam et al. (2017), Santos et al. (2019), Balon (2019).
Reverse logistics Recycling	Recovery of the company's end-of-life Items, Resale or reuse of used parts or components, Old/obsolete items being used or replaced, Recondition and refurbishing of used parts or components	Büyükoçkan and Çiğçi (2012), Govindan, Rajendran, Sarkis, and Murugesan (2015), Tseng and Chiu (2012, 2013), Azevedo, Carvalho, and Machado (2011), Younis, Sundarakani, & Prakash (2016), Islam et al. (2017), Balon (2019), Tseng et al. (2019)



## **2. SHIPBUILDING SECTOR**

Shipbuilding is one of the oldest and open sectors in the world. Since prehistory times, humans constructed small, medium ships for fishing, commercial travel, fighting a battle, and reaching overseas. The rapid development of the physical sciences, materials, and structures enabled bigger, durable ships with more economic value, creating more jobs and stable economies, causing many environmental and social problems. Finally, ship construction became a complicated compound of art and science, affecting both solid and liquid areas of the world.

China, South Korea, and Japan are world-leading shipbuilding countries. Shipbuilding requires huge backward industries and governmental subsidies. Enhanced globalization, increasing environmental regulations, and fierce competition are the main challenge factors in shipbuilding (K. A. Hossain & Zakaria, 2017).

### **2.1. Shipyards and Sustainability**

Sustainability has become a significant policy concern in global maritime transport and following in shipbuilding in recent years. Environmentally driven regulations are increasingly affecting shipping and shipbuilding market dynamics. The entry into force of several international environmental instruments and voluntary standards adopted in the sector has impacted shipbuilding and shipyards. They are responsible for incorporating new standards into the design and construction of ships. Pressure on the industry to develop cleaner and energy-efficient vessels is increasing. Certification schemes are being introduced, and considerable investment is going into developing better hydrodynamics, more energy-efficient engines, and low-carbon fuels for ships, (UNCTAD, 2020).

Shipyards and their supply chain have to protect the environment, respect human and labor rights, be transparent and report publicly. Like other business entities, Shipyards have a responsibility to meet international standards and expectations to address their adverse impacts on the environment, society, and workers, even where these may not

be set out in national law. Simultaneously they can also positively impact the sustainability dimensions, environmental, economic, and social.

United Nations set the goal for the shipping industry of 50%-70% carbon emission reduction that requires substantial more zero-emissions vessels by 2030. Coal and diesel-powered ships thrived maritime economy but caused significant environmental degradation for more than 100years. Hence, ship-owners need to have low-emission or zero-emission new-builds to reach desired CO<sub>2</sub> output of existing fleets. The business impact for the shipyards will be to improve their efficiency, competitiveness, and sustainability in building and delivering low-emission and zero-emission vessels. Some shipyards realized an inseparable link between environmental and commercial factors. The stakeholders have a strong business incentive to promote social and environmental sustainability. Ships and shipyards that reduce waste and emissions during the construction phase will accomplish technical, commercial, and environmental developments. Many shipyards emphasize the environmental standards and certificates in their website, presentation, and report. In addition, international shipyards started to focus on sustainability issues and published yearly reports under the corporate social responsibility report and sustainability report.

UN Global Compact has developed the Sustainable Ocean Principles concerning shipyards with more than 300 stakeholders worldwide, focusing on construction and repair, ship designers and suppliers, and similar business entities. The objectives of this document are to encourage shipyards to be social and environmentally responsible to be resilient, to encourage ship-owners. These financial institutions provide the financing to choose yards that commit to those principles and establish a voluntary global standard for shipyards. The nine principles cover three areas and are listed in Table 2.1 below (Sustainable Ocean Business, 2020).

Gourdon and Steidl (2019) studied the assessment of the shipbuilding industry in the context of global value chains by presenting new descriptive evidence on value-added generation and sourcing patterns of intermediate inputs for ship construction. The study is an OECD working paper and revealed that shipbuilding relies heavily on intermediate inputs as an assembly industry. In major shipbuilding economies, between 20% and 30% of value-added as a share of the final output is generated in the shipbuilding industry itself. Hence, 70-80% of the remaining output value of ship production is generated through supplier sectors.

**Table 2.1 : Sustainable Ocean Principles**

Cover Area	Id	Principles
Ocean Health and Productivity	1	Assess the short and long-term impact of their activities on ocean health and incorporate such impacts into their strategy and policies.
	2	Consider sustainable business opportunities that promote or contribute to restoring, protecting or maintaining ocean health and productivity and livelihoods dependent on the ocean.
	3	Take action to prevent pollution affecting the ocean, reduce greenhouse gas emissions in their operations to prevent ocean warming and acidification, and work towards a circular economy.
	4	Plan and manage their use of and impact on marine resources and space in a manner that ensures long-term sustainability and take precautionary measures where their activities may impact vulnerable marine and coastal areas and the communities that are dependent upon them.
	5	Engage responsibly with relevant regulatory or enforcement bodies on ocean-related laws, regulations and other frameworks
Governance and Engagement	6	Follow and support the development of standards and best practices that are recognized in the relevant sector or market contributing to a healthy and productive ocean and secure livelihoods.
	7	Respect human-, labor- and indigenous peoples' rights in the company's ocean-related activities, including exercise appropriate due diligence in their supply-chain, consult and engage with relevant stakeholders and communities in a timely, transparent and inclusive manner, and address identified impacts
Data and Transparency	8	Where appropriate, share relevant scientific data to support research on and mapping of relevance to the ocean
	9	Be transparent about their ocean-related activities, impacts and dependencies in line with relevant reporting frameworks.

Insurance company Gard believes that a modern, sustainable maritime sector must be built on transparency, fairness, and inclusion, (Roppestad, 2021).

Fincantieri group, one of the biggest shipyards globally, understood the value of sustainability as reflecting the fundamental principles of social responsibility, undertaking and contributing to stakeholders' expectations today and tomorrow in everyday work. Those are improving health and safety in the workplace, developing technological innovation, promoting a responsible supply chain, maintaining customer satisfaction and trust, engaging with local communities, and reducing environmental impact. The company joined the United Nations Global Compact in 2019 to emphasize sustainability in its strategic planning, (Bono, 2019). Fincantieri group adopted an integrated strategy to combine business growth and financial stability with social and environmental sustainability in coordination with the Sustainable Development Goals. Although the pandemic of COVID-19 caused reassessing the most relevant issues in terms of sustainability, the objectives of the 2018-2022 Sustainability Plan achieved in 2020 except for the optimization of the use of the supplier evaluation tool, which could not be completed on time owing to the second wave of the pandemic. The achieved objectives totaled 21 and included material topics such as following; Governance and business integrity, Local communities and relations with the local area, Human rights, Diversity and equal opportunity, Company welfare, Customer satisfaction, Product quality and safety, Innovation, research, and development, the environmental impact of products and services, Health and safety in the workplace,

Sustainable supply chain, Environmental management. Hence, Fincantieri claimed that it is the largest “sustainable” shipbuilder in the world, (Bono, 2020).

Damen shipyard defined sustainability as not only just about environmentalism but also as the balance between people, planet, and profit. Sustainability is about creating added value for economic, societal, and environmental purposes. The sustainability strategy is based on three pillars:

1. Moving sustainability from the realm of compliance to that of a critical driver of performance and innovation requires embedding it deeply into the organization’s core through commitment, open communication, and reliable reporting.
2. The yards need to align their working methods, generating growth through eco-efficiency and good working conditions while engaging with local communities.
3. Sustainable solutions will determine the future of the maritime market. The innovative solutions will support the customers' goals. By standardization, collaborating on technology development, and strategic sourcing, we will be able to define the sustainable ship of the future, working towards where zero emissions are the norm.

Damen is committed to achieving the Sustainable Development Goals of the United Nations. As an organization, Damen is focusing on seven goals, which, through the work, have a direct influence on Sustainable Cities and Communities, Responsible Production and Consumption, Climate Action, Life Below Water, Affordable and Green Energy, Decent Work, and Economic Growth and Industry, Innovation and Infrastructure, (Damen, 2020).

Yangzijiang shipyard took sustainability as a business approach to creating long-term value by operating in the economic, social, and ecological environment. Sustainability has become an increasingly pressing issue as the global economy progresses and its structure evolves. The sustainability reporting revolves around the three pillars of sustainability issues under the Global Reporting Standard (GRI) system, namely, economic development, environmental protection, and social development, (Letian, 2019). Economic growth is achieved by keeping a solid treasury situation, regularly paying the suppliers and taxes to the government, creating economic value via R&D and cost-saving actions. The usage of renewable energy in business operations and renewable materials in construction to reduce the environmental footprint are steps for

environmental protection. The R&D investment in processes and materials to minimize the pollution effect of shipbuilding activities on the environment and worker health is a sustainable practice. In the social development, Yangzijiang shipyard prioritized the health and safety of the employees and initiated internal and external tie-ups with training opportunities to encourage the employee in continuous learning and upskilling, (Letian, 2020).

Sustainability and Transparency in Shipbuilding Networks (SUSTIS) project concentrated on collecting, combining, and utilizing sustainability information of materials and manufacturing processes to create sustainability-based value in shipbuilding. The aim has been to identify the sustainability dimensions in the value chain and what is seen as the main challenges (Heikkilä, 2016). The results of the survey have been demonstrated in Table 2.2.

**Table 2.2 : Sustainability aspects and emerging issues in the shipbuilding value chain based on the interviews**

	Economic Sustainability	Social Sustainability	Environmental sustainability
Present status of sustainability	Owner's long-term planning as the economic sustainability and responsibility	Health, safety, and other regulated issues and employer's duties; Job satisfaction; Dialogue with the local community and other stakeholders	Impacts of cruise ships at sea; High technology solutions in the ship to advance environmental sustainability; Waste management and energy use at production sites;
Emerging issues	How to secure or optimize the availability of crucial expertise as the sector keeps changing? Employment branding: How to attract new people to work in companies related to the shipbuilding industry?	How to share the image of sustainable shipbuilding through stakeholder communication and media? How to enhance the internal communication of sustainability issues within companies?	What and whose perspective to prioritize when measuring the sustainability of the shipbuilding materials and process? For example, who decides to emphasize the sustainability of many materials with a high symbolic value (e.g., rare wood)? How to consider the sustainability of the whole life cycle of the ship already in the planning phase and how to share it with all partners?
Emerging cross-category issue	How to manage the costs of sustainability information creation? For example, it is a lot more affordable to focus simply on the recyclability and properties of the physical materials than on the social and ecological sustainability of their production and processing history		



### **3. RESEARCH METHODOLOGY**

There is an increasing number of studies about the relationship between GSCM practices and companies' performance categorized as environmental, economic, social, and operational performance. In contrast, various GSCM practices such as green purchasing, green packaging, recycling, eco-design, internal environmental management, reverse logistic, green production, green marketing, environmental collaboration with suppliers and customers have been questioned in these studies. The researchers found both negative and positive, primarily partial, relationships between GSM practices and the company's performances.

This study investigates the impact of green supply chain management practices on three sustainability performance dimensions, environmental, economic, and social performance, by conducting a case study in Turkish shipyards. In this context, the objectives to be achieved are stated below.

- Determining which green supply chain management practices are applicable in shipyards
- To investigate the impact of green supply chain management practices on the sustainability performance of shipyards.
- To investigate the moderator effect of environmental uncertainty on the relationship between green supply chain and sustainability performance.
- To investigate the mediator effect of environmental uncertainty between green supply chain and sustainability performance
- The penetration level of green supply chain management practices on the Turkish shipyards.

The research model is created by considering the objectives above and studying those referenced in the following paragraphs.

In a study in Portugal, the companies believed that adopting green supply chain practices could be more competitive. Due to the scope of the green practices, the

relationship between green practices and economic performance was inconclusive. Internal and external green supply chain practices contribute to improved environmental performance because for all companies, there is a positive relationship between green practices and environmental performance in terms of energy, water consumption, waste, and air emissions reduction, (Pinto, 2020).

Qinghua Zhu and Sarkis (2004) examined the relationships between GSCM practice and environmental and economic performance and found significant implications.

Rao and Holt (2005) studied the impact of the GSCM practices on the economic performance and competitiveness of the ISO 14001 certificated leading East Asian companies determined that GSCM practices improve competitiveness, environmental and economic performance.

Tsoufias and Pappis (2008) proposed a decision model based on environmental performance indicators, which may support decision-making in the case of supply chains in the presence of environmental considerations.

Azevedo, Carvalho, and Cruz Machado (2011) Identified which GSCM practices positively affect supply chain performance and negatively affect. Reverse logistics has a positive effect on efficiency but negatively impacts environmental costs. Environmental friendly packaging has a positive impact on both efficiency and quality.

Eltayeb, Zailani, and Ramayah (2011) applied a mail survey to a group of 569 ISO 14001 certified Malaysian companies to examine the relationship between GSCM practices and economic, environmental, operational, and intangible outcomes. Eco-design has been found to affect the four types of results above positively. In contrast, other practices like reverse logistics or green purchasing have been partially positively related to the four outcomes.

Tang, Lai, and Cheng (2012) found that green practices improve customer satisfaction, company reputation, contribute economic and environmental performance in a study about the 500 largest US enterprises.

Manufacturing industries started adopting the green concept in their supply chain management to focus on environmental issues. Consequently, the Indian enterprises implement GSCM after achieving economic performance goals because of the financial support, (Govindan, Kaliyan, Kannan, & Haq, 2014).

Küçüköğlü (2014) examined Turkish companies that are listed among ISO 500 companies for the previous three years and have ISO 14001 Environmental Management Certificate from the standpoint of sustainability and green innovation point of view. Green innovation activities have an important relationship with a company's environmental performance, competitive advantage, and sustainability.

One of the green supply chain practices, green logistics, seems to increase the economic, operational, and environmental performance of health enterprises in Istanbul, (Yangınlar, 2015).

Dilşad Güzel (2016) investigated the relationship between supply chain integration, green supply chain implementations, and the business performance of 102 packaging manufactures in the Marmara region. It was observed that supply chain integration affected the implementation of the green supply chain and affected business performance.

Younis, Sundarakani, and Vel (2016), using survey questionnaires from 117 firms in the manufacturing industry, found that GSCM practices (eco-design, green purchasing, environmental cooperation, and reverse logistics) impact the corporate performance dimensions differently. Although none of the four GSCM practices affected environmental performance, green purchasing and environmental cooperation significantly impacted operational performance. The study found that only green purchasing plays a role in improving economic performance.

A meta-analysis of GSCM practices (Intra-organizational management, supplier integration, eco-design, customer cooperation, reverse logistics) and Asian enterprises indicated that GSCM practices lead to better performance in three aspects: economic, environmental, and operational. The GSCM practice–performance relationship is most substantial for economic performance, followed by operational and environmental performance. Surprisingly, the GSCM practices did not significantly impact social performance (Geng, Mansouri, & Aktas, 2017).

Dizaji (2017) analyzed green marketing strategies and their effects on the performance of food manufacturing companies in Istanbul. Green marketing, green supply chain, and green innovation are significant for business performance.

Derya Öztürk (2018) engaged in a similar study with food packaging companies in the TR83 Region of Turkey. In this study, green purchasing, green production, and green

packaging positively affect business performance. Günday (2018) found that green supply chain practices positively impact business performance in the chemistry sector.

Ferri and Pedrini (2018) questioned whether social and environmental practices along the purchasing process to Italian enterprises' economic performance, competitiveness, and risk mitigation. The positive relationship between social and environmental dimensions and firm performance depends upon the stage into which those criteria are integrated. The integration of social standards has proven to impact only risk mitigation throughout the purchasing process. In contrast, the environmental dimension contributes to risk mitigation and competitiveness when included in the supplier selection phase and economic performance when considered in supplier relationship management.

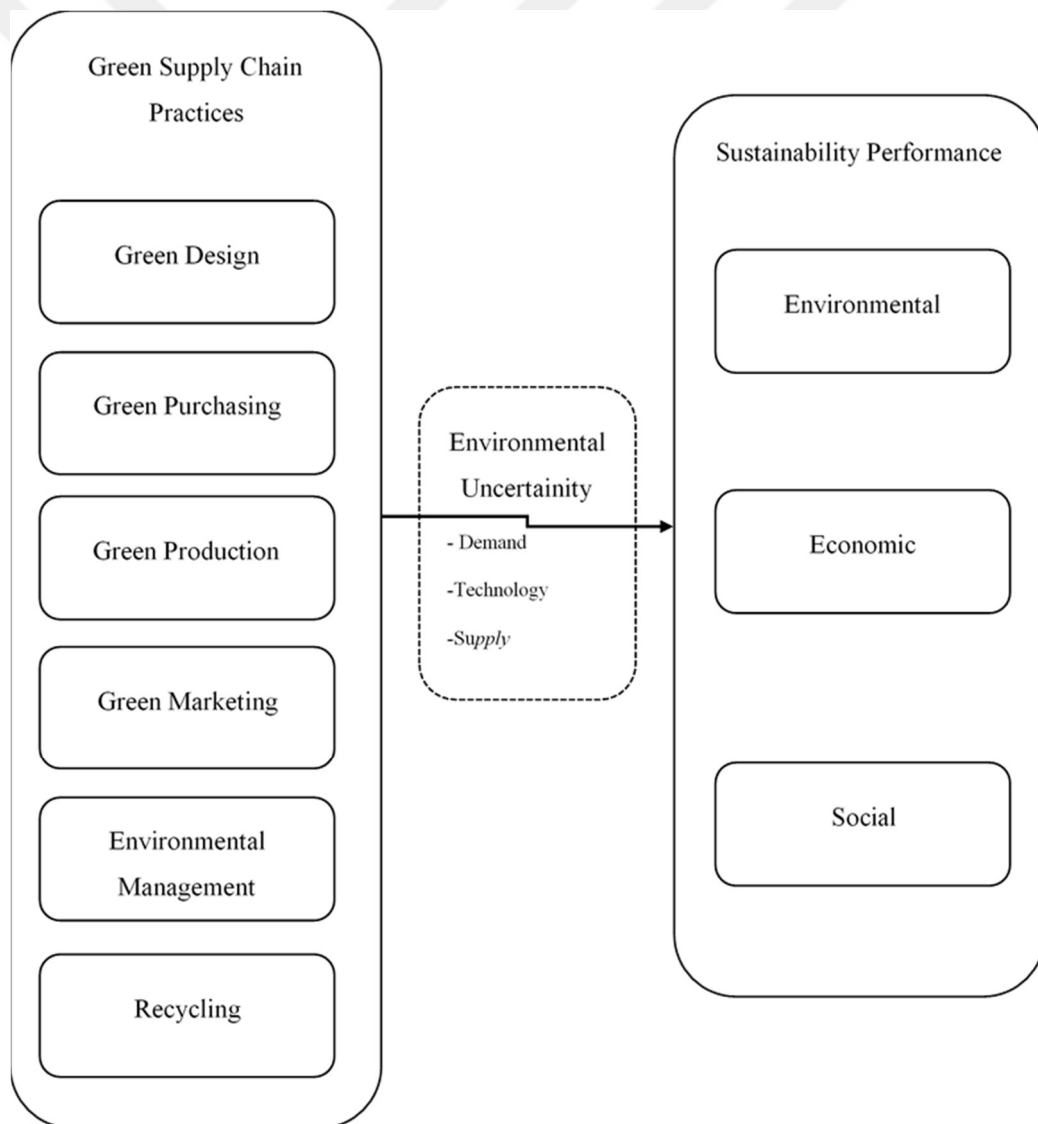
Younis, Sundarakani, and O'Mahony (2019) investigated in an online survey of the manufacturing companies in UAE. Environmental, operational, economic, and social performances were partially associated with GCSM practices (eco-design, green purchasing, environmental cooperation, reverse logistics). Green purchasing has a positive impact on operational and economic performance.

Santos, Lannelongue, and Gonzalez-Benito (2019) examined the impact of the adoption of green practices on operational performance among Brazilian manufacturers. The results show that the adoption of GSCM between suppliers and customers has a positive effect on operational performance. This means companies can benefit from a green supply chain by cooperating with upstream suppliers of environmentally responsible production technology and exchanging environmental information with them and considering the views of customers and green consumers in their production processes.

Yildiz Çankaya and Sezen (2019) studied the effect of green supply chain management practices on three essential elements of corporate sustainability – environmental, economic, and social performance – within 281 different companies, including the automotive and electronics, and chemistry sectors. Green production, green transport, and green packaging were found to have positive performance effects on the three sustainability dimensions, and others have positive impacts on one or two dimensions.

The research model and hypothesis are mostly adapted from the doctoral thesis prepared for the shipyards, (Çankaya, 2015). That dissertation examined green

production, green transportation, green packaging, green marketing, green purchasing, environmental training, internal environmental management, recycling. Some of these are unnecessary in shipbuilding, but other GSCM applications should be added. Green design is an essential factor in the green shipbuilding concept and added to the model. Green purchasing, green marketing, and recycling have been directly taken from those dissertations. Environmental training is a part of the internal environmental management, and therefore these two applications converged as environmental management. Green packaging and green transportation have little effect on the shipbuilding process and are omitted from the study. Finally, the research model has been created as below in Figure 3.1.



**Figure 3.1 : Research Model**

### 3.1. Hypotheses

According to the research model in Figure 3.1, the study hypotheses are created as follows.

Hypothesis 1: Each of the green supply chain management practices has a positive impact on environmental performance

- H<sub>1a</sub>: Green design has a positive impact on environmental performance
- H<sub>1b</sub>: Green purchasing has a positive impact on environmental performance.
- H<sub>1c</sub>: Green production has a positive impact on environmental performance.
- H<sub>1d</sub>: Green marketing has a positive impact on environmental performance
- H<sub>1e</sub>: Environmental management system has a positive impact on environmental performance
- H<sub>1f</sub>: Recycling has a positive effect on environmental performance

Hypothesis 2: Each green supply chain management practice has a positive impact on economic performance.

- H<sub>2a</sub>: Green design has a positive impact on economic performance
- H<sub>2b</sub>: Green purchasing has a positive impact on economic performance.
- H<sub>2c</sub>: Green production has a positive impact on economic performance.
- H<sub>2d</sub>: Green marketing has a positive impact on economic performance
- H<sub>2e</sub>: Environmental management system has a positive impact on economic performance
- H<sub>2f</sub>: Recycling has a positive effect on economic performance

Hypothesis 3: Each green supply chain management practice has a positive impact on operational performance.

- H<sub>3a</sub>: Green design has a positive impact on social performance
- H<sub>3b</sub>: Green purchasing has a positive impact on social performance.
- H<sub>3c</sub>: Green production has a positive impact on social performance.
- H<sub>3d</sub>: Green marketing has a positive impact on social performance

- H<sub>3e</sub>: Environmental management system has a positive impact on social performance
- H<sub>3f</sub>: Recycling has a positive impact on social performance

### **3.2. Environmental Uncertainty**

Environmental uncertainty reflects the sense of doubt experienced by managers when facing the problem of predicting future competitive conditions. The environmental uncertainty concept has drawn the attention of researchers who have mainly focused on how it affects corporate strategy. The relationships companies maintain with other economic actors to ensure access to resources and the prevailing instability in such relationships account for the significance of environmental uncertainty in corporate strategy. The impact of uncertainty in strategic processes does not come about impersonally, nor does it emerge from complex dependence relationships, but instead through management perception. This has led to much research addressing management perception of uncertainty, highlighting this variable's subjective nature. Uncertainty has also been used as a variable to describe the environment, applying specific easily-generalized quantitative indicators. Despite this kind of uncertainty being described as objective, it should be remembered that it also derives from perception developed by an outside observer (whether a researcher, expert, or analyst). It may therefore be concluded that in both cases, evaluation of uncertainty depends on individual perception, which aims to mirror the difficulties individuals face when anticipating future conditions in a business environment, (Santos Álvarez & García Merino, 2008)

A constant information flow between multiple lines of communication exists in a supply chain that creates uncertainty of predicting casual relationships. These uncertainties are very complicated. The researchers simplified the supply chain as a supplier-manufacturer–customer chain and measured uncertainty from manufacturers' perspectives to measure environmental uncertainty. Technology impacts the manufacturer in various ways like production processes, quality standards, innovations, etc. Therefore, technology should measure separately. Since supply differs from demand, both should measure separately too. Hence, demand, supply, and technology uncertainty reflect the overall level of Environmental Uncertainty in the simplified supply chain. Demand uncertainty measures the fluctuations and variations

level in demand. Supply uncertainty indicates the extent to which suppliers can meet manufacturers' requirements and produce materials with consistent quality. Technology uncertainty measures the time to which green technology changes within the industry, (Zhao, Feng, & Shi, 2018).

The environmental uncertainty may impact the relationship between GSCM practices and sustainability performance as a moderator or a mediating variable.

### **3.3. The Moderator Effect**

The moderator variable is the variable that strengthens or weakens the relationship between the dependent variable and the independent variable. The regulatory variable acts on the independent and dependent variables simultaneously. In this context, the regulatory variable always functions as an independent variable, (Çankaya, 2015).

Fynes, de Búrca, and Marshall (2004) developed a model of environmental uncertainty, supply chain relationship quality, and supply chain performance. They tested the data based on the Irish electronic sector and found that demand and supply uncertainty moderator roles were significant; in contrast, technology uncertainty was not substantial.

Wu employed a multi-dimensional approach to explore the relationship between green supply chain integration and green innovation and analyze environmental uncertainty's moderating effects. He applied hierarchical moderated regression analysis from 211 Taiwanese information technology manufacturers' survey data to identify the impact of green supply chain integration and environmental uncertainty on green innovation. Supplier, customer, and internal integration enhanced green product and process innovations. Demand uncertainty positively moderated each GSCI-green innovation link. However, the moderating effect of technology uncertainty is insignificant, (Wu, 2013).

Zhao et al. (2018) studied to explore the moderating roles of supply, demand, and technology uncertainty on the relationship between external involvement and green product innovation. They used survey data from 198 Chinese manufacturing firms and applied hierarchical moderated regression analyses. Customer involvement and supplier involvement positively affected green product innovation. Technological uncertainty enhanced the effects of customer involvement and supplier involvement

on green product innovation, whereas demand and supply uncertainty had no moderating effect.

The environmental uncertainty may change the strength or even the direction of a relationship between two GSCM practices and sustainability performance in the model. GSCM may be strengthened by the impact of environmental uncertainty and result in positive performance outputs. Hence, for this thesis the hypotheses regarding environmental uncertainty's moderator effect are as follows;

Hypothesis 4: Environmental uncertainty has a moderating effect between green supply chain management practices and sustainability performance.

- H<sub>4a</sub>: Demand uncertainty has a positive moderating effect between GSCM practices and sustainability performance
- H<sub>4b</sub>: Technology uncertainty has a positive moderating effect between GSCM practices and sustainability performance
- H<sub>4c</sub>: Supply uncertainty has a positive moderating effect between GSCM practices and sustainability performance.

### **3.4. The Mediation Effect**

Mediation occurs when a third variable, a mediator construct, intervenes between two directly related constructs. More precisely, in that study, a change in the GSCM practices results in a shift in the mediator (Environmental Uncertainty), which changes the environmental, economic, and social performance. The mediator analysis will evaluate the factors related to the cause-effect relationship between GSCM and sustainability performance.

Supply chain agility is seen as mediating the relationship between environmental uncertainty and supply chain performance. Inman and Green (2021) examined whether supply chain agility responds to the effects of environmental uncertainty. The model was statistically assessed using partial-least-squares structural equation modeling by analyzing survey data from 136 American manufacturing managers. The study did not indicate a significant relationship between environmental uncertainty and supply chain performance. Findings presented a significant positive relationship between agile manufacturing and supply chain performance using primarily operations-centered

measures rather than financial. In addition, agile manufacturing fully mediated the relationship between environmental uncertainty and supply chain performance.

In another study, 138 Omani manufacturing firms and Structural Equation Modeling are used to examine the collective impact of internal and external GSCM practices on two aspects of environmental performance: environmental impact and environmental cost savings. GSCM is proposed as a collaborative competency, combining four distinct but interrelated practices: environmental management systems, eco-design, source reduction, and external environmental practices. The authors found a strong positive relationship between collective GSCM competency and the environmental impact achieved that supported the belief that complementarities between GSCM practices lead to better performance. Therefore, managers should focus on implementing bundles of GSCM practices rather than searching for individual best practices. They found an indirect, mediated influence on environmental cost savings, consistent with previous results in other emerging market contexts, (Al-Sheyadi, Muyldermans, & Kauppi, 2019).

The mediating effects of environmental and operational performance on the relationship between green supply chain management (GSCM) and financial performance are analyzed using survey data from a sample of 126 automobile manufacturers in China. The results suggested that GSCM as an integrated supply chain strategy is significantly and positively associated with environmental and operational performance, indirectly leading to improved financial performance. The results indicated the possible complementarity effects between various internal and external GSCM practices, (Feng et al., 2018).

In a study based on a survey of 120 Jordanian managers, green supply chain, green innovation, and trust effect on firm performance are analyzed to determine if green innovation mediates the impact of green supply chain management on firm performance. The results presented as green innovation and trust significantly impact firm performance. However, a green supply chain has little to do with green innovation. Furthermore, green innovation contributed to green supply chain management and firm performance. Green Innovation appeared to mediate the link between Green supply chain management and firm performance, (Almajali, 2021).

Similarly, environmental uncertainty may mediate the relationship between GSCM and sustainability performance. Hence, for this thesis the hypotheses regarding environmental uncertainty's mediator effect are as follows.

- H<sub>5a</sub>: Environmental Uncertainty mediates the relationship between GSCM practices and Environmental Performance
- H<sub>5b</sub>: Environmental Uncertainty mediates the relationship between GSCM practices and Economic Performance
- H<sub>5c</sub>: Environmental Uncertainty mediates the relationship between GSCM practices and Social Performance





## **4. SURVEY APPLICATION**

### **4.1. Survey Design**

The study requires detailed data to be collected at the shipyard executive level. Therefore, the survey method is used in the study. The survey technique is one of the most frequently used techniques when it is aimed to collect primary data in studies. The questionnaire is commonly used in studies conducted to determine a situation, investigate a relationship, or test a hypothesis. The survey technique has very reliable results and the slightest error margin when taking the sample, preparing the questions, applying and evaluating it, (Aziz, 2008). A mixed data collection method (face-to-face interview, e-mail, phone calls) was preferred in the study. The survey went through from the Turkish Shipbuilders Association to its members to the shipyards executives to increase the participation rate and data accuracy.

The survey questions were prepared by considering the empirical studies conducted before in the same subject and mainly studies those applied in Turkey but different sectors like automobile, chemical, electronics, food industry, ISO (Istanbul Chamber of Industry), 500 companies, and hospitals. All the reference questions were collected in the data repository and categorized according to the research method of the thesis.

The survey consists of three main parts. The first part contains an introduction letter about a brief explanation of the study regarding scientific and social benefits, assuring confidentiality of the information taken from companies. The name of the Institution and the researchers with current contact information is also added to the letter. In the second part, general information about the company, its activities are requested. The respondent's name is not asked to ensure that respondents answer the questions comfortably and safely. The other questions were the foundation year, the personnel quantity, the constructed ship types, the name of the environmental department and number of the personnel, the obtained ISO certificates.

In the last part, the survey questions are grouped regarding the research model to each GSCM application, environmental uncertainty, and sustainable performance. The understanding of scales by the applicant and time constraints were two main obstacles to accomplishing the survey completion rate. Therefore, the author summarized the scales into expressed sentences and limited them to 33 questions. The survey filling time is a critical factor. It is arranged for around 15 minutes on average because most executives claim the intense work environment and use it as an excuse not to fill the survey. The survey used a 5-Likert type, the most preferred scale in the literature. The survey is given in the Appendix A. the original survey is prepared in Turkish. However, the English translation is added to Appendix B. The scales in the survey are given below;

Demographic questions;

Questions on business characteristics include information about the duration of the business, the number of employees, the quality certificates. In this context, the data showing the business characteristics were collected to evaluate whether the critical variables in the conceptual model differ according to the business characteristics and to measure the representation ability of the sample.

The scale:

As a result of the literature research, it has been determined that although a remarkable number of studies have been carried out in the field of the green supply chain, no research scale will include all the dimensions we have defined within the scope of our research, whose validity and reliability have been tested. For this reason, the scale of any previous study will not be used precisely. The scale in (Yildiz Çankaya & Sezen, 2015) study was based on the scales of (Shang, Lu, & Li, 2010), who is one of the authors who dealt with the most dimensions related to GSCM practices, and (Q. Zhu, Sarkis, & Lai, 2007), which is the most widely used in academic studies. Therefore, the scale of this study was prepared by deriving mainly from the scale developed by Çankaya but indirectly by Shang and Zhu. In addition, scales of (Dizaji, 2017), (Lam, 2015), (Green et al., 2012), (Islam, Karia, Fauzi, & Soliman, 2017), (Karabulut, 2003), and (Zhao et al., 2018) and others were used for several questions. All scale references are shown in Appendix C. The survey questions were revised in line with the opinions of academicians and the opinions of the survey experts. The questions in the scale are

grouped under sections and given reference to the scales cited. The first section contains GSCM applications; the second is for Environmental Uncertainty. The sustainability performances are in the third section.

#### GSCM applications

The green design requires continuous and sustainable innovation to decrease waste and energy requirements during production and product life. The questions and references are presented in the Table 4.1.

**Table 4.1 : Green Design questions and references**

ID	Question	Reference
S1	We use more environmentally friendly materials and systems in the design phase than before	(Çankaya, 2015), (Dizaji, 2017), (S. J. Lee et al., 2014)
S2	We design systems/products that will consume less energy than before	(Çankaya, 2015), (Dizaji, 2017), (S. J. Lee et al., 2014)
S3	We design systems/products to generate less waste than before	(Çankaya, 2015), (Dizaji, 2017), (S. J. Lee et al., 2014), (Green et al., 2012)

The environment criterion is an essential factor for choosing a supplier. The aim is to purchase eco-friendly materials and press suppliers to proceed with environmental actions. The questions and references are presented in the Table 4.2.

**Table 4.2 : Green Purchasing questions and references**

ID	Question	Reference
S4	The technical specifications for the inputs that are demanded from suppliers contain the request for the environmental protection	(Çankaya, 2015)
S5	We also use environmental criteria in evaluating suppliers	Authors
S6	We cooperate with suppliers for goals related to protecting the natural environment	Green et al., 2012)

Generate minimum waste and reduce environmental pollution are critical factors in green production. Companies should decrease hazardous or restricted materials during manufacturing and substitute toxic inputs with environmentally friendly ones. The questions and references are presented in the Table 4.3.

**Table 4.3 : Green Production questions and references**

ID	Question	Reference
S7	We minimize wastage, waste, and noise pollution in the production process.	(Çankaya, 2015), (Islam et al., 2017)
S8	The use of products and production processes harmful to nature and human health is reduced or abandoned	(Çankaya, 2015), (Islam et al., 2017)
S9	We pay attention to using recyclable raw materials in our production activities.	(Dizaji, 2017), authors

Green marketing talks about emerging and promoting products based on their actual or perceived sustainability. Green marketing means understanding environmental issues in marketing efforts, balancing the unbalanced resource distribution, and

avoiding socially harmful behaviors in all marketing decisions and practices (Çankaya, 2015). The questions and references are presented in the Table 4.4.

**Table 4.4 : Green Marketing questions and references**

ID	Question	Reference
S10	There are also environmental criteria in the technical specifications of the products we produce.	Authors
S11	Customer demands positively affect our company's green policy	(Bedük, 2017)
S12	In our promotional activities, the environmental aspects of our products are highlighted	(Çankaya, 2015)

Environmental management involves all stakeholders because all human activities ultimately have some environmental impact and requires a multidisciplinary perspective. It involves auditing, total quality management, pollution prevention, employee and supplier training. The questions and references are presented in the Table 4.5.

**Table 4.5 : Environmental Management questions and references**

ID	Question	Reference
S13	An effective environmental management system has been established in our company.	(Çankaya, 2015)
S14	An environmental performance index is created on recycling, reducing harmful emissions, and energy saving.	(Çankaya, 2015; Karabulut, 2003)
S15	Regular environmental training is organized for the personnel within the company.	(Çankaya, 2015), (Green et al., 2012)

Recycling includes recovering the company's end-of-life items, resale or reprocessing used parts or components, old/obsolete items being used or replaced. Two questions are derived from the environmental training and internal environmental management sections of the Çankaya scales, and the authors prepared one question. The questions and references are presented in the Table 4.6.

**Table 4.6 : Recycling questions and references**

ID	Question	Reference
S16	Scrap and used materials/tools are sold and evaluated	(Çankaya, 2015)
S17	A recycling system has been established for used and defective products	(Eltayeb et al., 2011)
S18	We pay attention to the recycling of the materials to be used	(Dizaji, 2017)

#### Environmental Uncertainty

Environmental uncertainty is categorized into three sections; demand, technology, and supply. Environmental uncertainty reflects the sense of doubt experienced by managers when facing the problem of predicting future competitive conditions. Demand uncertainty measures the degree of fluctuations and variations in demand. The questions and references are presented in the Table 4.7.

**Table 4.7 : Demand uncertainty questions and references**

ID	Question	Reference
S19	Demand for our products is often very volatile	(Çankaya, 2015)
S20	Customers want different features for each new product	(Zhao et al., 2018), Authors

Technology uncertainty measures the extent to which green technology changes within the industry. The questions and references are presented in the Table 4.8.

**Table 4.8 : Technology uncertainty questions and references**

ID	Question	Reference
S21	We can foresee the development of green technology	(Zhao et al., 2018), Authors
S22	We can anticipate new product/service offerings from competitors	(Çankaya, 2015), Authors

Supply uncertainty indicates the extent to which suppliers can meet manufacturers' needs and produce materials with consistent quality. The questions and references are presented in the Table 4.9.

**Table 4.9 : Supply uncertainty questions and references**

ID	Question	Reference
S23	The performance of our suppliers is difficult to predict.	(Çankaya, 2015)
S24	Suppliers offer products/services of desired quality and delivery time.	(Zhao et al., 2018), Authors

### Sustainability Performance

Buyukozkan and Karabulut (2018) defined sustainability performance as the aggregate negative or positive bottom line of an entity's economic, environmental, and social impacts against a defined baseline. Sustainability performance includes environmental, economic, and social performance dimensions. Responsible interaction with the environment to evade reduction or ruin of natural resources and allow for long-term environmental quality is the environmental sustainability,

Environmental sustainability requires using renewable by replacing them with non-renewable resources and avoiding environmental damage as much as possible. Companies need to minimize the use of materials and energy, control pollution, and reduce the damage caused by waste, (Çankaya, 2015). The questions and references are presented in the Table 4.10.

**Table 4.10 : Environmental Performance questions and references**

ID	Question	Reference
S25	Hazardous and harmful material consumption is reduced	(Çankaya, 2015; Kalpande & Toke, 2020)
S26	Pollution (wastewater and solid waste disposal, noise emission) decreased	(Çankaya, 2015)
S27	Environmental accidents have decreased	(Kalpande & Toke, 2020), Authors

Companies always focus on economic performance during the implementation of GSCM applications because the primary goal is to earn money. Therefore, economic sustainability deals with income, profitability, cost, and investment issues in the short-term, create value for stakeholders and evaluates the opportunities and risks in the long term. Energy consumption, cost of purchased goods and disposal costs, profitability, payback ratio, and other financial ratios are essential, (Çankaya, 2015). The questions and references are presented in the Table 4.11.

**Table 4.11 : Economic Performance questions and references**

ID	Question	Reference
S28	Revenue and profitability increased	(Çankaya, 2015; Kalpande & Toke, 2020), Authors
S29	Energy consumption costs decreased	(Çankaya, 2015)
S30	Waste disposal and treatment costs reduced	(Kalpande & Toke, 2020), Authors

Responsibility to society, personnel, the environment is social responsibility. The companies should consider personnel development, community activities and create close links with the stakeholders, (Çankaya, 2015). The questions and references are presented in the Table 4.12.

**Table 4.12 : Social Performance questions and references**

ID	Question	Reference
S31	Work accidents and work-related diseases have decreased	Authors
S32	There has been an increase in the welfare of all stakeholders (employees, partners, customers, and suppliers, etc.)	(Çankaya, 2015), Authors
S33	Investments in social and environmental projects have increased	(Çankaya, 2015), (Caniëls et al., 2016)

## 4.2. Survey Application

The shipyards in Turkey are the targeted research environment. GISBIR (Turkish Shipbuilders' Association) consists of almost all shipyards. Therefore, its member list is considered for the sampling group of this research. However, GISBIR has two membership categories. The first category contains the shipyards; the second category includes the individual co-founders of the association. In this study, the first category, shipyards, has been considered. The detailed list of the shipyards is given in Appendix D. There is a total of 67 members on the list. The researcher reached two other shipyards not included in the GISBIR list. On the other hand, 13 members, whose are duplicates names, stopped activities, and unreachable neither by email nor phone, have been dropped from the list. So, the total number of the surveyed group decreased to 56.

### **4.3. Pilot Survey**

The survey is one of the essential information-gathering tools in terms of scientific research. This tool should eliminate possible perception and interpretation problems in the data collection process and prevent the participant from being forced. Various cognitive (mental) processes are activated when a participant answers a question. The survey responder has to understand the question, recall information from memory, evaluate that information by comparison, and construct his answer. If the respondent encounters any cognitive difficulties during the course, the answer to the question will contain a certain amount of error. In this respect, survey pretests will help eliminate answering and other non-sampling errors, which constitute an essential part of the total survey error. Therefore, the pilot survey phase is one of the survey development phases, (Altunisik, 2008).

The pilot survey phase includes two stages. In the first stage, the survey has been applied to three academicians and three experts in the sector. After reviewing and correcting the scales, one survey expert professor reviewed the complete survey and gave his observations. These observations consist mainly of the wording and other grammar mistakes in the scales. In the second stage, seven executives from the sectors reviewed the survey. These seven executives were managers, owners of several shipyards, and one representative from GISBIR. The authors contacted them via email or phone and arranged an online meeting during work hours since there were strict travel restrictions during the pandemic era. Each online meeting took about 45 minutes in two weeks. The author presented the sustainability concept and explained the study's research purpose. The author and the responder reviewed the survey questions together. The authors noted the answers. The attendants commented that the questions were easy to understand, clear, and contained no ambiguity.

### **4.4. Final Survey**

After that phase, the final survey was applied. The application method is chosen as a web-based survey because of the curfew conditions and pandemic measures. Web-based surveys, or e-surveys, are designed and delivered using the internet. The use of these survey tools is becoming increasingly common in many types of research. Their advantages are to allow rapid development and administration of surveys, fast data

collection and analysis, low cost, and fewer errors due to manual data entry than telephone or mailed surveys, (Maymone, Venkatesh, Secemsky, Reddy, & Vashi, 2018).

The survey has been published to the VETI system (Veri Toplama ve İstatistik Sistemi) of Istanbul Technical University. VETI means in English “Data Collection and Statistic System.” VETI is a web-based form application developed by Istanbul Technical University Computer Center. The authors published the survey into the VETI system that generated a link for the web-based survey; the participants can fill the questionnaire through this link. GISBIR secretariat sent this link with a foreword to its 67 members in April and May, twice. The authors sent the link to two other shipyards that were not GISBIR members. In addition, the author hired a professional telephone-survey expert to contact the shipyards via phone and email to encourage them to fill the survey. The expert contacted the shipyard’s executive for three months. The authors realized that some shipyards were closed during the file, some listed twice in different names, few were non-profitable organizations and consulting companies. Hence, the unique shipyards numbers decreased to 56. Finally, the total number of the completed survey was achieved to 40.

## **5. FINDINGS**

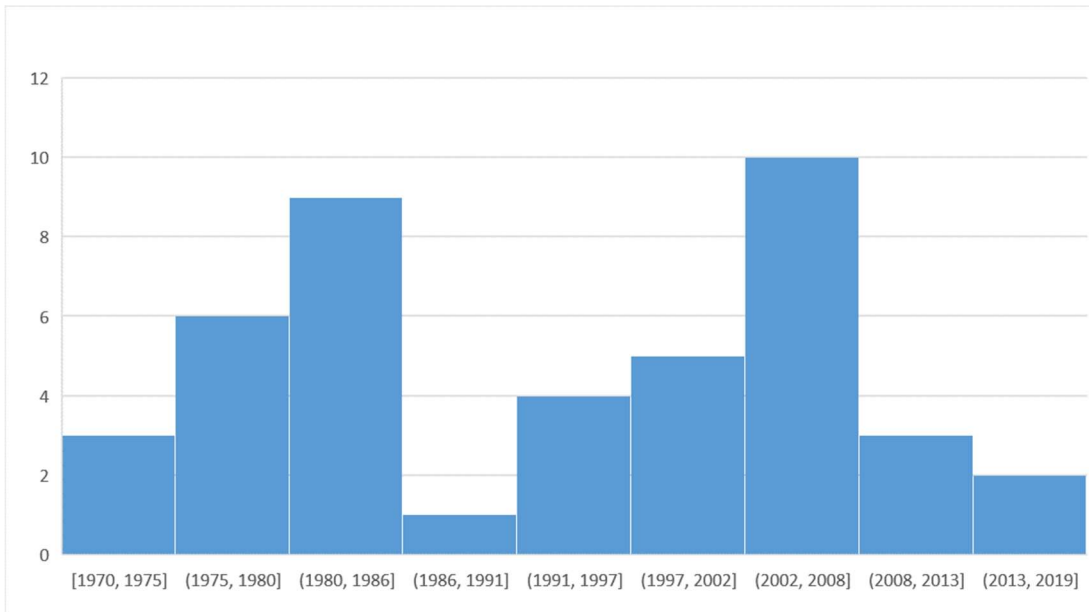
### **5.1. Demographics**

The demographic questions are placed in the first section of the survey. The answers were downloaded from the VETI system. There was a total of 43 shipyards responses. However, three of them did not continue other sections of the survey. The complete survey responses were limited to 40 samples.

The respondents were primarily company owners, board members, shipyards directors, business development managers, HSE or quality managers, and other middle-level managers. The responder scale showed that the survey had taken the high level of importance seriously.

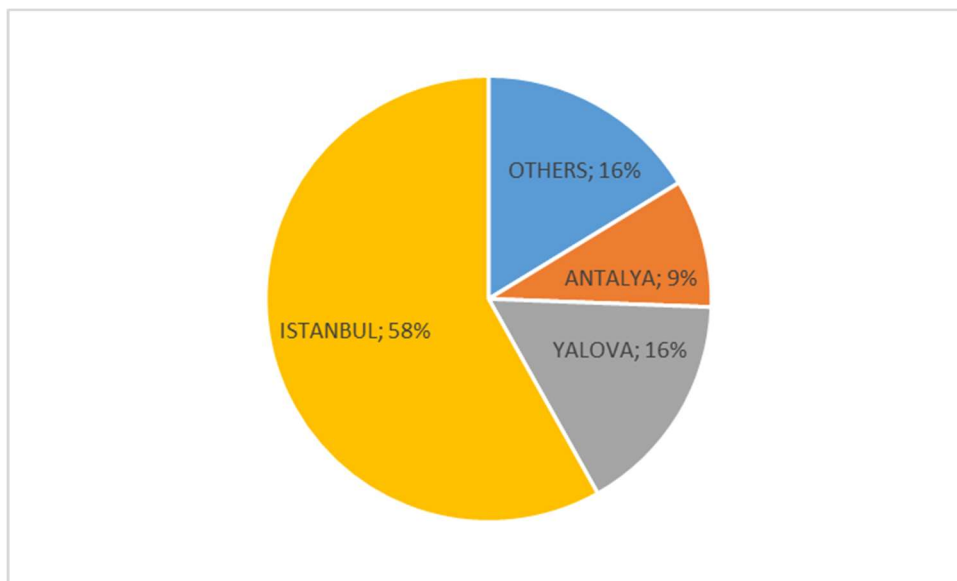
The shipyards had two main activities. The first activity is the reparation and maintenance works which create a continuous income generator. The second activity is the new-ship construction. Turkish shipyards construct small or medium-sized ships using composite, aluminum, and steel material. The ship types range widely like ferry, un-manned boats, cargo (chemical, container, dry cargo) ship, Ro-Ro, scientific research vessels, fishing vessel, live fish transport vessel, yacht, mega yacht, tugboat, military vessels (corvette, patrol, powerboat), landing craft, coast guard), floating dock, platform support vessels, tugboat, tugboat, shore safety boats.

Nearly 70% of the shipyards were established before 2002. The histogram of the establishment years is given in Figure 5.1. The periods of 1980-1986 and 2002-2008 showed the shipbuilding boom, where many shipyards were established.



**Figure 5.1 : Shipyards' Establishment Years**

Shipyards were located in several special organized zone in Turkey. As seen in Figure 5.2, more than half of the shipyards are located in the Istanbul region that is Tuzla bay. This area is the heart of the Turkish shipbuilding industry. The second region is the Yalova zone, created as an extension zone linked to Tuzla. The third zone is Antalya, where mostly the yacht sector is dominant. Others cities and regions like Trazon, Zonguldak, Bursa, and Çanakkale have one or two shipyards. These are summed in the others category.



**Figure 5.2 : Shipyards' Location**

The sixth question in the demographic section was whether shipyards have a department responsible for environmental activities. 79% of the shipyards answered yes, stating that shipyards took environmental issues in high sensitivity and seriously. The name of the departments varies as quality department, HSE, HSQE, administrative department, environmental and security department, environmental department, quality, and security department, production planning department. An average of 4 persons work in those departments because follow-up activities are subcontracted to different companies. Another favorable finding is the certification outcome. All shipyards have a minimum of two certificates (ISO 9001 and ISO 14001, 30% of the answers). Only two small shipyards have a single certification, ISO 9001. A high portion of the shipyards has all three certificates (ISO 9001, ISO 14001, and ISO 45001). Those findings proved that Turkish shipyards embraced environmental issues and took necessary internal and external actions to improve their business competence.

## **5.2. Analysis Method**

The structural equation model (SEM) method was preferred for conducting the hypothesis tests of the proposed research model. Statistical analysis has been an essential tool for social science researchers for more than a century. Applications of statistical methods have expanded dramatically with the advent of computer hardware and software, particularly in recent years with widespread access to many more forms due to user-friendly interfaces with technology-delivered knowledge. Researchers initially relied on the univariate and bivariate analysis to understand data and relationships. It is increasingly necessary to apply more sophisticated multivariate data analysis methods to comprehend more complex relationships associated with current research directions in the social science disciplines. The multivariate analysis involves the application of statistical methods that simultaneously analyze multiple variables. The variables typically represent measurements associated with individuals, companies, events, activities, situations, and so forth. The sizes are often obtained from surveys or observations used to collect primary data, but they may also be obtained from databases consisting of secondary data. Table 5.1 displays some of the significant statistical methods of multivariate data analysis. SEM is used to test causal relationships between observed and unobserved (hidden) variables (Joseph F Hair, Hult, Ringle, & Sarstedt, 2017).

There are two types of SEM: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM; also called PLS path modeling). CB-SEM is primarily used to confirm (or reject) theories (i.e., a set of systematic relationships between multiple variables that can be tested empirically). It does this by determining how well a proposed theoretical model can estimate the covariance matrix for a sample data set. In contrast, PLS-SEM is primarily used to develop theories in exploratory research. It does this by focusing on containing the variance in the dependent variables when examining the model.

**Table 5.1 : Statistical Techniques**

	Primarily Exploratory	Primarily Confirmatory
First generations techniques	Cluster analyses Exploratory factor analyses Multidimensional scaling	Analysis of variance Logistic regression Multiple regression Confirmatory factor analyses
Second generations techniques	Partial least squares structural equation modeling (PLS-SEM)	Covariance based structural equation modeling (CV-SEM)

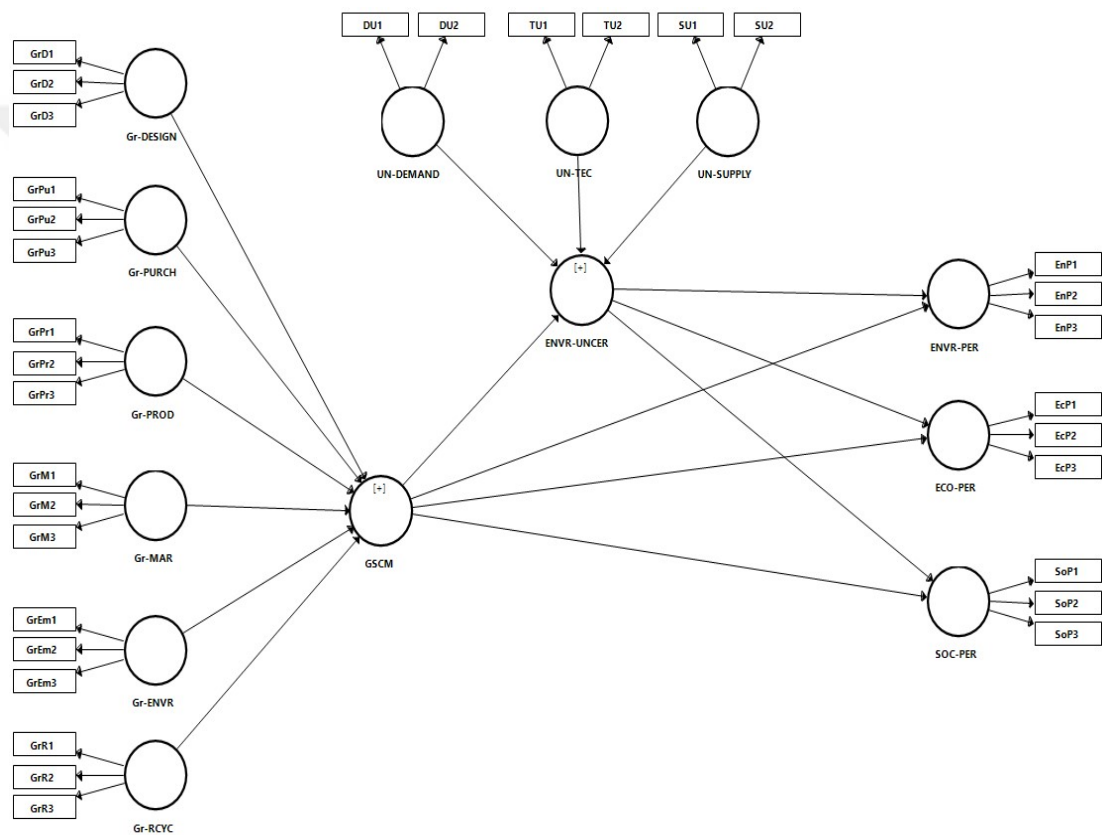
PLS-SEM has several advantages to the CV-SEM. The first advantage is the small sample size. PLS-SEM allows to examine data with small sample size, achieves generally high statistical power. Secondly, normally distributed data is not an obligation. As a non-parametric method, PLS-SEM handles complex models with many structural model relations and easily incorporates reflective and formative measurement models. Since there are only 40 samples in the study and the research model includes a complex structure, the PLS-SEM method is preferred to examine the sample data set. The author downloaded the student version of the SmartPLS software from the link “<https://www.smartpls.com/downloads>.” The student version is free but limited to 300 samples.

**5.3. Creating PLS-SEM Model in SmartPLS**

PLS-SEM analysis includes the assessment of the Measurement and Structural Model. The measurement model establishes the reliability and validity of the construct. The structural model ascertains the significance of hypothesized relationships. Different hypotheses were proposed to evaluate the relationship of predictors on the outcome.

The proposed research model in PLS-SEM using SmartPLS is configured in Figure 5.3. Green Supply Chain Applications are the exogenous constructs. Green design, green purchasing, green production, green marketing, environmental management,

and recycling are lower-order constructs and relate under GSCM higher-order construct by forming a hierarchical order model (HOM). In addition, demand uncertainty, technology uncertainty, and supply uncertainty form a second higher-order construct named ENVR-CER as environmental uncertainty. There are two main approaches to assess in PLS-SEM. One is the indicator approach; the other is the two-stage approach. The two-stage approach also differs into as embedded and disjoint two-stage approach. In this analysis, the disjoint two-stage approach is selected because of easy use and one of the most preferred solutions in the literature with the indicator approach.



**Figure 5.3 : Research Model in the PLS-SEM**

Since each GSCM practices form the higher-order construct, then the hypothesis should also adapt to the model. The updated hypotheses are;

H<sub>1</sub>: GSCM practices have a positive impact on environmental performance.

H<sub>2</sub>: GSCM practices have a positive impact on economic performance.

H<sub>3</sub>: GSCM practices have a positive impact on social performance.

H<sub>4a</sub>: Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.

H<sub>4b</sub>: Environmental uncertainty has a moderating effect between GSCM practices and economic performance.

H<sub>4c</sub>: Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.

H<sub>5a</sub>: Environmental uncertainty mediates the relationship between GSCM practices and environmental performance.

H<sub>5b</sub>: Environmental uncertainty mediates the relationship between GSCM practices and economic performance.

H<sub>5c</sub>: Environmental uncertainty mediates the relationship between GSCM practices and social performance.

In the disjoint two-stage approach, both exogenous and endogenous constructs are linked to each other without using the higher-order construct in the first stage. The first model is presented in Figure 5.4. PLS-Algorithm is calculated for the validation of the model. The basic settings configurations were path weighting scheme, maximum 300 iterations, and stop criterion  $10^{-7}$ .

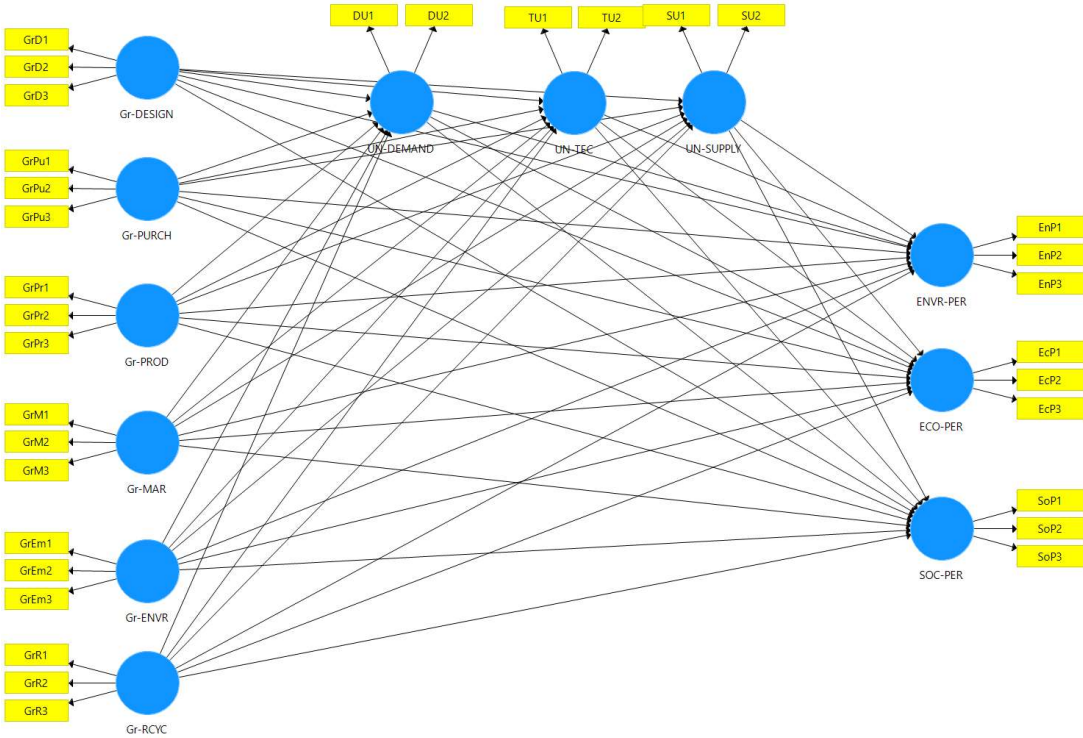


Figure 5.4 : First Stage Model

## 5.4. Measurement Model Assessment

The measurement model evaluates the quality of the constructs in the study. The assessment of the quality criteria starts with the analysis of the factor loadings which is followed by establishing the construct reliability and validity<sup>1</sup>.

Factor loadings refers to “the extent to which each of the items in the correlation matrix correlates with the given principal component. Factor loadings can range from -1 to +1, with higher absolute values indicating a higher correlation of the item with the underlying factor”. Factor loadings are presented in the Table 5.2. Although indicator SU1 (0,563) and SoP1 (0,431) are lower than 0,708, the other score of reliability and validities are over the threshold levels, and hence they are not removed from the model because of the small sample size (40 observations).

**Table 5.2 : Outer Loadings of the model**

	ECO- PER	ENVR- PER	Gr- DESIGN	Gr- ENVR	Gr- MAR	Gr- PROD	Gr- PURCH	Gr- RCYC	SOC- PER	UN- DEMAND	UN- SUPPLY	UN- TEC
DU1										0,965		
DU2										0,721		
EcP1	0,878											
EcP2	0,938											
EcP3	0,858											
EnP1		0,804										
EnP2		0,919										
EnP3		0,834										
GrD1			0,933									
GrD2			0,826									
GrD3			0,901									
GrEm1				0,874								
GrEm2				0,882								
GrEm3				0,718								
GrM1					0,860							
GrM2					0,732							
GrM3					0,819							
GrPr1						0,799						
GrPr2						0,819						
GrPr3						0,876						
GrPu1							0,876					
GrPu2							0,907					
GrPu3							0,910					
GrR1								0,796				
GrR2								0,736				
GrR3								0,892				
SU1											0,563	
SU2											0,932	
SoP1									0,431			
SoP2									0,885			
SoP3									0,847			
TU1												0,902
TU2												0,926

### Indicator Multi-collinearity

Variance Inflation Factor (VIF) statistic is utilized to assess multi-collinearity in the indicators. Multi-collinearity is not a serious issue if the value for VIF is below 5.

<sup>1</sup> This procedure is adapted from Fawad Latif's free online research courses channel at <https://www.youtube.com/channel/UCj4wQNQTmRPbOd1rcAOkU6Q>

Table 5.3 presents the VIF values for the indicators in the study and reveals that VIF for each of the indicators is below the recommended threshold.

### Reliability Analyses

Reliability is defined as the extent to which a measuring instrument is stable and consistent. The essence of reliability is repeatability. If an instrument is administered over and over again, will it yield the same results. The two most commonly used methods for establishing reliability include Cronbach Alpha and Composite Reliability (CR). The results for both Cronbach's alpha and composite reliability are presented in Table 5.4. The Cronbach's Alpha ranged from 0.366 to 0.871 whereas CR ranged from 0.733 to 0.926. UN-SUPPLY has a lower Cronbach's Alpha score but CR has a value of 0,733 and did not removed. Others indicators of reliability have reliability statistic over the required threshold of 0.70. Hence, construct reliability is established.

**Table 5.3 : Collinearity Statistics**

Indicator	VIF
DU1	1,360
DU2	1,360
EcP1	2,426
EcP2	3,036
EcP3	2,059
EnP1	1,591
EnP2	2,776
EnP3	2,143
GrD1	3,243
GrD2	1,918
GrD3	2,563
GrEm1	1,781
GrEm2	1,676
GrEm3	1,478
GrM1	1,434
GrM2	1,405
GrM3	1,622
GrPr1	1,502
GrPr2	1,651
GrPr3	2,046
GrPu1	2,298
GrPu2	2,647
GrPu3	2,437
GrR1	1,369
GrR2	1,585
GrR3	1,912
DU1	1,360
SU1	1,053
SU2	1,053
SoP1	1,240
SoP2	1,798
SoP3	1,528
TU1	1,831

### Construct Validity

Statistically using PLS-SEM, construct validity is established when there is convergent validity and discriminant validity.

## Convergent Validity

Convergent validity refers to how closely the new scale is related to other variables and other measures of the same construct. The idea is that two or more measure of the same thing should co-vary highly if they are valid measures of the concept. When AVE value is greater than or equal to the recommended value of 0.50, items converge to measure the underlying construct and hence convergent validity is established.

**Table 5.4 : Construct Reliability Analysis**

Construct	Cronbach's Alpha	Composite Reliability
ECO-PER	0,871	0,921
ENVR-PER	0,812	0,889
Gr-DESIGN	0,865	0,918
Gr-ENVR	0,779	0,866
Gr-MAR	0,736	0,846
Gr-PROD	0,777	0,871
Gr-PURCH	0,880	0,926
Gr-RCYC	0,742	0,851
SOC-PER	0,599	0,781
UN-DEMAND	0,679	0,838
UN-SUPPLY	0,366	0,733
UN-TEC	0,805	0,911

Convergent validity results based on the AVE statistics in the current study show that all the constructs have an AVE value greater than 0.50. Hence, convergent validity is established. Table 5.5 shows the AVE value for each of the constructs.

**Table 5.5 : Construct Convergent Validity (AVE)**

Construct	Average Variance Extracted (AVE)
ECO-PER	0,795
ENVR-PER	0,729
Gr-DESIGN	0,788
Gr-ENVR	0,686
Gr-MAR	0,648
Gr-PROD	0,692
Gr-PURCH	0,806
Gr-RCYC	0,657
SOC-PER	0,562
UN-DEMAND	0,726
UN-SUPPLY	0,592
UN-TEC	0,836

## Discriminant Validity

Discriminant validity is the degree to which measures of different concepts are distinct. The notion is that if two or more concepts are unique, then valid measures of each should not correlate too highly.

Fornell and Larcker Criterion: According to Fornell and Larcker criterion, discriminant validity is established when the square root of AVE for a construct is greater than its correlation with all other constructs. In this study, the square root of AVE (bold and italic in the table) for a construct was found greater than its correlation

with other constructs Table 5.6. Hence, providing strong support for the establishment of discriminant validity.

**Table 5.6 : Discriminant Validity – Fornell and Larcker Criterion**

	ECO- PER	ENVR- PER	Gr- DESIG N	Gr- ENV R	Gr- MAR	Gr- PRO D	Gr- PURC H	Gr- RCY C	SOC- PER	UN- DEMAN D	UN- SUPPL Y	UN- TEC
ECO-PER	<b>0,892</b>											
ENVR-PER	0,118	<b>0,854</b>										
Gr-DESIGN	0,276	0,145	<b>0,888</b>									
Gr-ENVR	0,353	0,207	0,469	<b>0,828</b>								
Gr-MAR	0,248	0,332	0,522	0,448	<b>0,805</b>							
Gr-PROD	0,276	0,358	0,604	0,453	0,616	<b>0,832</b>						
Gr-PURCH	0,250	0,120	0,422	0,427	0,699	0,519	<b>0,898</b>					
Gr-RCYC	0,129	0,064	0,544	0,638	0,579	0,591	0,641	<b>0,810</b>				
SOC-PER	0,349	0,259	0,488	0,353	0,560	0,595	0,434	0,494	<b>0,750</b>			
UN-DEMAND	-	0,025	-0,110	-0,349	-	0,024	-0,040	-0,115	-0,020	<b>0,852</b>		
UN-SUPPLY	-	0,300	0,252	0,020	0,384	0,414	0,512	0,252	0,357	0,177	<b>0,770</b>	
UN-TEC	0,028	0,120	0,291	0,613	0,327	0,475	0,483	0,218	0,377	0,536	0,053	<b>0,914</b>

Note: Bold and Italics represent the Square-root of AVE

Cross loadings help assess if an item belonging to a particular construct loads strongly onto its own parent construct instead of other constructs in the study.

**Table 5.7 : Discriminant Validity – Cross Loadings**

	ECO- PER	ENVR- PER	Gr- DESIG N	Gr- ENV R	Gr- MAR	Gr- PRO D	Gr- PURC H	Gr- RCY C	SOC- PER	UN- DEMAN D	UN- SUPPL Y	UN- TEC
DU1	-	0,032	-0,139	-0,329	-	0,096	0,016	-0,083	0,004	<b>0,965</b>	0,207	0,052
DU2	0,228	-	0,008	-0,273	0,051	-	-0,174	-0,157	-0,077	<b>0,721</b>	0,032	0,037
EeP1	<b>0,878</b>	0,085	0,353	0,274	0,291	0,343	0,212	0,197	0,318	-0,276	0,059	0,238
EeP2	<b>0,938</b>	0,097	0,278	0,386	0,213	0,226	0,233	0,083	0,360	-0,241	0,031	-
EeP3	<b>0,858</b>	0,138	0,103	0,266	0,166	0,181	0,223	0,077	0,245	-0,027	-0,182	0,137
EnP1	0,054	<b>0,804</b>	-0,061	0,105	0,252	0,229	0,028	-0,030	0,101	-0,021	0,214	0,146
EnP2	0,187	<b>0,919</b>	0,237	0,153	0,296	0,384	0,157	0,088	0,267	0,042	0,328	0,384
EnP3	0,054	<b>0,834</b>	0,197	0,283	0,305	0,301	0,123	0,109	0,301	0,045	0,221	0,205
GrD1	0,167	0,129	<b>0,933</b>	0,428	0,522	0,631	0,387	0,476	0,437	-0,022	0,362	0,590
GrD2	0,385	-0,039	<b>0,826</b>	0,459	0,405	0,373	0,284	0,419	0,415	-0,300	0,065	0,381
GrD3	0,214	0,259	<b>0,901</b>	0,377	0,456	0,577	0,436	0,544	0,449	-0,016	0,214	0,633
GrEm1	0,327	0,177	0,421	<b>0,874</b>	0,469	0,355	0,227	0,476	0,267	-0,286	-0,192	0,373
GrEm2	0,293	0,196	0,387	<b>0,882</b>	0,311	0,380	0,420	0,620	0,363	-0,374	0,106	0,331
GrEm3	0,258	0,129	0,372	<b>0,718</b>	0,352	0,442	0,485	0,491	0,226	-0,151	0,224	-
GrM1	0,128	0,472	0,498	0,418	<b>0,860</b>	0,482	0,610	0,468	0,579	-0,095	0,390	0,423
GrM2	0,280	0,042	0,429	0,282	<b>0,732</b>	0,556	0,461	0,399	0,355	-0,071	0,351	0,231
GrM3	0,238	0,181	0,317	0,360	<b>0,819</b>	0,480	0,604	0,538	0,367	-0,004	0,169	0,468
GrPr1	0,144	0,165	0,604	0,249	0,612	<b>0,799</b>	0,518	0,526	0,518	0,131	0,412	0,484
GrPr2	0,110	0,480	0,468	0,331	0,425	<b>0,819</b>	0,307	0,388	0,474	0,086	0,331	0,399
GrPr3	0,446	0,245	0,430	0,559	0,496	<b>0,876</b>	0,470	0,561	0,490	-0,167	0,286	0,316
GrPu1	0,182	0,144	0,353	0,278	0,586	0,462	<b>0,876</b>	0,533	0,359	-0,071	0,427	0,081
GrPu2	0,220	0,081	0,509	0,526	0,608	0,537	<b>0,907</b>	0,683	0,350	-0,139	0,474	0,209
GrPu3	0,262	0,103	0,284	0,340	0,680	0,407	<b>0,910</b>	0,516	0,451	0,084	0,475	0,276
GrR1	0,027	0,025	0,458	0,294	0,491	0,457	0,490	<b>0,796</b>	0,411	0,090	0,247	0,413
GrR2	0,179	-0,054	0,377	0,688	0,396	0,312	0,421	<b>0,736</b>	0,292	-0,249	0,058	0,166
GrR3	0,133	0,140	0,475	0,634	0,507	0,611	0,620	<b>0,892</b>	0,467	-0,171	0,257	0,299
SU1	-	0,284	0,109	-0,215	0,003	0,193	0,052	0,000	0,038	0,476	<b>0,563</b>	0,095
SU2	0,104	0,013	0,229	0,118	0,451	0,404	0,581	0,297	0,404	0,000	<b>0,932</b>	0,104
SoP1	0,379	0,432	0,177	0,258	0,345	0,198	0,060	0,076	0,431	-0,040	-0,085	0,267
SoP2	0,375	0,187	0,383	0,155	0,435	0,416	0,332	0,460	<b>0,885</b>	-0,009	0,327	0,444
SoP3	0,152	0,135	0,468	0,395	0,486	0,621	0,461	0,450	<b>0,847</b>	-0,012	0,383	0,466
TU1	0,075	0,243	0,503	0,191	0,410	0,393	0,150	0,325	0,456	0,091	0,075	<b>0,902</b>
TU2	0,141	0,286	0,613	0,393	0,456	0,485	0,242	0,363	0,520	0,011	0,146	<b>0,926</b>

The results in Table 5.7 shows that factor loading of all the items is stronger on the underlying construct to which they belong instead of the other construct in the study. Hence, based on the evaluation of cross-loadings, discriminant validity is attained.

#### Heterotrait-Monotrait Ration (HTMT)

HTMT is based on the estimation of the correlation between the constructs. Discriminant validity is established on the HTMT ratio. The HTMT results show Table 5.8 that HTMT ratio for is less than the required threshold of 0.90.

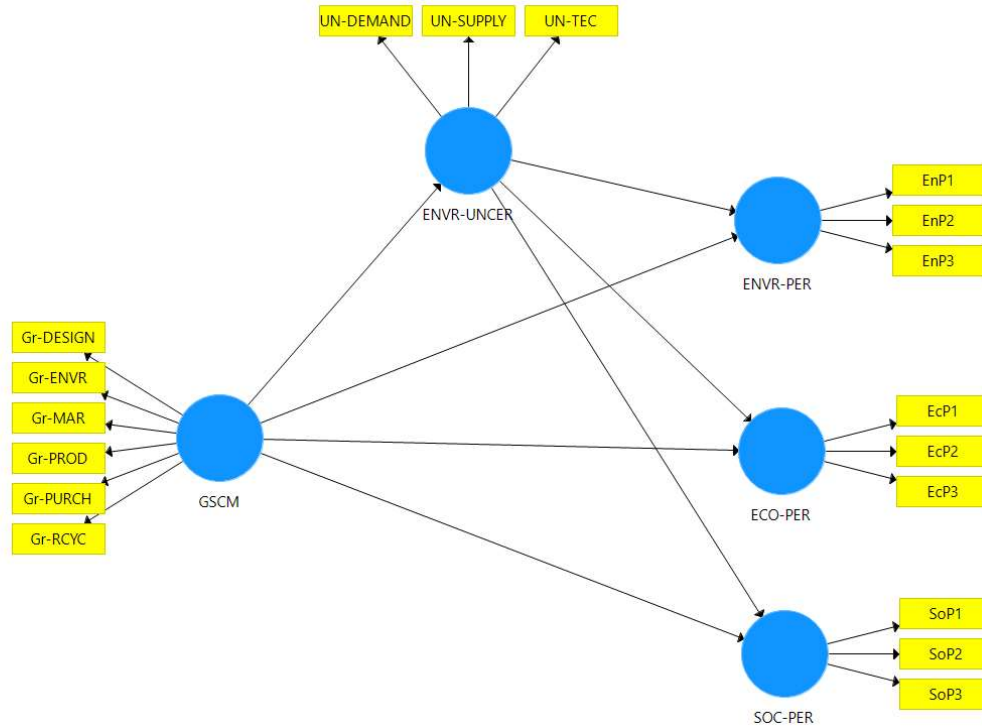
**Table 5.8 : Discriminant Validity – HTMT**

	ECO- -PER	ENVR- -PER	Gr- DESIG N	Gr- ENV R	Gr- MAR	Gr- PRO D	Gr- PURC H	Gr- RCY C	SOC- PER	UN- DEMAN D	UN- SUPPL Y	UN- TEC
ECO-PER												
ENVR- PER	0,139											
Gr- DESIGN	0,329	0,227										
Gr-ENVR	0,415	0,261	0,581									
Gr-MAR	0,337	0,373	0,639	0,586								
Gr-PROD	0,346	0,448	0,722	0,610	0,826							
Gr- PURCH	0,281	0,152	0,481	0,548	0,853	0,631						
Gr-RCYC	0,188	0,171	0,669	0,869	0,773	0,748	0,780					
SOC-PER	0,556	0,498	0,639	0,507	0,804	0,808	0,549	0,648				
UN- DEMAN D	0,254	0,078	0,142	0,449	0,145	0,273	0,207	0,301	0,114			
UN- SUPPLY	0,256	0,596	0,457	0,514	0,614	0,710	0,714	0,466	0,665	0,713		
UN-TEC	0,199	0,353	0,717	0,404	0,599	0,604	0,245	0,465	0,756	0,071	0,234	

#### Forming the Higher-Order Construct

The latent variables of the lower order constructs are copied and pasted into the existing data set as a new indicator variable. Hence, the latent variable of each lower-order construct becomes a new indicator of the higher-order construct. Since the indicators of LOC are reflective, also the new indicator of HOC “GSCM” was designed as reflective. Therefore, the model named as reflective-reflective higher-order construct model and presented in Figure 5.5.

Before starting to analyze the model, the HOC should be validated. These are the second stage of the disjoint two-stage approach. The procedure will be explained in the next sections.



**Figure 5.5 : Second Stage HOC Model**

### Validating Higher-Order Construct

These higher-order constructs are also validated as part of the measurement model assessment. Each of these constructs was assessed for reliability and convergent validity. Furthermore, the higher-order constructs were tested for discriminant validity with other lower-order constructs in the study as recommended by (Sarstedt & Cheah, 2019). The outer loading factors are presented in Table 5.9. Gr-ENVR (0,690), UN-DEMAND (0,047), UN-SUPPLY (0,645) are lower than 0,708.

**Table 5.9 : Outer loadings of HOC, 1st Calculation**

Indicators	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	SOC-PER
Gr-DESIGN				0,768	
Gr-ENVR				0,690	
Gr-MAR				0,833	
Gr-PROD				0,827	
Gr-PURCH				0,775	
Gr-RCYC				0,823	
UN-DEMAND			0,047		
UN-SUPPLY			0,645		
UN-TEC			0,833		

When the construct reliability and convergent validity checked, GSCM is confirmed as a Higher Order Construct, whereas ENVR-UNCER is not Table 5.10. CR and AVE have 0,552 and 0,371, respectively. The problem is clear when Fornell and Larcker

scores are compared, Table 5.11. Therefore, the indicator of UN-DEMAND has been removed and PLS-Algorithm is calculated again.

**Table 5.10 : Higher Order Construct Reliability and Convergent Validity, 1st Calculation**

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
ENVR-UNCER	0,286	0,552	0,371
GSCM	0,878	0,907	0,620

**Table 5.11 : Fornell and Larcker Criterion Higher-Order Discriminant Validity, 1rst Calculation**

	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	SOC-PER
ECO-PER	<b>0,892</b>				
ENVR-PER	0,134	<b>0,851</b>			
ENVR-UNCER	0,108	0,416	<b>0,609</b>		
GSCM	0,329	0,291	0,659	<b>0,787</b>	
SOC-PER	0,344	0,267	0,618	0,634	<b>0,748</b>

In the second calculation, the results for reliability and validity of the higher-order constructs show that both reliability and validity were established. The reliability and convergent validity for all constructs are established as the value for CR 0,715 and AVE 0.560, (Table 5.12). Further to the assessment of reliability and validity, discriminant validity of the higher-order constructs with the lower-order constructs is also assessed. The results of the Fornell and Larcker criterion (Table 5.13) shows that the square root of the AVE of the construct is higher than its correlation with all other constructs. VIF values are under 3, (Table 5.14).

**Table 5.12 : Higher Order Construct Reliability and Convergent Validity, 2nd Calculation**

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
ENVR-UNCER	<b>0,220</b>	0,715	0,560
GSCM	0,878	0,907	0,620

**Table 5.13 : Fornell and Larcker Criterion Higher-Order Discriminant Validity, 2nd Calculation**

	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	SOC-PER
ECO-PER	<b>0,887</b>				
ENVR-PER	0,122	<b>0,851</b>			
ENVR-UNCER	0,132	0,310	<b>0,914</b>		
GSCM	0,367	0,388	0,636	<b>0,715</b>	
SOC-PER	0,295	0,201	0,517	0,603	<b>0,881</b>

HTMT (Table 5.15) is also lower than 0.90 except ENVR-UNCER. Although the higher order construct ENVR-UNCER has a lower Cronbach's Alpha (0,220), higher HTMT value (0,924 – 1,389 – 1,620), the others criteria have been confirmed, and so hence ENVR-UNCER has been confirmed, too.

**Table 5.14 : VIF Statistic of HOC, 2nd Calculation**

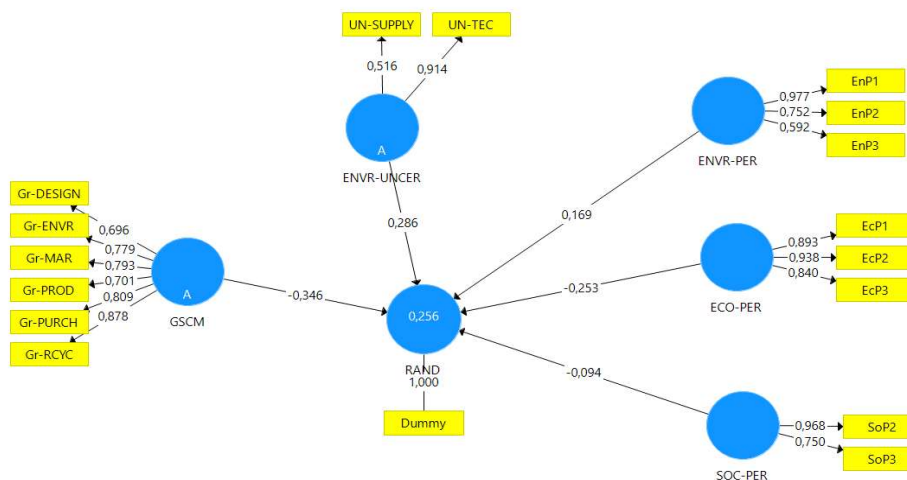
	VIF
Gr-DESIGN	1,806
Gr-ENVR	1,761
Gr-MAR	2,458
Gr-PROD	2,099
Gr-PURCH	2,352
Gr-RCYC	2,624
UN-SUPPLY	1,016
UN-TEC	1,016

**Table 5.15 : HTMT, Higher Order Discriminant Validity 2nd Calculation**

	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	SOC-PER
ECO-PER					
ENVR-PER	0,139				
ENVR-UNCER	0,375	0,924			
GSCM	0,371	0,327	1,389		
SOC-PER	0,556	0,498	1,620	0,806	

### 5.5. Common Method Bias

Common method bias, in the context of PLS-SEM, is a phenomenon that is caused by the measurement method used in an SEM study, and not by the network of causes and effects in the model being studied, (Kock, 2015). He wrote that the occurrence of a VIF greater than 3.3 is proposed as an indication of pathological collinearity, and also as an indication that a model may be contaminated by common method bias. Therefore, if all VIFs resulting from a full collinearity test are equal to or lower than 3.3, the model can be considered free of common method bias.



**Figure 5.6 : Revised Model to test Common Method Bias**

The authors created a dummy variable using random function in excel and added it as a dependent latent variable into the existing model, while all others construct became independent variables. The revised model presented in Figure 5.6. After calculation

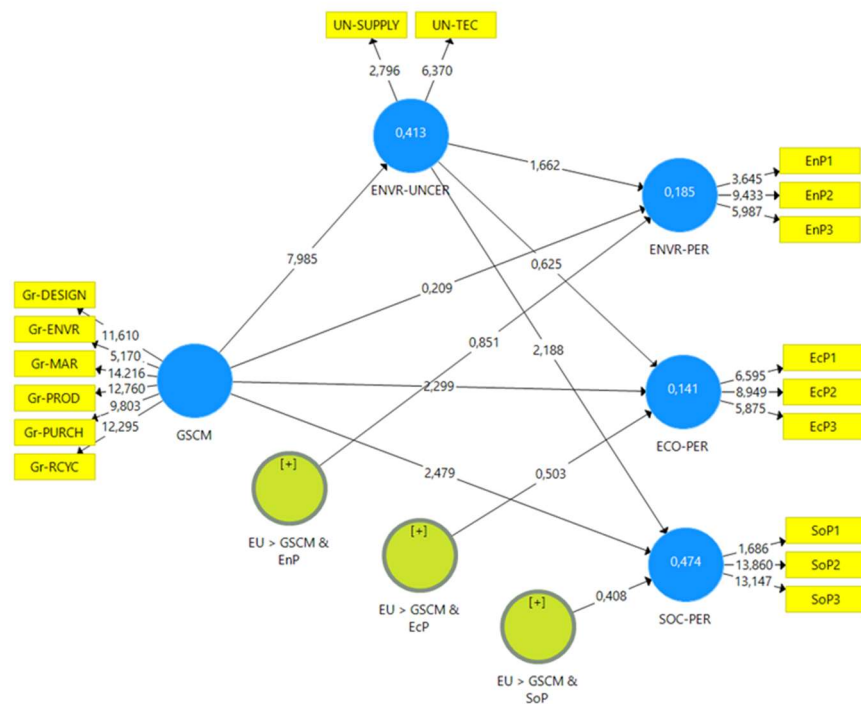
PLS algorithm, the inner VIF values are presented in below. As seen all values in Table 5.6 are below 3.3 threshold that states there is no common method bias in the model. As a supplementary information, the inner VIF values of first-degree and second-degree model is given in the Appendix E, where all values are lower than the threshold 3.3.

**Table 5.16 : Inner VIF Values**

	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	RAND
ECO-PER					1,240
ENVR-PER					1,101
ENVR-UNCER					1,969
GSCM					1,665
RAND					
SOC-PER					1,824

## 5.6. Structural Model Assessment

The final step in structural equation modeling is the assessment of the hypothesized relationship to substantiate the proposed hypotheses. The final model presented in Figure 5.7.



**Figure 5.7 : Structural Model including moderator effect**

Moderator variable are defined in the model according to the hypotheses. To get the result, bootstrapping algorithm is calculated in Smart-PLS. The subsamples number fixed at 5.000 with 5% confidence interval. In addition, the moderator construct also

nominated and taken into account in the structural model assessment, the final model for the bootstrapping procedure is given in Figure 5.7. The results are examined in the next section.

## 5.7. Hypothesis Testing

### Direct Effect

H<sub>1</sub>: Each of the green supply chain management practices has a positive impact on environmental performance

H<sub>1</sub> evaluates whether GSCM has a positive impact on ENVR-PER. The results revealed that GSCM has an insignificant effect on ENVR-PER ( $\beta=0,049$ ,  $t=0,309$ ,  $p=0,835$ ). Hence H<sub>1</sub> was not accepted.

H<sub>2</sub>: Each of the green supply chain management practices has a positive impact on economic performance.

H<sub>2</sub> evaluates whether GSCM has a positive impact on ECO-PER. The results revealed that GSCM has an insignificant effect on ECO-PER ( $\beta=0,459$ ,  $t=2,299$ ,  $p=0,022$ ). Hence H<sub>2</sub> was accepted.

H<sub>3</sub>: Each of the green supply chain management practices has a positive impact on social performance.

H<sub>3</sub> evaluates whether GSCM has a positive impact on SOC-PER. The results revealed that GSCM has a significant effect on SOC-PER ( $\beta=0,409$ ,  $t=2,479$ ,  $p=0,013$ ). Hence H<sub>3</sub> was accepted.

The results are summarized in Table 5.17 below.

**Table 5.17 : Direct Relationships Results**

Hypothesis	$\beta$	2.5%	97.5%	T Statistics	P Values	Result
H1 : GSCM -> ENVR-PER	0,049	-0,392	0,535	0,309	0,835	Insignificant
H2 : GSCM -> ECO-PER	0,459	0,012	0,814	2,299	0,022	Significant
H3 : GSCM -> SOC-PER	0,409	0,050	0,708	2,479	0,013	Significant

### Moderating Effect

Moderator analysis is performed to assess the moderating role of ENVR-UNCER. The hypotheses are as follows;

H<sub>4</sub>: Environmental uncertainty has a moderating effect between green supply chain management practices and sustainability performance. H<sub>4a</sub> evaluates whether ENVR-UNCER has a positive impact on the relationship between GSCM and ENR-PER. The results revealed that ENVR-UNCER has an insignificant effect on GSCM and ENVR-PER relationship ( $\beta=0,120$ ,  $t=0,851$ ,  $p= 0,395$ . Hence H<sub>4a</sub> was not accepted.

H<sub>4b</sub> evaluates whether ENVR-UNCER has a positive impact on the relationship between GSCM and ECO-PER. The results revealed that ENVR-UNCER has a (in) significant effect on GSCM and ECO-PER relationship ( $\beta= -0,092$ ,  $t=0,503$ ,  $p=0,615$ . Hence H<sub>4b</sub> was not accepted.

H<sub>4c</sub> evaluates whether ENVR-UNCER has a positive impact on the relationship between GSCM and SOC-PER. The results revealed that ENVR-UNCER has a (in) significant effect on GSCM and SOC-PER relationship ( $\beta=-0,049$ ,  $t=0,408$ ,  $p=0,683$ . Hence H<sub>4c</sub> was not accepted. The results are presented in Table 5.18.

**Table 5.18 : Moderator effects**

	Coefficient	T Statistics	P Values
H4a ENVR-UNCER -> GSCM & ENVR-PER	0,120	0,851	0,395
H4b ENVR-UNCER -> GSCM & ECO-PER	-0,092	0,503	0,615
H4c ENVR-UNCER -> GSCM & SOC-PER	-0,049	0,408	0,683

#### Mediating effect

Mediation analysis is performed to assess the mediating role of ENVR-UNCER. The hypotheses are as follows;

H<sub>5a</sub>: Environmental uncertainty mediates the relationship between GSCM practices and environmental performance.

H<sub>5b</sub>: Environmental uncertainty mediates the relationship between GSCM practices and economic performance.

H<sub>5c</sub>: Environmental uncertainty mediates the relationship between GSCM practices and social performance.

Table 5.19 shows that GSCM has a direct effect on ENVR-UNCER.

**Table 5.19 : Direct effects of GSCM on ENVR-UNCER**

Hypothesis	$\beta$	2.5%	97.5%	T Statistics	P Values	Result
GSCM -> ENVR-UNCER	0,643	0,492	0,809	7,985	0,000	Significant

The results (Table 5.20, Table 5.21, Table 5.22) revealed that ENVR-UNCER has an effect on SOC-PER but no effect on ENVR-PER and ECO-PER.

**Table 5.20 : Mediation Result 1**

Total effect (GSCM > ENVR-PER)		Direct effect (GSCM > ENVR- PER)		Indirect effects of GSCM on ENVR-PER			
Coefficient	p-value	Coefficient	p-value	Coefficient	T-value	p-value	
0,283	0,063	0,049	0,835	GSCM > EU > ENVR-PER	0,234	1,498	0,134

Neither direct effect between GSCM > ENVR-PER nor indirect effect between GSCM > EU > ENVR-PER is significant. This is no-effect nonmediation.

**Table 5.21 : Mediation Result 2**

Total effect (GSCM > ECO-PER)		Direct effect (GSCM > ECO-PER)		Indirect effects of GSCM on ECO-PER			
Coefficient	p-value	Coefficient	p-value	Coefficient	T-value	p-value	
0,335	0,043	0,459	0,022	GSCM > EU > ECO-PER	-0,124	0,589	0,556

The direct effect between GSCM>ECO-PER is significant but the indirect effect between GSCM>EU>ECO-PER is not significant. This is direct-only nonmediation.

**Table 5.22 : Mediation Result 3**

Total effect (GSCM > SOC-PER)		Direct effect (GSCM > SOC-PER)		Indirect effects of GSCM on SOC-PER			
Coefficient	p-value	Coefficient	p-value	Coefficient	T-value	p-value	
0,638	0,000	0,409	0,013	GSCM > EU > SOC-PER	0,229	2,098	0,036

The direct effect between GSCM and SOC-PER and the indirect effect between GSCM>EU>SOC-PER both are significant and point in the same direction. There is complementary mediation.

#### Other Criteria

After Blindfolding, D=7 the  $Q^2$  values are > 0 and indicate that GSCM (exogenous construct) has predictive relevance for the ENVR-PER, ECO-PER and SOC-PER (endogenous construct). Results are presented in Table 5.23.

**Table 5.23 :  $Q^2$ ,  $R^2$  and  $f^2$**

Construct	$Q^2$	$R^2$	$f^2$
ECO-PER	0,049	0,141 (weak)	0,143 (medium)
ENVR-PER	0,058	0,185 (weak)	0,002 (small)
ENVR-UNCER	0,202	0,413 (moderate)	0,704 (large)
SOC-PER	0,170	0,474 (moderate)	0,186 (medium)

## 5.8. Summary of Analysis and Results

The software SmartPLS allows to complex model, however the number of relationship is high in the proposed model in Figure 5.3 and 5.4. To make model more parsimonious and simple, authors preferred to form a hierarchical-order model, and ease the calculation and simplify the research model. The disjoint two-stage approach is implemented. Green design, green purchasing, green production, green marketing, environmental management, and recycling formed the higher-order construct named GSCM. Demand uncertainty, technology uncertainty, and supply uncertainty develop the Environmental Uncertainty, the second higher-order construct.

During the assessment of the measurement model, the indicator of supply uncertainty was found insignificant and omitted from the model. All GSCM practices indicators were found significant and kept in the model. Then, the hypothesizes were updated according to the structural model; because of the limitation of sample size, each GSCM practice became an indicator variable of the higher-order latent variable of GSCM that replaced the GSCM practices in the hypothesize. Similarly, the higher-order latent variable of Environmental Uncertainty replaced demand uncertainty and technology uncertainty. After bootstrapping procedure, the structural model was assessed. The summary of the hypothesis and results are in Table 5.24.

First of all, all GSCM practices indicators were found significant. But, GSCM practices were found to impact positively economic and social performance. Surprisingly, the relationship between GSCM practices and environmental performance was insignificant. The reason may be the shipyards do not recognize the environmental issues regarding the GSCM practices. The executives may see the GSCM practices as a requirement of the customers, a necessity of a certificate or classification institution, and a tool for competitive advantage.

The environmental uncertainty did not have a moderator effect on the relationship between GSCM practices and sustainability performances. Since this moderator effect is not present, the strength of the relationship between GSCM practices and sustainability performance is assumed to be constant. This result seems normal since the moderator effect can (and should) be seen as a means to account for heterogeneity in the data, (Sarstedt & Cheah, 2019). Çankaya (2015) stated there is no moderator

effect of environmental uncertainty on the relationship between GSCM practices and sustainability performance, too.

The mediation effects exist only in the relationship between GSCM practices and social performance. The relation represents a complementary mediation. The relation between GSCM and environmental performance is a non-effect nonmediation and, with economic performance a direct-effect nonmediation.

**Table 5.24 : Hypotheses and Results**

	Hypothesis	Result
H1	GSCM practices have a positive impact on environmental performance.	Rejected
H2	GSCM practices have a positive impact on economic performance.	Accepted
H3	GSCM practices have a positive impact on social performance.	Accepted
H4a	Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.	Rejected
H4b	Environmental uncertainty has a moderating effect between GSCM practices and economic performance.	Rejected
H4c	Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.	Rejected
H5a	Environmental uncertainty mediates the relationship between GSCM practices and environmental performance.	Rejected
H5b	Environmental uncertainty mediates the relationship between GSCM practices and economic performance.	Rejected
H5c	Environmental uncertainty mediates the relationship between GSCM practices and social performance.	Accepted

## 6. CONCLUSIONS AND RECOMMENDATIONS

This study examined the impact of green supply chain management practices on three sustainability performance dimensions, environmental, economic, and social performance, by conducting a case study in Turkish shipyards. In this context, the objectives to be achieved are stated below.

- Determining which green supply chain management practices are applicable in shipyards
- To investigate the impact of green supply chain management practices on the sustainability performance of shipyards.
- To investigate the moderator effect of environmental uncertainty on the relationship between green supply chain and sustainability performance.
- To investigate the mediator effect of environmental uncertainty between green supply chain and sustainability performance.
- The penetration level of green supply chain management practices on the Turkish shipyards.

This study will contribute essentially to the literature where few studies about shipyards' sustainability exist. Caniels et al. (2016) examined the relations of green supply chain readiness, customer requirements, governmental involvement, social responsibility, and competitive advantage to the willingness of two big Dutch shipyards to participate in green supply chain management initiatives with their suppliers. In a different study, Wang et al. (2020) examined which sustainable development goals correlate with the maritime industry based on publicly published corporate social responsibility and sustainable development reports. Neither study focused on green supply chain practices as a performance evaluation method for the three sustainable dimensions nor used shipyards as a research sample.

Shipyards operate in an international and highly competitive market. To keep their current market share and penetrate new markets, they should adopt new approaches, update marketing strategies, and invest in new technologies and innovations.

Shipyards can create and implement plans by implementing GSCM practices and meet their economic, environmental, and social performance goals, in other words, sustainability performance goals.

Turkish shipyards have basic knowledge about sustainability, mainly about the environmental dimension. This is a constraint and also a challenge to develop for the shipyards. As a result, there is a gap in the sustainability performance of Turkish shipyards. Therefore, this study will fill this gap by focusing on the GSCM practices and their impacts on the shipyards' economic, environmental, and social performance. The result will contribute to the emerging literature on shipyard sustainability by increasing awareness of sustainability issues and opportunities among shipyard executives.

The authors studied the GSCM practices and sustainability conceptually. The systematic literature review revealed a lack of study in this area. The shipyards started to emphasize sustainability, sustainable development goals, but the impact of GSCM practices is unclear. Although several studies in Turkey focused on the effects of GSCM practices on the company's sustainability performance in different sectors like automotive, chemical, packaging, and electronics companies, this study is the first study for the shipbuilding industry. The survey scale is developed regarding several scales in different doctoral thesis applied in Turkey. The survey methodology is selected as web-based because of the pandemic conditions and completed in three months. The primary constraint of the study is the sample size. Since they are limited to only 56 shipyards, the main concern was not having sufficient survey responses for a significant statistical result. PLS-SEM modeling got involved in the analysis phase to overcome the sample size problem. This modeling provides statistically significant results for small sample sizes and non-conformity distributed sample data.

In the analysis phase, the authors preferred to form a hierarchical-order model, and ease the calculation and simplify the research model. The disjoint two-stage approach is implemented. Green design, green purchasing, green production, green marketing, environmental management, and recycling formed the higher-order construct named GSCM. Demand uncertainty, technology uncertainty, and supply uncertainty develop the Environmental Uncertainty, the second higher-order construct.

During the assessment of the measurement model, the indicator of supply uncertainty was found insignificant and omitted from the model. All GSCM practices indicators were found significant and kept in the model. Then, the hypothesizes were updated according to the structural model; because of the limitation of sample size, each GSCM practice became an indicator variable of the higher-order latent variable of GSCM that replaced the GSCM practices in the hypothesize. Similarly, the higher-order latent variable of Environmental Uncertainty replaced demand uncertainty and technology uncertainty. After bootstrapping procedure, the structural model was assessed. The summary of the hypothesis and results are in Table 6.1.

First of all, all GSCM practices indicators were found significant. But, GSCM practices were found to impact positively economic and social performance. Surprisingly, the relationship between GSCM practices and environmental performance was insignificant. The reason may be the shipyards do not recognize the environmental issues regarding the GSCM practices. The executives may see the GSCM practices as a requirement of the customers, a necessity of a certificate or classification institution, and a tool for competitive advantage.

**Table 6.1 : Hypotheses and Results**

	Hypothesis	Result
H1	GSCM practices have a positive impact on environmental performance.	Rejected
H2	GSCM practices have a positive impact on economic performance.	Accepted
H3	GSCM practices have a positive impact on social performance.	Accepted
H4a	Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.	Rejected
H4b	Environmental uncertainty has a moderating effect between GSCM practices and economic performance.	Rejected
H4c	Environmental uncertainty has a moderating effect between GSCM practices and environmental performance.	Rejected
H5a	Environmental uncertainty mediates the relationship between GSCM practices and environmental performance.	Rejected
H5b	Environmental uncertainty mediates the relationship between GSCM practices and economic performance.	Rejected
H5c	Environmental uncertainty mediates the relationship between GSCM practices and social performance.	Accepted

The environmental uncertainty did not have a moderator effect on the relationship between GSCM practices and sustainability performances. Since this moderator effect is not present, the strength of the relationship between GSCM practices and sustainability performance is assumed to be constant. This result seems normal since the moderator effect can (and should) be seen as a means to account for heterogeneity in the data, (Sarstedt & Cheah, 2019). Çankaya (2015) stated there is no moderator

effect of environmental uncertainty on the relationship between GSCM practices and sustainability performance, too.

The mediation effects exist only in the relationship between GSCM practices and social performance. The relation represents a complementary mediation. The relation between GSCM and environmental performance is a non-effect nonmediation and, with economic performance a direct-effect nonmediation.

Çankaya (2015) found that GSCM practices had a significant relationship with environmental, economic, and social performance in her study. With no sample size constraint, she statistically analyzed each GSCM practice with each sustainability performance. GSCM practices; green purchasing, green packaging and transportation, green marketing, green purchasing, environmental training, environmental management, and recycling were included in the research model. The moderator effect of environmental uncertainty was insignificant in the relationship between GSCM practices and sustainability dimensions. However, the mediation effect of the environmental uncertainty was not analyzed. She proposed that managers see environmental awareness activities as a competitive advantage rather than a cost item or threat. Secondly, since the companies' internal activity about GSCM is not sufficient, they need to establish closer relations with their suppliers and include environmental issues in their strategies. Executives should make an accurate cost-benefit analysis because implementing any GSCM practices has positive and negative consequences. Research and development activities should be supported. She concluded that GSCM is necessary for sustainable development and an effective tool. It provides a competitive advantage to the business and leads to cost savings in some items. Dizaji (2017) stated that there is a significant relationship between the green marketing mix, green supply chain, green innovation, green and food industry performance. There is no significant relation between green brand and the food industry performance. Neither moderation nor mediation effect of environmental uncertainty was in the research model.

Green et al. (2012) concluded that green purchasing impacts directly and positively economic performance but does not impact environmental performance. On the other hand, eco-design impacts environmental performance directly and positively but does not significantly impact economic performance. Karabulut (2003) presented that green management practices such as production activities, human resource activities,

marketing activities, accounting and finance activities, and research and development activities were found positively significant on the company success indicators.

The authors proposed several research themes for further study. First, a similar approach and research model may apply to the supplier companies in the sub-industry. The shipyards are operating within a substantial network of suppliers. This network includes not the local companies but also international companies. The regulations and standards applied in the shipyards are gradually transferring to their suppliers through technical specifications and quality standards. Therefore, sub-industry companies should consider sustainability and GSCM practices for satisfying their customers and other stakeholders. The study can also extend to the ship-breaking yards in Turkey, Bangladesh, or China. One similar study may be in another developing country like Poland, the Philippines, or Vietnam, and compare with the result in Turkish shipyards.

Many international companies, including shipyards, started to publish yearly sustainability reports. One research theme may propose a standardized framework for small and medium-sized shipyards. The framework should converge on sustainable development goals, dimensions, and GSCM practices, determining sustainable development indicators for the Turkish shipyards.

The innovation of green technologies and new standards for sustainability provides an opportunity and threat to shipyards. In addition, the increasing competition creates pressure on small and medium-sized companies. The shipbuilding industry is still a labor-intensive and capital-intensive production industry. Therefore, it is an important sector in developing countries. Japan, China, and South Korea donated many privileges and incentives to their shipbuilding industry, and they are currently the big three shipbuilding countries. This created unequal competition in the market caused to shift of new-build order to those countries. Other countries switched to niche and customized products like fishing boats, mid-sized chemical tankers, ferries, and cruise ships.

In conclusion, environmental, social, and economic concerns are growing globally. The study stated that GSCM practices have a significant effect on the economic and social performance of the company. External and internal stakeholders have essential roles in the sustainable development of shipyards. Shipyards can reach sustainability objectives by implementing GSCM practices. The implementation should be

supported by creating corporate culture. This would not be possible without an effective management system to organize the development and implementation phase and coordinate the whole supply chain with other stakeholders and customers with the entire supply chain.



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## **APPENDICES**

**APPENDIX A:** Survey (Turkish, Original)

**APPENDIX B:** Survey (English, Translation)

**APPENDIX C:** Reference of the Survey Questions

**APPENDIX D:** Sampling group

**APPENDIX E:** VIF values





## APPENDIX A: Survey (Turkish, Original)

Sayın Yönetici ;

Bu anket formu, İstanbul Teknik Üniversitesi, Lisansüstü Eğitim Enstitüsü, İşletme Mühendisliği programında yürütülmekte olan “Türkiye Tersanelerinde Sürdürülebilirlik Konsepti” isimli araştırmanın uygulama bölümünü kapsamaktadır. Bu araştırma tamamen akademik bir amaca yöneliktir. GİSBİR yönetimi üyelerine uygulanmasına onay vermiştir. Anketin sonuçlarından Türkiye tersanelerinde sürdürülebilirliğin ekonomik, sosyal ve çevre boyutları hakkında farkındalığın ilerlemesine ve yeşil tedarik zinciri uygulamaların gelişmesine katkıda bulunacağına inanıyoruz. Aynı zamanda global ticaret ortamında rekabetçi üstünlük sağlayacak bilgiler edinilmesini amaçlıyoruz. Bu doğrultuda ankete ayırdığınız vakit ve değerli katkılarınız için çok teşekkür eder, saygılarımızı sunarız.

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## DEMOGRAFIK SORULAR

Firma hakkında genel bilgi

1-Firmanızın adı: \_\_\_\_\_

2-Lütfen firmanızdaki ortalama çalışan sayısını (kadrolu/alt işveren) belirtiniz: \_\_\_\_\_ / \_\_\_\_\_

3-Lütfen firmanızın kuruluş yılını belirtiniz: \_\_\_\_\_

4-Lütfen firmanın üretim yaptığı başlıca gemi tiplerini belirtiniz; \_\_\_\_\_

5-Lütfen firmanızın sahip olduğu kalite ve çevre belgelerini seçiniz;

ISO 9001       ISO 14001       ISO 45001

6-Çevreyle ilgili faaliyetlerden sorumlu bir departmanınız var mı ?

Evet                                       Hayır

7-Evet ise, lütfen çevreyle ilgili faaliyetlerden hangi departmanın sorumlu olduğunu ve bu departmanda kaç kişinin çalıştığını belirtiniz.

Departmanın Adı \_\_\_\_\_

Çalışan Sayısı \_\_\_\_\_

8-Lütfen firmanızın bulunduğu bölgeyi (ilçe/il) belirtiniz \_\_\_\_\_

9-Lütfen çalıştığınız departmanı belirtiniz \_\_\_\_\_

Lütfen anketi cevaplarırken, aşağıdaki numaralandırmayı gözönünde bulunduralım.

1- Kesinlikle Katılmıyorum 2- Katılmıyorum 3- Kararsızım 4- Katılıyorum 5- Kesinlikle Katılıyorum

### YEŞİL TEDARİK ZİNCİRİ UYGULAMALARI

<b>Yeşil Tasarım</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Tasarım aşamasında eskiye nazaran daha çevreci malzeme ve sistemler kullanırız					
2. Eskiye nazaran daha az enerji tüketen sistemler / ürünler tasarlarız					
3. Eskiye nazaran daha az atık verecek şekilde sistemler / ürünler tasarlarız					

<b>Yeşil Satınalma</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Satın aldığımız girdiler için tedarikçilerimizden istediğimiz şartnamelerde doğal çevreyi koruma ile ilgili taleplerimiz de bulunmaktadır					
2. Tedarikçilerin değerlendirilmesinde çevresel kriterleri de kullanırız					
3. Tedarikçiler ile doğal çevreyi koruma ile ilgili hedefler için işbirliği yaparız					

<b>Yeşil Üretim</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Üretim sürecinde israf, atık ve gürültü kirliliğinin en aza indirilmesi için faaliyetlerde bulunuruz					
2. Doğaya ve insan sağlığına zararlı ürünler ve üretim süreçlerinin kullanımı azaltılmakta ya da terk edilmektedir					
3. Üretim faaliyetlerimizde geri dönüşebilen ham maddeler kullanmaya dikkat ederiz.					

1- Kesinlikle Katılmıyorum 2- Katılmıyorum 3- Kararsızım 4- Katılıyorum 5- Kesinlikle Katılıyorum

<b>Yeşil Pazarlama</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Kendi ürettiğimiz ürünlerin teknik şartnamelerinde çevresel kriterler de bulunmaktadır					
2. Müşteri talepleri firmamızın yeşil politikasını olumlu etkilemektedir					
3. Tanıtım faaliyetlerimizde ürünlerimizin çevreci yönleri ön plana çıkartılmaktadır.					

<b>Çevre Yönetimi</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Firmamızda etkin bir çevre yönetim sistemi oluşturulmuştur					
2. Geri dönüşüm, zararlı emisyonların azaltılması ve enerji tasarrufu üzerine çevre performans endeksi oluşturulmaktadır					
3. Firma içinde personele düzenli çevreyle ilgili eğitimler düzenlenmektedir					

<b>Geri Dönüşüm</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Hurda ve kullanılmış malzeme/araç gereçler satılarak değerlendirilmektedir					
2. Kullanılmış ve arızalı ürünler için bir geri dönüşüm sistemi oluşturulmuştur					
3. Kullanılacak malzemelerin geri dönüşümün olmasına dikkat ederiz					

1- Kesinlikle Katılmıyorum 2- Katılmıyorum 3- Kararsızım 4- Katılıyorum 5- Kesinlikle Katılıyorum

### ÇEVRESEL BELİRSİZLİK

<b>Arz Belirsizliği</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Ürünlerimize olan talep genellikle çok değişkendir					
2. Müşteriler her yeni üründe farklı özellikler isterler					

<b>Teknoloji Belirsizliği</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Yeşil teknolojinin gelişimini öngörebiliyoruz					
2. Rakiplerin yeni ürün/hizmet sunumunu öngörebiliyoruz					

<b>Tedarik Belirsizliği</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Tedarikçilerimizin performansının tahmin edilmesi zordur.					
2. Tedarikçiler istenilen kalitede ve termin süresinde ürün/hizmet sunarlar					

1- Kesinlikle Katılmıyorum 2- Katılmıyorum 3- Kararsızım 4- Katılıyorum 5- Kesinlikle Katılıyorum

## SÜRDÜREBİLİRLİK PERFORMANSI

<b>Çevresel Performans</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Tehlikeli ve zararlı malzeme tüketimi azalmıştır					
2. Kirlilik (pis su ve katı atık atılımı, gürültü salınımı) azalmıştır					
3. Çevre kazaları azalmıştır					

<b>Ekonomik Performans</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Gelir ve karlılık artmıştır					
2. Enerji tüketim maliyeti azalmıştır					
3. Atık elden çıkarılması ve arıtma maliyetleri azalmıştır					

<b>Sosyal Performans</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. İş kazaları ve işten kaynaklanan hastalıklar azalmıştır					
2. Tüm paydaşların (çalışanlar, ortaklar, müşteri ve tedarikçiler vb.) refahında artış yaşanmıştır					
3. Sosyal ve çevre projelerine yapılan yatırımlar artmıştır					

**APPENDIX B: Survey (English, Translation)**

Dear Director;

This questionnaire covers the application part of the research titled “The Concept of Sustainability in Turkish Shipyards”, which is being carried out in the Management Engineering program of Istanbul Technical University. This research is purely for academic purposes. GISBIR management has approved its application to its members. We believe that the results of the survey will contribute to the advancement of awareness about the economic, social, and environmental dimensions of sustainability and the development of green supply chain practices in Turkish shipyards. At the same time, we aim to obtain information that will provide a competitive advantage in the global trade environment.

In this direction, we thank you very much for your time and valuable contributions to the survey, and we present our respects.

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Please consider the following numbering when answering the questionnaire.

1- Strongly Disagree 2- Disagree 3- Undecided 4- Agree 5- Strongly Agree

**GREEN SUPPLY CHAIN APPLICATIONS**

<b>Green Design</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. We use more environmentally friendly materials and systems in the design phase than before					
2. We design systems/products those will consume less energy than before					
3. We design systems/products to generate less waste than before					

<b>Green Purchasing</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. The technical specifications for the inputs those demanded from suppliers contain the request for the environmental protection					
2. We also use environmental criteria in evaluating suppliers					
3. We cooperate with suppliers for goals related to protecting the natural environment.					

<b>Green Production</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. We take action to minimize wastage, waste, and noise pollution in the production process.					
2. The use of products and production processes that are harmful to nature and human health is reduced or abandoned.					
3. We pay attention to using recyclable raw materials in our production activities.					

1- Strongly Disagree 2- Disagree 3- Undecided 4- Agree 5- Strongly Agree

<b>Green Marketing</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. There are also environmental criteria in the technical specifications of the products we produce.					
2. Customer demands positively affect our company's green policy.					
3. In our promotional activities, the environmental aspects of our products are highlighted.					

<b>Environmental Management</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. An effective environmental management system has been established in our company.					
2. An environmental performance index is created on recycling, reduction of harmful emissions, and energy saving.					
3. Regular environmental training is organized for the personnel within the company.					

<b>Recycling</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Scrap and used materials/tools are sold and evaluated.					
2. A recycling system has been established for used and defective products					
3. We pay attention to the recycling of the materials to be used					

1- Strongly Disagree 2- Disagree 3- Undecided 4- Agree 5- Strongly Agree

### ENVIRONMENTAL UNCERTAINTY

<b>Demand Uncertainty</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Demand for our products is often very volatile					
2. Customers want different features for each new product					

<b>Technological Uncertainty</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. We can foresee the development of green technology.					
2. We can anticipate new product/service offerings from competitors					

<b>Supply Uncertainty</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. The performance of our suppliers is difficult to predict.					
2. Suppliers offer products/services of desired quality and delivery time.					

1- Strongly Disagree 2- Disagree 3- Undecided 4- Agree 5- Strongly Agree

**SUSTAINABILITY PERFORMANCE**

<b>Environmental Performance</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Hazardous and harmful material consumption is reduced.					
2. Pollution (wastewater and solid waste disposal, noise emission) decreased					
3. Environmental accidents have decreased					

<b>Economic Performance</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Revenue and profitability increased.					
2. Energy consumption cost decreased					
3. Waste disposal and treatment costs reduced					

<b>Social Performance</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. Work accidents and work-related diseases have decreased					
2. There has been an increase in the welfare of all stakeholders (employees, partners, customers, and suppliers, etc.)					
3. Investments in social and environmental projects have increased					

## APPENDIX C Reference of the Survey Questions

### Reference of Green Design Questions

(Çankaya, 2015)

Eko-ürün yeniliği
İşletmenizin son 3 yıl içerisinde aşağıdaki faaliyetleri hangi düzeyde gerçekleştirdiğini düşünmektесiniz
1 Kullanılan hammadde, malzeme ve ambalaj miktarını azaltmak için yeni çevreci ürünler geliştirmeye çalışmaktadır.
3 Tehlikeli hammadde, malzeme ve ambalaj kullanımını önlemek için yeni çevreci ürünler geliştirmeye çalışmaktadır.
4 Mümkün olduğunca atıkları azaltabilmek için yeni çevreci ürünler geliştirmeye çalışmaktadır.
5 Mümkün olduğunca atıkların neden olduğu zararları azaltmak için yeni çevreci ürünler geliştirmeye çalışmaktadır
6 Mümkün olduğunca daha az enerji (su, elektrik, doğalgaz) kullanmak için yeni çevreci ürünler geliştirmeye çalışmaktadır.

(Dizaji, 2017)

Yeşil inovasyon
15. Ürünlerin veya hizmetlerin materyal ihtiyacını azaltmayı düşünüyoruz.
16. Ürünlerin veya hizmetlerin enerji yoğunluğu azaltmayı düşünüyoruz.
17. Ürünlerimizdeki zehirleyici maddeleri azaltmayı düşünüyoruz.

(S. J. Lee et al., 2014)

### Table Design requirements for a sustainable maritime supply chain

Notations	Design requirements
DR1 ISCW	Integrated Supply Chain Workflow
DR2 CS	Cooperation with Shippers
DR3 CST	Cooperation with Seaports and Terminals
DR4 ORS	Optimal Routing and Scheduling
DR5 GDS	Use of Green Design Ships, Engines, and Machinery
DR6 LSRE	Use of Low Sulphur Fuel and Renewable Energy
DR7 BWT	Ballast Water Treatment and Residue/Waste Control
DR8 PMA	Preventive Measures for Accidents

(Green et al., 2012)

### Eco-design

Please indicate the extent to which you perceive that your plant is implementing each of the following. (Five-point scale: 1 ¼ not considering it; 2 ¼ planning to consider it; 3 ¼ considering it currently; 4 ¼ initiating implementation; 5 ¼ implementing successfully).

- Design of products for reduced consumption of material/ energy.
- Design of products for reuse, recycle, recovery of material and/or component parts.
- Design of products to avoid or reduce use of hazardous products and/or their manufacturing process.

### Reference of Green Purchasing Questions

(Çankaya, 2015)

- 1 Tedarikçilerimize satın alınan ürünler için çevresel talepleri içeren tasarım şartnamesi sunarız.
- 2 Çevresel hedeflerin başarılması için tedarikçilerimiz ile işbirliği yaparız.
- 3 Tedarikçiler çevresel hedeflerimizi destekleme yetenekleri dikkate alınarak seçilmektedir.

(Green et al., 2012)

Please indicate the extent to which you perceive that your plant is implementing each of the following. (Five-point scale: 1 =not considering it; 2 ¼ planning to consider it; 3 ¼ considering it currently; 4 ¼ initiating implementation; 5 ¼ implementing successfully).

- Eco labeling of products.
- Cooperation with suppliers for environmental objectives.
- Environmental audit of suppliers' internal management.
- Suppliers' ISO 14000 certification.
- Second-tier supplier environmentally friendly practice evaluation.
- Providing design specification to suppliers that include environmental requirements for the purchased item

### Reference of Green Production Questions

(Çankaya, 2015)

- 1 Üretim sürecinde gürültü kirliliğinin en aza indirilmesi için faaliyetlerde bulunuruz
- 2 Doğaya ve insan sağlığına zararlı ürünler ve üretim süreçlerinin kullanımı azaltılmakta ya da terk edilmektedir.
- 4 Üretim faaliyetlerimizde, atıkların azaltılması ve israfın önlenmesine odaklanıyoruz.

(Dizaji, 2017)

7. Üretim süreçlerimizde geri dönüştürülmüş maddelerin kullanılması maliyetleri düşürdüğü için daha fazla tercih etmekteyiz

(Islam et al., 2017)

Green manufacturing

41. Generate minimum waste, and reduce environmental pollution.
42. Re-manufacturing and lean production
43. Cleaner production
44. Improved capacity utilization
45. Lower raw material costs, gain production efficiency, and improve their corporate image
46. Increase amount of goods delivered on time
47. Does not use hazardous or restricted materials during manufacturing and minimize waste during production

#### **Reference of Green Marketing Questions**

(Çankaya, 2015)

- 1 Çevresel faaliyetlerle ilgili müşterilere/kamuoyuna düzenli bilgi akışı sağlanmaktadır
- 2 Çevreyle ilgili etkinliklerde sponsorluk yapılmaktadır
- 3 Ürün tanıtım faaliyetlerinde ürünlerimizin çevreci yönleri ön plana çıkartılmaktadır.
- 4 Çevresel konularla ilgili yaptığımız gelişmeler web sitemizde periyodik olarak güncellenmektedir.
- 5 Ürün etiketlerinde geri dönüşümle ilgili bilgiler yer almaktadır.
- 6 Çevreci ürünlerin tüketicilerin satın alma isteklerini artırdığı düşüncesiyle hareket edilmektedir

(Bedük, 2017)

5. In general, your customers greatly affect the green environmental practices of your company
9. Most of the customers have environmental values that impact your company's green policy

### **Reference of Environmental Management Questions**

(Çankaya, 2015)

- 2 Yöneticiler için doğal çevrenin korunması ile ilgili seminerler düzenlenmektedir.  
3 Firma çalışanları için doğal çevrenin korunması ile ilgili eğitimler düzenlenmektedir.  
2 Geri dönüşüm, zararlı emisyonların azaltılması ve enerji tasarrufu üzerine çevre performans endeksi oluşturulmaktadır.  
3 Firmamızın bir çevre yönetim sistemi oluşturulmuştur.

(Green et al., 2012)

Internal environmental management is the practice of developing green supply chain management as a strategic organizational imperative through commitment and support of the imperative from senior and mid-level managers

(Karabulut, 2003)

13. tüm çalışanlarımızın evreye duyarlı olmasına yönelik eğitimler verilmektedir.  
14. işletmemizde bilinçlendirme faaliyetleri çerçevesinde çevre panosu oluşturularak tüm çalışanlarımızın çevre duyarlılığı konusunda bilgilendirilmesi sağlanır.  
15. çalışanlarımız çevreye zarar veren faaliyetleri fark ettikleri anda yönetisine haber verirler.

### **Reference of Recycling Questions**

(Çankaya, 2015)

- 1 Hurda ve kullanılmış malzeme/araç gereçler satılarak değerlendirilmektedir.  
2 Kullanılmış ve arızalı ürünler için bir geri dönüşüm sistemi oluşturulmuştur

(Dizaji, 2017)

2. Ürettiğimiz ürünler kadar; tedarikçilerimizin de ürettiği ürünlerin geri dönüşebilir, yeniden kullanılabilir ve yenilenebilir enerji kaynakları kullanılarak üretilmiş olması gerekmektedir  
7. Üretim süreçlerimizde geri dönüştürülmüş maddelerin kullanılması maliyetleri düşürdüğü için daha fazla tercih etmekteyiz

(Eltayeb et al., 2011)

Recycling is the process of collecting used products, disassembling them, separating them into material categories, and processing them into recycled products, components, and/or materials. The identity and functionality of the original materials are lost.

### **Reference of Demand Uncertainty Questions**

(Çankaya, 2015)

- 1 Ürünlerimize olan talep genellikle çok değişkendir.

(Zhao et al., 2018)

DU1: Our master production schedule has a high percentage of variation in demand

DU2: Our customer demand fluctuates drastically from week to week\* (deleted after reliability)

DU3: Our supply requirements vary drastically from week to week

### **Reference of Technology Uncertainty Questions**

(Çankaya, 2015)

3 Sektörümüzdeki rakiplerin yeni ürün/hizmet sunumunu öngörmek zordur

4 Sektörümüzdeki teknolojinin önümüzdeki üç beş yıl içinde hangi noktaya varacağını öngörmek oldukça zordur

(Zhao et al., 2018)

TU1: Our industry is characterized by rapidly changing green technology

TU2: It will be difficult for us to remain sustainable if we do not keep up with changes in green technology\* (deleted after reliability)

TU3: The rate of process obsolescence is high in our industry

TU4: Green technology changes frequently and sufficiently

### **Reference of Supply Uncertainty Questions**

(Çankaya, 2015)

2 Tedarikçilerimizin performansının tahmin edilmesi zordur.

(Zhao et al., 2018)

SU1: The suppliers consistently meet our requirements

SU2: The suppliers produce materials with consistent quality

### **Reference of Environmental Performance Questions**

(Çankaya, 2015)

1 Çevreyle ilgili yasal düzenlemelere uygunlukta olumlu gelişmeler yaşanmıştır

2 Atık üretimi azalmıştır.

4 Zararlı kimyasalların kullanımı azalmıştır.

(Kalpande & Toke, 2020)

Environmental performance performances

1.1 Reduction of air emission performances-

1.2 Reduction of wastewater performances

1.3 Reduction of solid wastes performances

1.4 Reduction of physical performances

1.5 Decrease of consumption for hazardous/harmful/toxic materials performances

1.6 Decrease of frequency for environmental accidents performances

1.7 Improve an enterprise's environmental situation

### **Reference of Economic Performance Questions**

(Çankaya, 2015)

1 Satın alınan malzemenin maliyeti azalmıştır.

2 Enerji tüketim maliyeti azalmıştır.

3 Atıklarla ilgili maliyetler azalmıştır.

4 Hisse başına kazanç artmıştır.

5 Yatırım getirisi artmıştır.

6 Satışlar artmıştır.

7 Karlılığımız artmıştır.

(Kalpande & Toke, 2020)

2.1 Decrease of cost for materials purchasing performances

2.2 Decrease of cost for energy consumption performances

2.3 Decrease of fee for waste treatment performances

2.4 Decrease of fee for waste discharge performances

2.5 Decrease of fine for environmental accidents performances

3.1 Increase in investment performances

3.2 Increase of operational cost performances

3.3 Increase of training cost performances

3.4 Increase of costs for purchasing eco-friendly materials

## Reference of Social Performance Questions

(Çankaya, 2015)

- 3 Sosyal projelere (eđitim, kltr, spor) yapılan yatırımlar artmıřtır.  
4 Tm Paydařlar ile (rn sivil toplum kuruluřları, alıřanlar, mřteriler) iliřkilerde anlamlı geliřmeler yařanmıřtır.  
7 İřletme iinde alıřanların kazaya uđramaları ve yaralanmalarını nleyici tedbirler artmıřtır.  
8 Tm paydařların refahında artıř yařanmıřtır.

(Canils et al., 2016)

Our firm is maintaining or presenting an environmentally or socially responsible image.

Our organization presents itself as an environmentally responsible company.

Our firm tries to meet social expectations.

Our firm is subjected to pressure from the insurance industry.

Our firm is subjected to pressure from shareholders or investors (when applicable).



## APPENDIX D Sampling group

**Table A.1 : Sampling Group**

Shipyards Name	Shipyards Name
ADA SHIPYARD	AEGEAN YACHT
ANADOLU SHIPYARD	ARES SHIPYARD
ARGEM SHIPYARD	ARK YACHT
ARKADAS SHIPYARD	ASTAS SHIPYARD
AYKIN SHIPYARD	BESIKTAS SHIPYARD
BOGAZICI SHIPPING	CEKSAN SHIPYARD
CELIKTRANS SHIPYARD	CEMRE SHIPYARD
CIMTAS SHIPYARD	CINDEMIR SHIPYARD
DAMEN SHIPYARDS	DEARSAN SHIPYARD
DENTAS SHIPYARD	DESAN SHIPYARD
ENGIN DORTLER SHIPYARD	EREGLI SHIPYARD
GE-TA SHIPYARD	GELIBOLU SHIPYARD
GEMAK SHIPYARD	GEMSAN SHIPYARD
GEMTIS SHIPYARD	GISAN SHIPYARD
GISAS SHIPBUILDING INDUSTRY CO.INC.	GROUP ICT YACHTS
HIDRODINAMIK SHIPYARD	S.S. NUH SMALL INDUSTRY SITE
ICDAS SHIPYARD	ISTANBUL SHIPYARD
KPT SHIPYARD	KUZEY STAR SHIPYARD
MENGI YAY YACHTS	NESA SHIPYARD
NUR GEMİCİLİK SHIPYARD	NUR-ISTANBUL SHIPYARD
OZATA SHIPYARD	SIERRA MARINE
RMK MARINE	S.S GEMDOK INDUSTRY SITE
S.S ISTANBUL BOĞAZIÇI AÇIKDENİZ BALIKÇI	HİCRİ ERCİLİ TERSANECİLİK
TEKNELERİ ve YAT YAPIMCILARI ONARIMCILARI KO.	SAN.VE TİC. A.Ş.
SANMAR SHIPYARD	SARP YACHTS
SEDEF SHIPYARD	SEFINE SHIPYARD
SELAH SHIPYARD	SHIPYARD FAMAGUSTA (CYPRUS)
SNR SHIPYARD	TERSAN SHIPYARD
TGE SHIPYARD	TORGEM SHIPYARD
TORLAK SHIPYARD	TURKTER SHIPYARD
TURQUOISE YACHTS INC.	TUZLA SHIPYARD
URSA SHIPYARD	UZMAR SHIPYARD
VIKING MARIN	YARDIMCI SHIPYARD
YASARSAN SHIPYARD	YILDIZ SHIPYARD
YONCA - ONUK SHIPYARD	ARKIN PRUVA YAT
OZKAREDENİZ NAK. VE DENİZ TASIMACILIĞI SAN.VE	
TIC.LTD.STI.	



**APPENDIX E VIF values**

**Table A.2 : Inner VIF values of the first-degree model**

CONSTRUCT	ECO-PER	ENVR-PER	SOC-PER	UN-DEMAND	UN-SUPPLY	UN-TEC
ECO-PER						
ENVR-PER						
Gr-DESIGN	2,213	2,213	2,213	1,800	1,800	1,800
Gr-ENVR	2,102	2,102	2,102	1,777	1,777	1,777
Gr-MAR	2,685	2,685	2,685	2,447	2,447	2,447
Gr-PROD	2,265	2,265	2,265	2,098	2,098	2,098
Gr-PURCH	3,030	3,030	3,030	2,349	2,349	2,349
Gr-RCYC	2,671	2,671	2,671	2,636	2,636	2,636
SOC-PER						
UN-DEMAND	1,190	1,190	1,190			
UN-SUPPLY	1,656	1,656	1,656			
UN-TEC	1,909	1,909	1,909			

**Table A.3 : Inner VIF values of the second-degree model**

CONSTRUCT	ECO-PER	ENVR-PER	ENVR-UNCER	GSCM	SOC-PER
ECO-PER					
ENVR-PER					
ENVR-UNCER	1,755	1,755			1,755
GSCM	1,710	1,710	1,000		1,710
SOC-PER					

**Table A.4 : Outer VIF values of the second-degree model with bias**

CONSTRUCT	VIF
Dummy	1,000
EcP1	2,426
EcP2	3,036
EcP3	2,059
EnP1	1,591
EnP2	2,776
EnP3	2,143
Gr-DESIGN	1,806
Gr-ENVR	1,761
Gr-MAR	2,458
Gr-PROD	2,099
Gr-PURCH	2,352
Gr-RCYC	2,624
SoP2	1,453
SoP3	1,453
UN-SUPPLY	1,016
UN-TECH	1,016



## CURRICULUM VITAE

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**EDUCATION** :

- **B.Sc.** : 1997, İTÜ, Faculty of Naval Architecture and Ocean Engineering, Naval Architect
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### PROFESSIONAL EXPERIENCE AND REWARDS:

- 2009-today Director Les Grands Chantiers, Tangier, Morocco.
- 2007-2009 Director of BGM Engineering and BGMS Composites, Istanbul, Turkey
- 2000-2007 Variable position in different companies, Istanbul, Turkey

### PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- **Tantan M., Akdağ Camgöz H., 2020:** “Sustainability Concept in Turkish Shipyards” WIT Transactions on Ecology and the Environment, 241, 269-281 doi:10.2495/SDP200221
- **Tantan M., Akdağ Camgöz H., 2022;** "Green supply chain management practices' effect on the sustainability performance: A case study in Turkish shipyards" Proceeding of the Ninth International Conference on Environmental Management, Engineering, Planning & Economics, pg.487-497, Mykonos Island, Gree, June 5-9, 2022, ISBN: 978-618-5494-97-1
- **Tantan, M., & Akdağ, H. C. (2023).** The Effect of Green Supply Chain Management Practices on the Sustainability Performance of Turkish Shipyards. Sustainability, 15(8), 6677. <https://doi.org/10.3390/su15086677>

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- **Tantan M., Akdağ Camgöz H., Özdemir M., 2022:** “Turkish Shipyards during COVID-19 pandemic” 2022 World of Shipping Portugal. An International Research Conference on Maritime Affairs 27 - 28 January 2022, Online Conference, from Portugal to the World
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