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Correspondence Address / ***Yazışma Adresi***
Istanbul University, Faculty of Transportation and Logistic,
Avcilar Campus, 34320 Avcilar, Istanbul, Turkey
Phone / Telefon: +90 (212) xxx xx xx / xxxx
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RESEARCH ARTICLE

İnsanı Yardım Kuruluşlarının, Verimlilik, Etkinlik ve Lojistik Performans Değerlendirmesi*

Productivity, Efficiency and Logistics Performance Assessment of Humanitarian Relief Organizations*

İbrahim Akben[1], **Orhan Taşdoğan**[2]

ÖZ

İnsani yardım kuruluşlarının gerçekleştirdiği yardım faaliyetlerinin en önemli aşamalarından birisi lojistik faaliyetleridir. Bu faaliyetler, çoğu zaman en kritik rolü üstlenmektedir. Lojistiğin en önemli tanımı olan, doğru zamanda, doğru yerde, doğru miktarda tedarik, insani yardım konusunda önemli bir hal almaktadır. Bu faaliyetler genellikle gıda, sağlık hizmetleri, giyim, eğitim ve psikolojik destek vb. çeşitli insani alanlarda gerçekleştirilmektedir. Bu yüzden, insani yardım kuruluşları insani krizlerin gerçekleştiği bölgeye yardım ulaştırırken lojistik performansları ciddi önem arz etmektedir. Son zamanlarda, ortaya çıkan insani krizlerin etkisi ile bu alanda faaliyet gösteren insani yardım örgütlerinin tepki süreleri, lojistik yeterlilikleri ve performanslarının nasıl ölçüleceği sorusu gündeme gelmeye başlamıştır. Bu çalışmanın temel amacı, insani yardım alanında faaliyet gösteren sivil toplum kuruluşlarının lojistik performansını değerlendirmektir. Kuruluşların lojistik performansını etkileyen değişkenleri incelemek ve bu değişkenlerin etkilerini belirlemektir. Çalışmanın kapsamı gereği Türkiye'de faaliyet gösteren yerli ve yabancı menşeili sivil toplum kuruluşları, araştırmanın ana kütlesini oluşturmuştur. Bu kuruluşlar üzerinde bir alan çalışması yapılmış, edinilen veriler ve bilgiler istatistik analiz programında analiz edilerek araştırmanın hipotezleri test edilmiştir. Çalışma sonucunda; verimlilik performansının lojistik performans üzerinde anlamlı ve pozitif bir etkiye sahip olduğu; etkinlik performansının lojistik performans üzerinde anlamlı ama negatif bir etkiye sahip olduğu belirlenmiştir.

Anahtar Kelimeler: Lojistik Performans, Verimlilik Performansı, Etkinlik Performansı, İnsani Yardım Kuruluşları

ABSTRACT

One of the most important stages of aid activities carried out by humanitarian aid organizations is logistics activities. These activities are generally carried out in various humanitarian areas such as food, health services, clothing, education, and psychological support. Therefore, their logistics performance is of great importance when humanitarian organizations deliver aid to a region where humanitarian crises occur. The main aim of this study is to evaluate the logistical performance of non-governmental organizations operating in the field of humanitarian aid to examine the variables that affect the logistic performance of organizations and to determine the effects of these variables. Due to the scope of work of domestic and foreign origin, non-governmental organizations operating in Turkey have been the main focus of research. A field study was conducted on these organizations, the data and information obtained were analyzed in the statistical analysis program, and the hypothesis of the research was tested. At the end of study, it was seen that productivity performance has a meaningful and positive effect on logistic performance. It has been determined that efficiency performance has significant but negative effect on logistic performance.

Keywords: Logistics Performance, Productivity Performance, Efficiency Performance, Humanitarian Aid Organizations

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[1] **Sorumlu yazar/Corresponding author:** İbrahim Akben (Dr. Öğr. Üyesi), Hasan Kalyoncu Üniversitesi, İktisadi, İdari ve Sosyal Bilimler Fakültesi, Uluslararası Ticaret ve Lojistik Bölümü, Gaziantep, Türkiye. E-mail: ibrahim.akben@hku.edu.tr, ORCID: 0000-0003-3268-0242

[2] Orhan Taşdoğan, Uzman, Sığınmacılar ve Göçmenlerle Dayanışma Derneği, İzmir, Türkiye. ORCID: 0000-0003-1645-9177

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EXTENDED ABSTRACT

One of the most important stages of aid activities carried out by humanitarian aid organizations is logistics activities. These activities often play a key role. Logistics, which is defined as procurement at the right time, in the right place, and in the right amount, becomes important in humanitarian aid. These activities are generally carried out in various humanitarian areas such as food, health services, clothing, education, and psychological support.

Therefore, their logistics performance is of great importance when humanitarian organizations deliver aid to a region where humanitarian crises occur. Recently, with the impact of humanitarian crises, the question of how to measure the response times and logistics competencies and performance of humanitarian organizations operating in this field has come to the fore.

Aim: The main purpose of this study is to evaluate the logistics performance of NGOs working in the field of humanitarian aid. Other objectives are to examine the impact of productivity and efficiency performance of organizations on logistics performance and to determine the effects of these variables.

In order to reach the aim of the study, it was supported with a field study. The research model was created with the data obtained from the field study and the model was tested with the collected data.

This study aims to contribute to the literature by determining the factors that affect the logistics performance of organizations and drawing conclusions containing useful information for organizations.

Method: Due to the scope of work of domestic and foreign origin, non-governmental organizations operating in Turkey have been the target of the research group. A field study was conducted on these organizations, the data and information were analyzed in the SPSS statistical analysis program, and the hypotheses of the research were tested.

The hypotheses established to achieve the purpose of the study are as follows:

"*H1:* *The productivity performance of the organization positively affects its logistics performance,"* and

"H2: *The organization's efficiency performance positively affects its logistics performance."* These hypotheses were tested.

Findings: According to the results, productivity performance has a significant and positive effect on logistics performance and efficiency performance has a significant but negative effect on logistics performance.

As a result of the analysis, the first hypothesis of the study ("***H1****: The productivity performance of the organization affects the logistics performance positively*.") was accepted.

According to the established regression model, it was determined that efficiency performance has a negative effect on logistic performance.

Therefore, the second hypothesis of the study ("***H2:*** *The efficiency performance of the organization affects the logistics performance positively.*") was rejected

Result: Good tooling, good equipment, and good timing with bureaucratic permits are essential for good logistics performance. A well-established logistics coordination system ensures that the organization always performs logistics well.

It has been observed that productivity performance and efficiency performance have effects on logistics performance. Finding trained personnel in civil society (the third sector), presents difficulties compared to the private and public sectors. This situation causes the personnel working in humanitarian aid organizations to either work temporarily or work on a project-based contract. Therefore, employees cannot provide stability in the organizations they work with.

Finally, it is important to note that there are several factors necessary for good logistic performance. Even if all of these come together, sometimes additional problems occur and cause the logistics activity to be interrupted or even halted. Good teams, good equipment, and good timing are absolutely necessary for good logistics performance, together with bureaucratic permits. A well-established logistics coordination system ensures that the organization always exhibits good logistics performance.

1. GİRİŞ

İnsani yardım kuruluşlarının gerçekleştirdiği yardım faaliyetlerinin en önemli basamaklarından birisi olan lojistik faaliyetleri zaman zaman en kritik rolü üstlenmektedir. Lojistiğin en önemli tanımı olan, doğru zamanda doğru yerde doğru miktarda tedarik, insani yardım konusunda önemli bir rol oynamaktadır. Bu faaliyetler genellikle gıda, sağlık hizmetleri, giyim, eğitim ve çeşitli insani alanlarda (psikolojik destek vb.) olmaktadır. Bu çalışma ile insani yardım kuruluşlarının etkinlik ve verimlik performansının lojistik performans üzerindeki etkileri araştırılmıştır. İnsani yardım lojistiği, ticari lojistikten farklı olarak nerede ne zaman gerçekleşeceği bilinmeyen insani krizler sebebiyle ortaya çıkmaktadır. Bu durumda insani yardım kuruluşları insani krizin gerçekleştiği bölgeye yardım ulaştırırken bu kuruluşların lojistik performansları ciddi önem arz etmektedir. Bu nokta da sosyal hizmetler dahilinde afet müdahale ve yardım alanında faaliyet gösteren kamu kuruluşlarının yanı sıra, stratejik önemleri giderek artan ve çoğunlukla gönüllülük temelinde çalışmalar yapan ulusal veya uluslararası sivil toplum örgütlerinin desteği kaçınılmazdır (Kaynak ve Erel, 2016: 2). Son zamanlarda ortaya çıkan insani krizlerin etkisi ile bu alanda faaliyet gösteren insani yardım örgütlerinin tepki süreleri, lojistik yeterliliklerinin ve performanslarının nasıl ölçüleceği sorusu gündeme gelmeye başlamıştır. 2011 yılından bu yana Suriye'de yaşanan insani kriz de ise bu yardımların nasıl ve ne şekilde yapıldığını görmemize yardımcı olmuştur. Bu alanda gerçekleştirilen çalışmalara ait bilgilerin merkezi bir sistem ile bir araya getirilmesi, sınırlı bilgi iletişim teknolojileri altyapısı, her insani krizden sonra çabuk değişen dinamik hatta karışık bir ortam, dış faktörler (coğrafik, politik tepkiler vb.) örgüt kültürlerinin farklı olması gibi faktörler, insani kriz yönetim performansının ölçümünde sıkıntılara neden olmaktadır (Kaynak ve Erel, 2016: 2).

Bu bağlamda bu çalışmanın amacı Türkiye'de faaliyet gösteren yerli ve yabancı menşeili insani yardım kuruluşlarının etkinlik performansı, verimlilik performansı ve lojistik performanslarının belirlenmesi, etkinlik performansının ve verimlilik performansının lojistik performansı üzerindeki etkisini araştırmaktır.

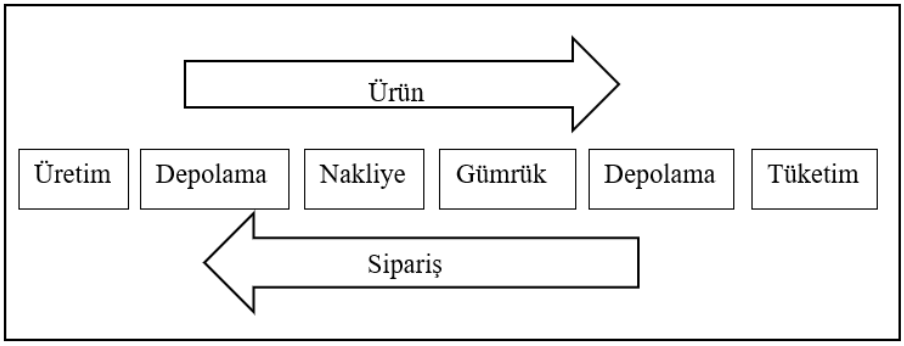
Çalışma, bu amaca ulaşabilmek için bir alan çalışması ile desteklenmiştir. Yapılan alan çalışmasından elde edilen verilerin analiz edilmesiyle araştırmanın modeli test edilmiştir. Bu çalışma ile kuruluşların lojistik performansını etkileyen faktörlerin neler olduğunu belirlenerek, literatüre katkıda bulunmak ve bu kuruluşlar için faydalı bilgiler içeren sonuçlar ortaya çıkarmak amaçlanmıştır.

2. Lojistik ve Lojistik Yönetimi

Oxford Advanced Learner's Dictionary of Current English isimli sözlükte lojistik, logic kelimesinden türemiş olarak bir kelime olarak bahsedilmektedir. Bu sözlükteki açıklamalarda lojistik genel olarak; "ikmal, dağıtım, personel ve malzemenin değiştirilmesi" şeklinde tanımlanmıştır (Keskin, 2011a: 26).

Tedarik Zinciri Yönetimi Konseyi'ne göre lojistik, "müşterilerin ihtiyaçlarını karşılamak üzere her türlü ürün, hizmet ve bilgi akışının, hammaddenin başlangıç noktasından, ürünün tüketildiği son noktaya kadar olan tedarik zinciri içindeki hareketinin, etkin ve verimli

bir şekilde akış ve depolanmasının sağlanmasını, kontrol altına alınması ve planlaması sürecidir".



Şekil 1. Lojistik Kavramı
Kaynak: MEGEP, 2011: 6

Lojistiğin temel amacını gerçekleştirmek için operasyonel seviyede bazı gayelerin elde edilmesi gerekmektedir. Bunlar hızlı yanıt, düşük operasyonel maliyet, kalite, izlenebilirlik ve sürdürülebilirlik olarak sıralanmaktadır (Acar ve Köseoğlu, 2014: 2).

Lojistik yönetimi ise; "Etkili ve müşteri isteklerine uygun ürünlerin tedarikçilerden ya da üretim tesislerinden, depolama ve dağıtım merkezlerine buradan da perakendecilere ve mağazalara hareketindeki her aşamada mevcuttur. Bazı durumlarda tedarikçilerin tedarikçileri, müşterilerin müşterileri de hesaba katılması gerekmektedir"(Acar ve Köseoğlu, 2014: 2). Lojistik yönetiminin ana hedefi işletme planları hedefine paralel olarak belirlenmiş bir üretim veya pazarlama hedefine uygun değer toplam maliyetle ulaşmaktır.

Lojistik yönetimi sadece bir firmayı değil, birbirleriyle iletişim halinde olan birçok firmayı kapsamaktadır. Firmalar arasındaki iletişim bir ürünün var edilmesinden, tüketildiği ana kadar bütün zaman dilimi boyunca devam etmektedir.

Günümüzde, lojistik yönetimi ve tedarik zinciri yönetimi kavramları çoğu zaman birbirine karıştırılabilmektedir (Küçük, 2012: 27-28). Çancı ve Erdal, (2013a: 4)'a göre lojistik yönetiminin amacı; "Bir firmanın varlığını devam ettirebilmesi için, firmanın kendisini kalite, fiyat, zaman ve hizmet gibi hayati pazar değişkenliklerine karşı dayanıklı hale getirmesi gerekmektedir. Lojistik yönetimi, tedarik zinciri dâhilindeki tüm yönetim ve sevk faaliyetlerinin sağlamayı amaçlayan bir süreçtir" şeklinde tanımlanmaktadır.

3. Verimlilik, Etkinlik ve Lojistik Performansları

1.1. Verimlilik Performansı

En bilinen tanımı ile, üretim sürecine dahil olan çeşitli girdilerle bu prosesin sonunda ortaya çıkan ürünler arasındaki ilişkiyi tanımlayan verimlilik, savurganlıktan uzak durarak, kaynakları en iyi biçimde değerlendirerek üretmek anlamına gelmektedir. Fakat, ekonominin dışındaki disiplinlerin de giderek daha çok incelemeye alınması ve ülkelerin gündemlerinin ilk sıralarında yer alır hale gelmesinden dolayı, verimlilik tanımında da değişiklikler ortaya çıkmaya başlamıştır. Verimlilik çoğu yerde kullanılabilmesi

basitliğinden ve kolay bir ölçüt olması nedeniyle yaygın bir şekilde kullanılan bir performans ölçütüdür (Akdeniz ve Durmaz, 1998: 85).

1.2. Etkinlik Performansı

Etkinlik, kuruluşların düzenledikleri aktivitelerin sonucunda amaçlara ulaşma derecesini belirleyen bir performans boyutudur (Horngren vd., 2000: 229). Kurumsal etkinlik, kurumsal amaçlara ulaşma ve onları elde etme derecesidir. Bu görüşe göre, bir kuruluş önceden saptadığı amaçlara ne ölçüde ulaşabiliyorsa, o kadar etkindir (Aldemir, 1985: 201-202).

Yüksek performanslı kuruluşlar, doğru işleri doğru şekilde yapan kuruluşlardır. Bu kuruluşlar ihtiyaç sahiplerinin istedikleri ürün ve hizmetleri daha yüksek kalitede ve daha düşük maliyetle meydana getirirler. Hedef grupların ve çalışanlarının beklentilerini karşılayacak veya aşacak şekilde katma değer yaratırlar. Kuruluş açısından etkinlik, işçilik, hammadde, malzeme ve diğer girdilerin kuruluş içinden saptanan amaçlar doğrultusunda ne denli etkin ya da yeterli kullanıldığını gösteren bir değerlendirme kriteridir. Etkinlik, bir kuruluşun hizmet faktörleri ya da hizmetin kendisi için önceden saptadığı programın gerçekleştirilme derecesini gösterir. Etkinlik derecesi aşağıdaki eşitlik ile belirlenebilir.

Etkinlik = Standart Performans / Gerçekleşen (fiili) performans

Örneğin; bir işin standart süresi 2 saat ise, fakat uygulamada bu iş 3 saatte gerçekleşiyorsa;

Etkinlik = 2 / 3 = 0,66'dır.

Buna göre, işin yeteri kadar etkin olmadığı sonucuna varılabilir. Etkinlik oranının "1" değerinin altında olması, faaliyetin istenildiği gibi gerçekleşmediği anlamına gelmektedir. Oranın "1" den büyük olması ise, standarttan daha büyük bir etkinlik düzeyini gösterir (Elitaş ve Ağca, 2006: 346).

3.3. Lojistik Performans

Lojistik performans, önceden planlanmış, lojistik faaliyetlerinin belirli bir süre sonunda ortaya çıkmış sonuçlarının nitel ve nicel olarak tanımlanmasıdır. Lojistik hizmetler üç aşamada gerçekleştirilmektedir. Birinci aşama, firmanın lojistik ögelere ve kaynaklara sahip olması ve bu sayede ürünlerin, malzemelerin ve bilginin zamanında teslim edilebilmesi aşamasıdır.

Bu aşamanın ardından işletme performans yeteneğini geliştirmeye başlayabileceği ikinci aşamaya geçmiş olmaktadır. Bu aşama dağıtım süresini ve dağıtım esnekliğini içermektedir. Özellikle müşteri siparişlerinin, pazara uyumlu üretim çıktılarına dönüştürülmesi yeteneğine ve müşterilerin beklentilerine cevap verebilme, değişime ayak uydurabilme esnekliğine sahip olunması amaçlanmaktadır. Lojistik hizmetlerindeki bu iki aşamanın gerçekleştirilmesinin ardından lojistik süreçlerin kalitesinin kalıcı olduğundan emin olunması gerekmektedir. Bu amaçla teslim güvenilirliği, hasar oranı ve fire miktarı gibi bazı performans göstergeleri baz alınarak, malzeme ve bilgi elde etme sürecinin güvenilirliğinin artırılması gerekmektedir (Deepen, 2007). Lojistik performans;

bu üçüncü aşamada karşımıza çıkmaktadır ve lojistik hizmet sağlayan firmaların kendi stratejik planları doğrultusunda belirli bir faaliyet sonunda elde etmiş oldukları çıktıların istenilen duruma ne derece yaklaştığını ifade etmektedir. Lojistik performans bileşenleri; sosyal sorumluluk, güvenirlilik, tam zamanlı teslimat, erişim kolaylığı, kullanıcı tatmini, maliyet etkinliği, az hasar ya da fire miktarı, uygun fiyat, iş güvenliği ve çalışma şartları, esnekliktir.

Bu çıktılar farklı kültürlerde önem düzeyleri değişse de ana hatlarıyla; teslim hızı, maliyet, etkinlik, verimlilik, yenilikçilik, kalite, esneklik, üretkenlik, karlılık olarak özetlenebilmektedir (Liu ve Lyons, 2011: 547-570). Lojistik performans; çok boyutlu olması nedeniyle, birçok tedarikçi, perakendeci, taşıyıcı gibi paydaşları da ilgilendirmekte; maliyetin düşük olması, müşteri memnuniyetinin sağlanması, çevresel sorumluluklar, iş güvenliği, karlılık, esneklik gibi konuları da içermektedir (Deepen, 2007: 1).

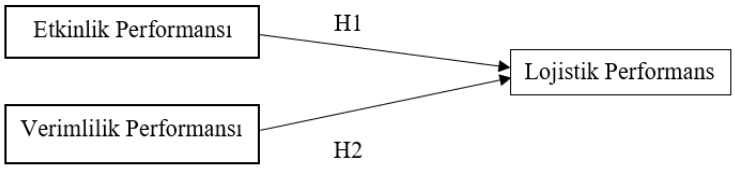
3. METODOLOJİ

Bu bölümde, araştırmanın amacı, kapsamı, ana kütle ve örneklem seçimi, verilerin toplanması ve araştırmanın hipotezleri ve verilerin analizlerine dair bilgiler bulunmaktadır.

3.1. Ana Kütle ve Örneklem Seçimi

Bu çalışmanın ana kütlesini Türkiye'de faaliyet gösteren, T.C. İçişleri Bakanlığı Dernekler Dairesi Başkanlığı'na kayıtlı yerli ve yabancı menşeili 144 insani yardım kuruluşu oluşturmaktadır. Bu kuruluşların, hepsine ulaşılmaya çalışılmış ancak 103 kuruluşa ulaşılarak veriler toplanmıştır.

3.2. Araştırmanın Modeli ve Hipotezleri



Şekil 2. Araştırma Modeli

Şekil 2'de verilen araştırma modelinde, etkinlik performansının ve verimlilik performansının, lojistik performansı ile ilişkisi görülmektedir. Ayrıca model üzerinde araştırmanın hipotezleri olan "H1" ve "H2" hipotezleri gösterilmiştir. Söz konusu "H1" ve "H2" hipotezleri şu şekildedir;

H1: Kuruluşun verimlilik performansı, lojistik performansını pozitif yönde etkilemektedir.

H2: Kuruluşun etkinlik performansı, lojistik performansını pozitif yönde etkilemektedir.

3.3. Veri Toplama Süreci ve Geri Dönüş Oranı

Araştırmada veri toplama yöntemi olarak anket yöntemi kullanılmıştır. Anketin uygulanacağı kuruluşlar T.C. İçişleri Bakanlığı Dernekler Dairesi Başkanlığı'na kayıtlı yerli ve yabancı menşeili insani yardım alanında faaliyet gösteren kuruluşlar arasından

seçilmiştir. Çalışma kapsamında oluşturulan anket formu altı bölümden oluşmaktadır. Ankette; kuruluşların karakteristik özelliklerini, kuruluşların verimlilik performansını, etkinlik performansını ve kuruluşların lojistik performansını ölçmeye yönelik sorular yer almaktadır.

Ankette kullanılan ve 9 maddeden oluşan verimlilik performansı ölçeği ve6 maddeden oluşan etkinlik performansı ölçeği Krause, Pagell ve Curkovic (2001) ile Ward vd. (1995) çalışmalarından alınmıştır. Ankette kullanılan ve 15 maddeden oluşan, lojistik performans ölçeği, Liu ve Lyons, (2011)'in çalışmasından alınmıştır. Ölçeklerde yer alan sorular 5'li likert ölçeği şeklinde sorulmuştur. Anket formu, google drive dokümanlar çevrimiçi aracında oluşturularak elektronik ortama aktarılmıştır. Bu işlemden sonra anket uygulanmaya başlanmıştır. Çalışmanın örneklemi olan 144 kuruluşun öncelikle e-posta adreslerine, internet siteleri veya sosyal medya hesapları yardımı ile ulaşılarak lojistik birimlerinin cevaplaması konusunda açıklayıcı bir yazı ile çalışmanın anket linki gönderilmiştir. Çalışma sonucunda 144 kuruluştan 103 kuruluş ankete cevap vermiştir. Başka bir ifade ile bakıldığında % 71,52 oranında bir geri dönüş oranına ulaşılmıştır.

3.4. Araştırmanın Kısıtları ve Güvenilirliği

Bu araştırmanın alan çalışması yapılırken özellikle yabancı menşeili kuruluşlar anket sorularını cevaplama konusunda çekimser kalmışlar, bazı kuruluşlar ise hiçbir soruya cevap vermemişlerdir. Son yıllarda yaşanan Suriye iç çatışma nedeniyle birçok yabancı menşeili kuruluş Türk hükümeti ile yaşadığı problemlerden dolayı kapanmış ya da başka bir ülkeye taşınmıştır. Bu durum da hali hazırda çalışma yapan yabancı menşeili kuruluşların anketi cevaplamasında çekinceler oluşturmuştur. Bu çalışma da elde edilen verilerin doğruluğu, anket çalışmasına katılan kuruluşların lojistik birim sorumlularının verdikleri cevapların doğruluğu ile sınırlıdır.

4.5. Analizler ve Bulgular

Çalışmanın bu bölümünde yapılan anket çalışmalarının analizleri ve bu analizlere yönelik yorumlar yer almaktadır. Bu çalışma kapsamında 5'li Likert ölçeği kullanılan anket çalışması kullanılmıştır. Katılımcılar sorulara 1'den 5'e kadar olan 1: Kesinlikle Katılmıyorum, 2: Katılmıyorum, 3: Orta Düzeyde Katılıyorum, 4: Katılıyorum, 5: Kesinlikle Katılıyorum, şeklinde cevaplar vermişlerdir. Elde edilen verilere istatistik paket programı kullanılarak, güvenirlilik analizi, normal dağılım testi, frekans analizi, korelasyon ve regresyon analizi yapılmıştır. Bu bölümün alt başlıklarında bu analizlere yönelik bulgular verilmiştir.

4.5.1. Araştırmanın Güvenirlilik ve Geçerlilik Analizi Sonuçları

Güvenirlilik değeri bir ölçme aracının tekrarlanan ölçümlerde aynı sonucu verme derecesinin göstergesidir (Ercan ve Kan, 2004: 212). Güvenirlilik kavramı yapılan her ölçüm için gereklidir, çünkü güvenirlilik bir test ya da ankette yer alan soruların birbirleri ile olan tutarlılığını ve kullanılan ölçeğin ilgilenilen sorunu ne derece yansıttığını ifade eder (Kalaycı, 2010: 403). Güvenirlilik analizinde kullanılan modellerden biri de Alfa modelidir (*Cronbach Alpha Coefficient*) (Kalaycı, 2009: 405). Bu araştırmanın alan

çalışmasında kullanılan ölçeklerin güvenirliliğin test edilmesinde de *Cronbach's Alfa* katsayısı kullanılmıştır.

Tablo 1. Araştırmada Yer Alan Ölçeklere İlişkin Güvenirlilik Analizi Sonuçları

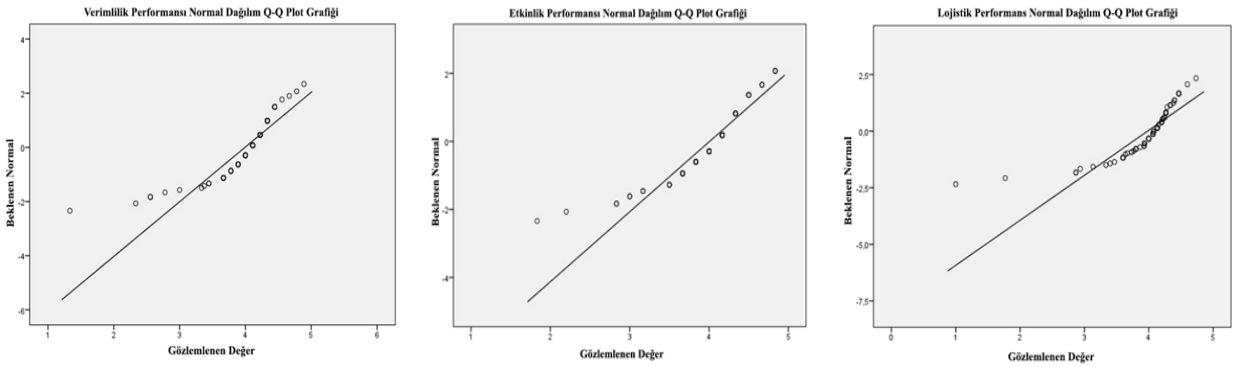
Ölçekler	***Cronbach's Alpha***	***Önerme Sayısı***
Verimlilik Performansı	0,822	9
Etkinlik Performansı	0,657	6
Lojistik Performans	0,784	15
Genel	**0,885**	**30**

Anket çalışmasında, güvenirlilik analizi yapmaya uygun olan, verimlilik performansı, etkinlik performansı ve lojistik performansı önermeleri için güvenirlilik analizi yapılmıştır. Tablo 1 incelendiğinde bu analiz sonucundan, verimlilik performansı ile ilgili 9 önermenin alfa değeri 0,822, etkinlik performansı ile ilgili 6 önermenin alfa değeri 0,657 ve lojistik performans ile ilgili 15 önermenin alfa değeri 0,784 olarak belirlenmiştir. Ölçeklerin genelinin güvenirliliğine bakıldığında *Cronbach's Alpha* değeri 0,885 olarak belirlenmiştir.

Nunnally (1978) ve Kalaycı'ya (2009)'a göre alfa değeri 0,70 veya üzerinde bir değere sahip ($0,70 \leq \alpha \leq 1$) ise ölçek güvenilir kabul edilmektedir.

1.1.2. Basıklık ve Çarpıklık Analizine İlişkin Bulgular

Verilerin normallik durumunu test etmek için, grafik yöntemine göre toplanmış olan verilerin Q-Q Plot grafiği oluşturulur ve verilerin normal dağılım eğrisi üzerinde bir form oluşturup oluşturmadığı incelenir. Normal dağılım eğrisi üzerinde bir dağılım oluşturan veri setinin normal dağıldığı kabul edilir (Tabachnick vd., 2013). Verimlilik performansı, etkinlik performansı ve lojistik performans için Q-Q Plot grafiği Şekil 3'te verilmiştir. Q-Q Plot grafikleri incelendiğinde, analizde kullanılan verilerin normal dağılıma sahip olduğu görülmektedir.



Şekil 3. Verimlilik performansı, etkinlik performansı ve lojistik performans için Q-Q plot grafiği

Çalışmadaki verilerin normal dağılım göstermesi çarpıklık ve basıklık değerlerinin ±3 arasında olmasına bağlıdır (Tabachnick vd., 2013). Basıklık ve Çarpıklık Analizi Sonuçları tabloları incelendiğinde, değişkenlerin ±3 sınırları içinde yer aldığı görülmektedir. Bu nedenle verilerin normallik varsayımını sağladıkları söylenebilir.

1.1.3. Kuruluşların Karakteristikleri İle İlgili Tanımlayıcı İstatistikler

Analizin bu kısmında, kuruluşların sahip oldukları karakteristik özelliklerin istatistik değerlerine yer verilmiştir.

4.5.3.1. Kuruluşların Türüne İlişkin Bulgular

Çalışmaya katılan kuruluşların cevapları incelendiğinde kuruluş türleri %93,2'sinin dernek, %3,9'unun vakıf ve %2,9'unun temsilcilik olduğu belirlenmiştir. Tablo 2 incelendiğinde kuruluşların çok büyük çoğunluğunun hukuki statüsünün dernek olduğu görülmektedir.

Tablo 2. Kuruluş Türlerine İlişkin Bulgular

Kuruluş Türü	***Frekans (f)***	***Yüzde(%)***
Dernek	96	93,2
Vakıf	4	3,9
Temsilcilik	3	2,9
Toplam	**103**	**100,0**

4.5.3.2. Kuruluşların Faaliyet Alanlarına İlişkin Bulgular

Elde edilen veriler kuruluşların faaliyet alanlarına göre Tablo 3 incelendiğinde, kuruluşların faaliyet alanlarının %11,7'sinin eğitim, %1'nin doğal afet, %11,7'sinin sağlık, %14,6'sının gıda tarım, %50,5'nin insani yardım, %1'nin koruma, %1'nin sağlık, eğitim ve gıda, %3,9'unun mülteciler, %2,9'unun kalkınma ve %1'nin göçmenler olduğu görülmektedir. Ayrıca %1'i cevap vermemiştir. Tablo 3 incelendiğinde çalışmaya katılan kuruluşların yarısının insani yardım alanında faaliyet gösterdiği görülmektedir.

Tablo 3. Kuruluşların Faaliyet Alanlarına İlişkin Bulgular

Kuruluş Faaliyet Alanı	***Frekans (f)***	***Yüzde (%)***
Eğitim	12	11,7
Doğal Afet	1	1,0
Sağlık	12	11,7
Gıda Tarım	15	14,6
İnsani Yardım	52	50,5
Koruma	1	1,0
Sağlık, Eğitim ve Gıda	1	1,0
Mülteciler	4	3,9
Kalkınma	3	2,9
Göçmenler	1	1,0
Kayıp	1	1,0
Toplam	**103**	**100,0**

4.5.3.3. Kuruluşların Bağlı Olduğu Ülkelere İlişkin Bulgular

Çalışmaya katılan kuruluşlar, menşei'leri açısından incelendiklerinde; kuruluşların %58,3'nün Türkiye, %1'inin Danimarka, %1'inin Japonya, %1'inin Polonya, %1'inin Avustralya, %1'inin Katar, %1'inin Libya, %1'inin İtalya, %1'inin İrlanda Cumhuriyeti, %1,9'unun Fransa, %1,9'unun Belçika, %1,9'unun Hollanda, %1,9'unun İsviçre,

%1,9'unun Norveç ve %1,9'unun Çek Cumhuriyeti, %4,9'unun Almanya, %4,9'unun Birleşik Krallık ve son olarak %12,6'sının ABD olduğu görülmektedir.

Tablo 4. Kuruluşların Bağlı Olduğu Ülkelere İlişkin Bulgular

Menşei Ülke	*Frekans (f)*	*Yüzde(%)*
Türkiye	60	58,3
Belçika	2	1,9
Danimarka	1	1,0
Japonya	1	1,0
Fransa	2	1,9
Polonya	1	1,0
Hollanda	2	1,9
Avustralya	1	1,0
Katar	1	1,0
Libya	1	1,0
ABD	13	12,6
Almanya	5	4,9
İsviçre	2	1,9
İtalya	1	1,0
İrlanda Cumhuriyeti	1	1,0
Birleşik Krallık	5	4,9
Norveç	2	1,9
Çek Cumhuriyeti	2	1,9
Toplam	**103**	**100,0**

4.5.3.4. Kuruluşların Üye Oldukları Kuruluşlara İlişkin Bulgular

Tablo 5 incelediğinde, çalışmaya katılan kuruluşların üye oldukları uluslararası kuruluşların %7,8'inin UN, % 1,9'unun Alliance ve Unicef, % 1'inin UNHCR, WHO, FAO ve ECRE Euromed olduğu görülmektedir. %84,5'lik bir kesimin ise herhangi bir kuruluşa üye olmadığı görülmüştür. Tablo 5 genel olarak incelendiğinde 87 kuruluş herhangi bir kuruluşa üye olmadığı görülmektedir.

Tablo 5. Kuruluşların Üye Oldukları Uluslararası Kuruluşların Dağılımı

Üye Olunan Kuruluşlar	*Frekans (f)*	*Yüzde(%)*
UN	8	7,8
Alliance	2	1,9
Unicef	2	1,9
UNHCR	1	1,0
WHO	1	1,0
FAO	1	1,0
ECRE, Euromed	1	1,0
Bir kuruluşa üye olmayanlar	87	84,5
Toplam	**103**	**100,0**

1.1.4. Araştırma Modelindeki Değişkenleri Tanımlayıcı Bulgular

Araştırmanın bu bölümünde analizi yapılan verimlilik performansı, etkinlik performansı ve lojistik performans değişkenlerini tanımlayıcı bulgulara yer verilmiştir.

Ortalama, birçok terimden oluşan bir sayıyı temsil ve ifadeye yeterli olan tek bir rakam olarak ifade denir (Kalaycı, 2009: 51). Aritmetik ortalama bir veri setindeki tüm değerlerin toplamının, o serideki veri sayısına bölünmesiyle bulunur (Kalaycı, 2009: 51). Standart sapma ise gözlemlerin ortalamalardan ne kadar uzaklaştığını gösterir ve varyansın pozitif karekökünе eşittir (Kalaycı, 2009: 53). Bu çalışmada frekans, yüzde, toplam, ortalama ve standart sapma gibi ölçüler yardımıyla analizler gerçekleştirilmiştir. Bu bulgular için 5'li Likert ölçeği kullanılmıştır. Ölçek 1-5 arası olarak kurgulanmış ve her bir ifade grubu için ayrı yargılarla ifade edilmiştir. Genel olarak ölçekte 1: ifadeye katılımın hiç olmadığını, 5: ise ifadeye katılımın en üst düzeyde olduğunu göstermektedir.

4.5.4.1. Verimlilik Performansının Ölçülmesine İlişkin Bulgular

Çalışmaya katılan kuruluşların verimlilik performanslarını ölçmek için katılımcılara 9 önerme yöneltilmiştir. Katılımcıların sorulara 5'li Likert tipi ölçeğe göre cevap vermeleri istenmiştir. Bu bölümdeki ifadelere verilen cevapların ortalamalarının genel ortalaması alındığında 3,96 sonucu çıkmaktadır. Bu sonuç, 5'li Likert tipi ölçeğe göre, katılımcı kuruluşların bu bölümdeki ifadelere katıldıklarını ve verimlilik performanslarının iyi olduğunu göstermektedir.

4.5.4.2. Etkinlik Performansının Ölçülmesine İlişkin Bulgular

Çalışmaya katılan kuruluşların etkinlik performanslarını ölçmek için katılımcılara 6 önerme yöneltilmiştir. Katılımcıların sorulara 5'li Likert tipi ölçeğe göre cevap vermeleri istenmiştir. Bu bölümdeki ifadelere verilen cevapların ortalamalarının genel ortalaması alındığında 3,98 sonucu çıkmaktadır ve etkinlik performanslarının iyi olduğunu göstermektedir.

4.5.4.3. Lojistik Performans Ölçümlerine İlişkin Bulgular

Çalışmaya katılan kuruluşların lojistik performanslarını ölçmek için katılımcılara 15 önerme yöneltilmiştir. Katılımcıların sorulara 5'li Likert ölçeğine göre cevap vermeleri istenmiştir. Bu bölümdeki ifadelere verilen cevapların ortalamalarının genel ortalaması alındığında 3,97 sonucu çıkmaktadır. Bu sonuç lojistik performanslarının iyi olduklarını göstermektedir.

4.5.5. Araştırmanın Diğer Bulguları

Araştırmanın bu bölümünde, araştırmada yer alan temel bulgulara ilişkin korelasyon ve regresyon analizlerine ve bu analizlerin sonuçlarına ilişkin bulgulara yer verilmiştir.

4.5.5.1. Korelasyon Analizi Sonuçları

Araştırmada yer alan değişkenlerin birbirleri arasında ilişki olup olmadığı ve ilişkinin yönünü araştırmak için kurulan hipotezler doğrultusunda korelasyon analizleri yapılmıştır.

Tablo 6 Lojistik performans ile verimlilik performansı, etkinlik performansı değişkenleri, aralarındaki ilişkiler açısından incelendiğinde; verimlilik performansı ile lojistik performans arasında pozitif yönlü ve istatistiksel olarak anlamlı bir ilişki (r=0,720; p≤ 0,01); etkinlik performansı ile lojistik performans arasında pozitif yönlü ve istatistiksel olarak anlamlı bir ilişki (r=0,515; p≤0,01); etkinlik performansı ile verimlilik performansı arasında ise pozitif yönlü güçlü bir ilişki belirlenmiştir(r=0,734; p≤0,01).

Tablo 6. Lojistik Performans ile Diğer Bileşenler Korelasyon Analiz Sonuçları

	Lojistik Performans	**Verimlilik Performansı**	**Etkinlik Performansı**
Lojistik Performans	1		
Verimlilik Performansı	,720** ,000	1	
Etkinlik Performansı	,515** ,000	,734** ,000	1

*p≤0,10, **p≤0,05,***p≤0,01

4.5.5.2. Regresyon Analizi Sonuçları

Tablo 7'de yer alan çoklu regresyon analizi sonuçları incelendiğinde araştırmada yer alan tüm değişkenlerin lojistik performansa olan etkileri görülmektedir. Araştırmada analizin bağımlı değişkenini lojistik performans, bağımsız değişkenlerini ise; kuruluş işbirliği, bilgi paylaşımı, verimlilik performansı, etkinlik performansı ve lojistik strateji oluşturmaktadır. Tablo 7'de yer alan düzeltilmiş R^2 değeri 0,823 olduğu ve tüm değişkenlerin lojistik performans üzerinde istatistiksel olarak anlamlı bir etkiye sahip olduğu görülmüştür (F=95,925; p≤0,01). Diğer bir ifadeyle verimlilik performansı ve etkinlik performansının, lojistik performansa ait varyansı % 82,3 oranında açıkladığı görülmektedir.

Tablo 7. Çoklu Regresyon Analizi Sonuçları

Bağımsız Değişkenler	***β***	***T***	***p***	***R2***	***Düzeltilmiş R2***	***F***
		-1,298	,000	0,832	0,823	95,925
Verimlilik Performansı	,335*	3,932	,000			
Etkinlik Performansı	-,206***	-3,115	,000			

Bağımlı değişken: Lojistik Performans,
*p≤0,10, **p≤0,05,***p≤0,01

5. Sonuç ve Öneriler

Bu çalışmanın odak noktasını, Türkiye'de faaliyet gösteren insani yardım kuruluşların lojistik performans değerlendirmesi oluşturmaktadır. Çalışmanın teorik kısmını takip eden alan çalışması kısmında Türkiye'de faaliyet gösteren insani yardım kuruluşlarının lojistik performansını değerlendirmek amaçlanmıştır.

Çalışmada yer alan değişkenler arasında oluşturulan hipotezler SPSS istatistik paket programı aracılığı ile Frekans, Güvenirlilik, Basıklık ve Çarpıklık, Regresyon ve Korelasyon analizleri yapılarak araştırılmıştır. Yapılan frekans analizinde kuruluşların karakteristik özellikleri ile ilgili sorulara verilen cevapların istatistiki verileri incelenmiştir.

verimlilik performansı, etkinlik performansı ve lojistik performans değişkenleri için uygulanan 5'li Likert ölçeğine verilen cevaplar incelenip tablolaştırılmıştır.

Bu çalışmada yer alan sorulara uygulanan güvenirlilik analizi sonuçlarına göre alan çalışması, yüksek güvenirlilik seviyesindedir. Çalışmada yer alan değişkenlerden etkinlik performansı ve lojistik performans güvenilir ölçek seviyesinde olup, diğer değişken olan verimlilik performansı yüksek güvenirlik seviyesindedir.

Lojistik performans alanında yapılan çalışmalarda güvenirlilik analizinin aksine geçerlilik analizi pek yapılmamıştır. Bu çalışmada kullanılan ölçekler daha önceki çalışmalarda uygulanıp olumlu sonuçlar elde edildiği görülmüştür. Bu neden bu araştırmada geçerlilik analizi yapılmamıştır. Kurulan regresyon modeline göre kuruluş işbirliğinin lojistik performans üzerinde etkili olduğu görülmektedir.

Kurulan regresyon modeline göre verimlilik performansını lojistik performans üzerinde etkili olduğu görülmektedir. Bu durumda araştırmanın ilk hipotezi olan *"**H1**: Kuruluşun verimlilik performansı, lojistik performansını pozitif yönde etkilemektedir."* **kabul** edilmiştir.

Kurulan regresyon modeline göre etkinlik performansını lojistik performans üzerinde negatif yönde etkili olduğu görülmektedir. Bu durumda araştırmanın ikinci hipotezi olan *"**H2**: Kuruluşun etkinlik performansı, lojistik performansını pozitif yönde etkilemektedir."* **red** edilmiştir (Tablo 8).

Tablo 8. Araştırmada Yer Alan Hipotezlerin Kabul / Ret Durumu

Hipotezler	**Kabul / Red Durumu**
H1: Kuruluşun verimlilik performansı, lojistik performansını pozitif yönde etkilemektedir.	Kabul
H2: Kuruluşun etkinlik performansı, lojistik performansını pozitif yönde etkilemektedir.	Red

4.3. Sonuç ve Tartışma

Son yıllarda meydana gelen, deprem, sel, orman yangını, salgın hastalıklar ve mülteci teknelerinin batması gibi insani krizler incelendiğinde, insani yardım kuruluşları aniden oluşan krizlere hızlı ve kaliteli lojistik destek sağlamak istedikleri görülmektedir. İstenilen hızda, kalitede ve etkinlikte lojistik destek sağlayabilmek için kuruluşların dikkat etmesi gereken unsurları bu çalışmada incelenmiş ve yapılan anket çalışması ile bu unsurların lojistik performansı ne derece etkilediği incelenmiştir.

Yapılan analizler sonucunda verimlilik performansı ve etkinlik performansının lojistik performans üzerinde etkiye sahip olduğu görülmüştür. Üçüncü sektör olarak adlandırılan sivil toplum alanında yetişmiş kalifiye personel bulmak, özel sektör ve kamu sektörlerine göre oldukça zorluk göstermektedir. Bu durum da insani yardım kuruluşlarında çalışan personelin ya geçici olarak çalışmasını ya da proje bazlı sözleşmeli olarak çalışmasına neden olmaktadır. Bu yüzden çalışanlar, çalıştıkları kuruluşlarda istikrar gösterememektedirler.

Ancak özellikle yurtdışı kaynaklı olan kuruluşların çalışanlarına uyguladıkları iyi ücret politikaları ve sundukları iyi çalışma şartları düşünüldüğünde buralarda çalışmak daha cazip hale gelmektedir.

İyi bir lojistik performans için birden fazla etken bulunmaktadır. Bu etkenlerin hepsi bir araya gelse bile kimi zaman yaşanan problemler bütün etkenleri yok sayıp lojistik faaliyetin aksamasına hatta durmasına neden olmaktadır. İyi bir lojistik performans için bürokratik izinlerle beraber iyi takım, iyi ekipman ve iyi zamanlama gibi olguların gerekliliği kesindir. İyi kurgulanmış bir lojistik koordinasyon sistemi kuruluşun her zaman iyi lojistik performans sergilemesini sağlar.

Ülkemizde de hem kamuya hem de özel sektöre bağlı kuruluşlar sahip oldukları organizasyonel yetenekler ve maddi imkanlar sayesinde son derece etkin çalışmaktadırlar.

Gelecekte bu konuda yapılacak çalışmalarda, insani yardım kuruluşlarının kendi tedarikçileri ile olan entegrasyonları da araştırılmaya dahil edilebilir. Çünkü tedarikçi entegrasyonu da kurumların performansları üzerinde önemli etkilere sahiptirler (Yıldız ve Çetindaş, 2020).

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RESEARCH ARTICLE

Evaluation of the Possible Use of the Ankara-Sivas High-Speed Railway Line for Freight Transport

Hülya Zeybek[1]

ABSTRACT

Logistics trends and the growing awareness of more sustainable transport in the global market have been a strong impetus for the growth of rail freight transport, particularly evident in the transport of time-sensitive, high-value, and capital-intensive goods. Therefore, expanded High-Speed Railway (HSR) systems provide a reliable opportunity for fast freight transport. In Turkey, the length of the HSR has reached 1,213 km and 1,889 km more are under construction, mostly dedicated to passenger transport. This research investigates the possible use of the new Ankara-Sivas HSR line for freight by analyzing the future traffic potential to find out the spare capacity for freight traffic. The results of the research reveal that the traffic potential on the Ankara-Sivas HSR line might not be justified by passenger traffic alone and the spare capacity should be used by express freight trains. Considering that Turkey is well prepared to become a Eurasian transport hub connecting Europe with Asia via the Middle Corridor, the outcome of this research may contribute to the development of suitable solutions that may improve the economic, environmental, and social sustainability of HSR systems.

Keywords: High-speed railways, Freight transport, Ankara-Sivas HSR, Middle Corridor, Trade

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[1] **Sorumlu yazar/Corresponding author:** Hülya Zeybek (Dr), Eskişehir Teknik Üniversitesi, Ulaştırma Meslek Yüksek Okulu, Eskişehir, Türkiye
E-mail: hulyazeybek@eskisehir.edu.tr ORCID: 0000-0002-4671-5330

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1. Introduction

In Turkey, expenditure on rail infrastructure increased significantly between 2003 and 2019. Within this 16-year period, USD 26.6 billion have been invested in rail infrastructure, mostly for passenger transport. For instance, in 2020, almost half of the planned rail investments are projected to be spent on HSR and SR (speed-rail), in which the Ankara-Sivas HSR line takes the biggest share, as in the previous year (UAB,2020). HSR has the ability to move goods in a more efficient, safe, and cost-effective way, which can improve trade links in Europe and Asia (Pazour et al. 2010). Although the majority of HSR lines around the world are dedicated to passenger traffic, in a number of countries freight services are operated on HSR (Watson et al., 2018). Without a doubt, HSR is a technological advance and a symbol of modernity. However, there are questions regarding its economic, social, and environmental impacts, which are enormously restrictive, as argued by Albalate and Bel (2012). Despite that, the growth of e-commerce and the development of digital technologies have increased the demand for fast delivery, requiring time-sensitive, reliable services. Currently, most of these goods are transported by road or air. However, all of these could be an opportunity for HSR freight services.

In general, high-speed lines are suitable where there are densely populated centers located between 100 and 1,000 km apart, especially between 200 and 600 km apart (UNECE, 2017). Cars at short distances and planes at longer distances are more competitive than HSR. Although HSR was first designed only for passenger transport, in the 1990s, some countries attempted to use high-speed rail networks for express freight services to yield economic benefits (Gao et al., 2017).

There are four different operational models for high-speed rail systems: 1) The exclusive exploitation model (Japanese Shinkansen): a complete separation between high-speed and conventional services, each with its own infrastructure; 2) Mixed high-speed model (the French TGV): high-speed trains run either on specifically built new lines or upgraded segments of conventional lines; 3) The mixed conventional model (Spain-AVE): some conventional trains run on high-speed lines; and 4) Fully mixed model allowing both high-speed and conventional services to run (at their corresponding speeds) on each type of infrastructure (Germany-ICE), where high-speed trains occasionally use upgraded conventional lines, and freight services use the spare capacity of high-speed lines during the night (de Rus et al., 2009).

High-speed rail infrastructure is an expensive investment. The cost of a line increases proportionally with the design speed, and infrastructure capable of handling very high-speed operations (300 km/h or more) is particularly costly (European Court of Auditors, 2018). Currently, many HSR lines have trouble covering construction costs with passenger revenues only, except for busy corridors such as Tokyo-Osaka or Paris-Lyon. Recovery of construction costs of HSR systems can be possible only through intensive use of their infrastructure. According to Amos et al. (2010), in a developing country with sufficient purchasing power, at least 20 million passengers per year must be expected to meet only the working expenses and interest costs of providing this capacity with high-speed service. If the market potential is not big enough to justify dedicated passenger use,

HSR could be designed for mixed traffic: freight and passenger operations. That is, the incremental cost of the construction of a high-speed rail system can only be recovered with the intensive use of the line.

In literature, there are few studies on freight transport using HSR. Troche (2005) analysed methods of coordinating passenger and freight transport on high-speed rail. In their study, Watson et al. (2018) considered the future trends and possibilities of shifting freight from roads to HSR lines and studied the operational and technological constraints concerning freight traffic and the corresponding capabilities of HSR. Pazour et al. (2010) proposed a model to design a national high-speed rail network for freight distribution. Some scholars focused on express freight transport by high-speed rail in China (Gao et al., 2017). Ertem and Özcan (2016) presented a mathematical model for adding freight trains on HSR systems in Turkey and tested the model's applicability on the Ankara–Eskişehir, Ankara–Konya, Ankara–Sivas, and Eskişehir–Istanbul lines, considering various scenarios. They concluded that using HSR for freight transport increases the capacity of railway systems substantially. However, there is no study on a specific HSR project. In this study, we focus on a specific HSR project in Turkey and evaluate the possible use of the Ankara-Sivas High-Speed Railway line for freight transport by analysing the future traffic potential to find out the spare capacity for freight traffic.

HSR in the World and Turkey

After the birth of the high-speed rail system in the world in Japan in 1964 (Shinkansen at 210 km/h), the first European high-speed train (TGV) launched in 1981 in France at 260 km/hour (UIC, 2020a). In Turkey, the first HSR train started operations between Ankara and Eskişehir in 2009. Ankara-Konya HSR launched in 2011 and, finally, Eskişehir-Istanbul HSR was put in service in 2014. They are all dedicated to passenger transport and 8.1 million passengers in total were transported by HSR in 2018 (UAB, 2020).

Regarding HSR freight services, trains running from Europe to London use HS1 through the Channel Tunnel Rail Link for freight transport. Sweden has high-speed freight trains delivering post regularly. In France, TGV passenger trains were converted to transport express freight on the North and South railway network. In Germany and France, the freight trains on HSR operate during the night with a fixed schedule. Currently, approximately 5% of express cargo is transported by HSR in China (Watson et al., 2018). China started developing freight HSR, which will deliver high-value freight, such as e-commerce parcels. With the rise of e-commerce between Europe and China, Russian Railways (RZD) is working to develop a concept for a high-speed freight train between Moscow and Kazan (700 km) that can achieve 2-3 days transit time across Russia (Railway Technology, 2018). In Europe, with the Euro-Carex project, major European freight airports (Liège, Paris, Frankfurt, Koln, Amsterdam, Brussels, and London) are connected to carry air containers using the existing HSR network (Strale, 2016). In the USA, Amtrak offers freight express services by using HSR trains to carry freight and post (Watson et al., 2018).

Express freight services can be operated on HSR lines in two ways, either integrated

with high-speed passenger trains or using special high-speed freight trains (Watson et al., 2018). Newly designed HSR freight trains are based on passenger rolling stock and organized as passenger trains. This operation eliminates the line capacity problem since freight multiple units (EMU's) can travel at the same speed as passenger trains. This will help improve the train utilisation rate.

This paper investigates the possible use of the new Ankara-Sivas HSR line for freight by analysing the traffic potential.

The Importance of the Ankara-Sivas HSR Line for Freight Transport on the Middle Corridor

The Turkish economy relies on an export-oriented development model, and brings imports from other countries that require high logistics performance in terms of speed, reliability, and connectivity (11th Development Plan of Turkey 2019-2023). In recent years, one significant characteristic of the Turkish economy is the increase in e-commerce. E-commerce is becoming an important export channel, as mentioned in Turkey's e-Export Strategy and Action Plan (2018-2020). The growing demand for e-commerce and express delivery services increases the opportunity for HSR to take part in the supply chain.

As an extention of the Baku-Tbilisi-Kars (BTK) Railway line and a section of the Kars-Edirne transit route, the construction of Ankara-Sivas High-Speed Rail (Figure 1) is an important mega project on the Middle Corridor connecting Asian countries to Europe via Turkey, with costs estimated over USD 1 billion. The Ankara-Sivas HSR project was designed for 250 km/h speed. The project includes 49 tunnels, totaling some 66 kilometers in length, with the longest being around 5.12 kilometers long. It will also have 53 viaducts totaling 27.5 kilometers in length. The line will also include 611 bridges and culvert structures and 217 overpasses and underpasses.

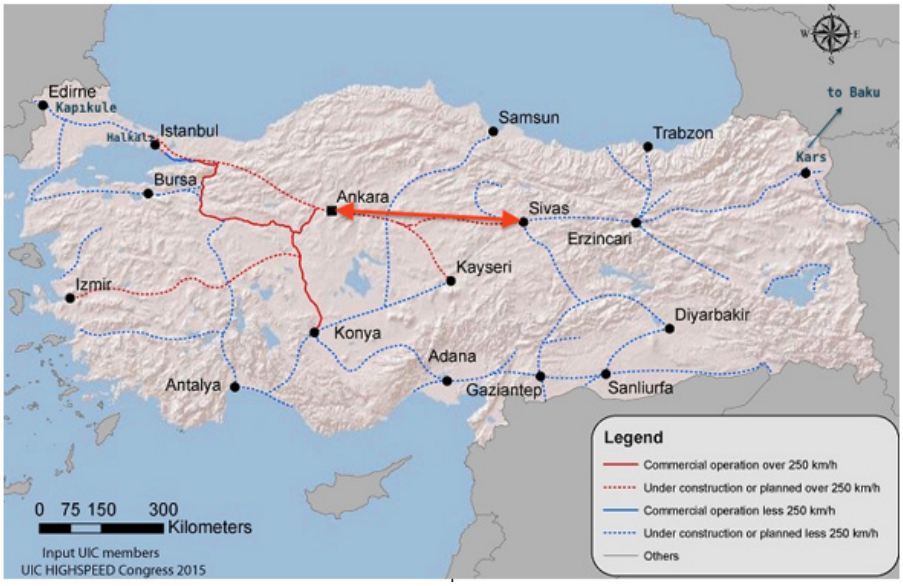

Figure 1. HSR Map of Turkey and the Ankara-Sivas HSR line

Source: Adapted from UIC, 2020b.High-Speed Database and Maps, https://uic.org/passenger/highspeed/article/high-speed-database-maps

The Ankara-Sivas HSR line is projected to be used as a passenger route. The population of Ankara is around 5.6 million, and Sivas has 600,000 people. This dedicated line could be quite expensive and unjustifiable on a cost-benefit basis, thus making mixed solutions a more viable option. If it is used as a cargo route as well, it can increase convenience and decrease the transit time of freight transport. Within this context, we will evaluate the importance of the Ankara-Sivas HSR Line for freight traffic from various aspects.

1. The Ankara-Sivas HSR Line is on the Eurasian Middle Corridor

The Middle Corridor is a multimodal corridor that aims to provide an alternative to the Eurasian northern routes and provides a strategic diversification away from reliance on Russia (Calabrese, 2019). It was launched in late 2013 to connect east and west, envisaging the revival of the ancient Silk Road.

This route starts from the Chinese port of Lianyungang and passes through Kazakhstan, the Caspian Sea, Azerbaijan, Georgia, and Turkey via the Baku–Tbilisi–Kars (BTK) railway extending further to Europe (Figure 2).

The Middle Corridor has gained a significant competitive advantage in terms of transport time and transport cost after the commissioning of the Baku-Tbilisi-Kars (BTK) railway line in 2017 and the opening of the Marmaray Bosphorus Tube Crossing to freight trains in 2019. There is an opportunity for the transport of high-tech electronic products such as laptops, hard disks, and semi-finished TV panels; textile products; auto parts; food and pharmaceutical products; and semi-finished and finished vehicles that require fast transport (Nikkei Asian Review, 2019). E-commerce transport could be a new market for this route. Thus, as an extension of the BTK Railway line, Ankara-Sivas HSR can contribute much to the competitiveness of the Middle Corridor.

Figure 2. Middle Corridor Route
Source: Middle Corridor (2020) https://middlecorridor.com/en/route

2. Significantly shortens the existing rail route; provides a direct link between Ankara and Sivas.

The current Ankara-Sivas railway is 603 km connecting the two cities via Kayseri, and the travel time is 12 hours (UAB, 2019). The Ankara-Sivas HSR line (Figure 1) will shorten the existing railway by 198 km, and traveling will take just two hours. Ankara-

Sivas HSR is an important section of the Kars-Edirne transit railway line connecting to the BTK line. However, as only passenger trains are planned to operate, this line will not contribute to the reduction of freight transport time on the Middle Corridor.

3. Other projects on the Kars-Edirne transit route are designed for mixed traffic

The line connecting Sivas to Kars will be upgraded to 200 km/h speed for mixed traffic-passenger and freight (UAB, 2019). Therefore, to extend the freight line to Ankara, it is logical to use the Ankara-Sivas HSR line for cargo transport as well.

The other important project on the transit route between Europe and China is the Halkalı-Kapıkule railway project, launched in October 2019 to modernize the 229-km railway connection between Halkalı (Istanbul) and Kapıkule (the Bulgarian border). This project has a total value of EUR 1 billion, of which the EU provided Turkey a 275 million grant. The EU funding is part of the investment portfolio in Turkey financed through the Instrument for Pre-Accession Assistance (IPA) funds for the period 2014-2020. The double-track electrified line will have 200 km/h design speed and will be equipped with signaling systems that are compatible with EU standards (ERTMS/ETCS Level 1) (Railwaypro, 2019).

4. Rail transport is suitable for the transport of high-value and e-commerce goods in Eurasian trade

The choice of rail instead of maritime or road shortens the transport time between Europe and China. Therefore, more high-value and capital-intensive products can be transported by intercontinental rail. Moreover, as a result of developments in logistics, less cargo than a full container load (LCL-Less than Container Loads) is now possible on Eurasian rail routes (Rastogi and Arvis, 2014), so shipments not large enough to fill a whole container be transported. This development creates a competitive advantage for rail freight. Transport of e-commerce products has great potential for the Eurasian container transport market, and the railway will play an important role in this market by filling a market niche with minimum environmental impact.

5. Contribute to sustainable Eurasian transport

The sustainability of a transport system is measured by its effectiveness, efficiency, and environmental impacts (Jeon and Amekudzi, 2005). The development of HSR freight transport may create great economic, social, and environmental benefits for society by reducing the number of trucks on roads, minimizing carbon dioxide emissions, and attracting new enterprises to HSR freight.

2. Data and Methodology

To find out if the market potential of Ankara-Sivas HSR (currently under construction) is enough to justify dedicated passenger use, and if there will be spare capacity for freight operations, we applied a simplified "gravitation approach" to the Ankara-Sivas HSR line to determine the "absolute traffic demand potential" (ATDP). ATDP only reflects the geographical and demographic conditions in the region, it does not consider the effect

of the economic environment (GDP per capita value of a country and the time horizon in consideration) and the corresponding mobility level of the country. This approach was adapted from UNECE's Trans-European Railway High-Speed Master Plan Study-Phase 1 (2017). The absolute traffic demand potential shows the total potential of passenger traffic between two links, covering all modes in the considered route.

The formula of ATDP is as follows:

$P_{i\text{-}k} = a \cdot U_i \cdot Uk / D_{i\text{-}k}^{\ f}$.

$P_{i\text{-}k}$ number of travellers (e.g. per day)

a coefficient depending on several parameters, in particular GDP per capita (To compare links, as foreseen in the context of this study, this factor may be set a = 1, to obtain relative results Pi-k, not absolute figures.)

U_i number of inhabitants of city i

U_k number of inhabitants of city k (It is better to use inhabitants of entire agglomerations, but these data are not generally available.)

$D_{i\text{-}k}$ distance of the urban agglomerations U_i and U_k

f exponent describing the abating of the mutual attractiveness of the agglomerations dependening on distance (f = 1.7 is used in all calculations).

The cities are listed with their numbers of inhabitants (in millions, e.g. Ankara 4,78 means 4.78 million inhabitants) and the links with their beeline lengths (in hundred kilometres, e.g. Ankara-Sivas 3,41 means 341 km). In the first column and in the first row of the first section of Table 1, the names of the cities Ui-ν, respectively Uk-μ; in the field where the second row and the second column cross, the beeline distance between Ui and Uk is listed. The second part of Table 1 for Ankara–Sivas has been completed with the individual results of applying the "gravitation formula," by multiplying together the numbers of inhabitants of the relative cities (see left columns and upper rows of the Table) and dividing each of the products by their mutual distance (see second columns from the left and second rows from above in the matrices of Table 1) to the power of 1.7.

Table 1. Absolute traffic demand potential (ATDP) of Ankara-Sivas HSR line

		Sivas+ Yozgat	Samsun	Erzurum	Kars	Tbilisi	Baku	Kayseri	Malatya	Diyarbakir	Van	Teheran
		0,49	0,61	0,35	0,12	1,17	2,14	1,06	0,35	0,93	0,35	8,15
Ankara+												
Kirikkale	4,78	3,41	1,53	7,39	9,10	11,03	15,45	2,56	5,35	7,21	8,96	16,73
Eskisehir	0,69	5,47	5,35	9,45	11,16	13,08	17,51	4,62	6,92	8,66	11,02	18,79
Adapazarı	0,27	6,52	6,40	10,50	12,21	14,14	18,56	5,67	8,47	9,01	12,07	19,84
Istanbul	14,66	7,77	7,65	11,75	13,46	15,39	19,81	6,92	9,72	10,23	13,32	21,09
Edirne	0,15	9,90	9,78	13,88	15,59	17,52	21,94	9,05	11,85	12,39	15,45	23,22
Sofia	1,21	12,83	12,71	16,81	18,52	20,45	24,87	11,98	14,78	16,63	18,38	26,15
Bucharest	1,88	13,31	13,19	17,29	19,00	20,93	25,35	12,46	15,26	17,11	18,86	26,63
Belgrade	1,35	16,18	16,06	20,16	21,87	23,80	28,22	15,33	18,13	19,98	21,73	29,50
Kutahya	0,20	6,04	5,92	10,02	11,73	13,66	18,08	5,19	7,28	9,05	11,59	19,36
Balikesir	1,19	7,82	7,70	11,80	13,51	15,44	19,86	6,97	9,12	14,08	13,37	21,14
Manisa	0,28	9,06	8,94	13,04	14,75	16,68	21,10	8,21	9,47	11,19	14,61	22,38
Izmir	4,11	9,35	9,23	13,33	15,04	16,97	21,39	7,28	9,74	11,44	14,90	22,67
Afyon	0,21	6,99	6,87	10,97	12,68	14,61	19,03	6,14	6,77	8,50	12,54	20,31
Denizli	1,00	8,06	7,94	12,04	13,75	15,68	20,10	7,21	8,10	9,78	13,61	21,38
Konya	1,22	5,69	5,57	9,67	11,38	13,31	17,73	4,84	5,13	6,80	11,24	19,01
Antalya	2,22	7,62	7,50	11,60	13,31	15,24	19,66	4,68	6,89	8,47	11,24	20,94
Mersin	0,96	8,67	8,55	12,65	8,46	16,26	20,68	2,28	3,67	5,08	13,17	22,09
Adana	1,72	3,40	4,85	6,10	7,84	16,00	20,42	1,94	3,03	4,43	7,27	21,83
Gaziantep	1,56	3,00	4,85	4,63	6,34	8,23	11,44	2,50	1,65	2,68	5,51	16,02
Ankara+												
Kirikkale		0,291	1,415	0,056	0,013	0,094	0,097	1,025	0,097	0,155	0,040	0,324
Eskişehir		0,019	0,024	0,005	0,001	0,010	0,011	0,054	0,009	0,016	0,004	0,038
Adapazarı		0,005	0,007	0,002	0,000	0,003	0,004	0,015	0,003	0,006	0,001	0,014
Istanbul		0,220	0,281	0,078	0,021	0,164	0,196	0,580	0,107	0,262	0,063	0,670
Edirne		0,001	0,002	0,001	0,000	0,001	0,002	0,004	0,001	0,002	0,001	0,006
Sofia		0,008	0,010	0,003	0,001	0,008	0,011	0,019	0,004	0,009	0,003	0,038
Bucharest		0,011	0,014	0,005	0,002	0,013	0,017	0,027	0,006	0,014	0,004	0,058
Belgrade		0,006	0,007	0,003	0,001	0,007	0,010	0,014	0,003	0,008	0,003	0,035
Kutahya		0,005	0,006	0,001	0,000	0,003	0,003	0,013	0,002	0,004	0,001	0,011
Balikesir		0,018	0,023	0,006	0,002	0,013	0,016	0,046	0,010	0,012	0,005	0,054
Manisa		0,003	0,052	0,042	0,039	0,036	0,031	0,054	0,056	0,065	0,039	0,030
Izmir		0,045	0,057	0,018	0,005	0,039	0,048	0,149	0,030	0,061	0,015	0,166
Afyon		0,004	0,005	0,001	0,000	0,003	0,003	0,010	0,003	0,005	0,001	0,010
Denizli		0,014	0,018	0,005	0,001	0,011	0,013	0,037	0,010	0,019	0,004	0,045
Konya		0,031	0,040	0,009	0,002	0,018	0,020	0,089	0,026	0,044	0,007	0,067
Antalya		0,034	0,044	0,012	0,003	0,025	0,030	0,171	0,029	0,055	0,013	0,103
ATDP	9,338											

The sum of all the inner fields of the second part of Table 1 is the ATDP value of the Ankara-Sivas HSR line, which is 9,338. This value only represents sizes and distances between cities. In order to also include the influence of growing traffic demand, "weighted traffic demand potential" (WTDP) of Ankara-Sivas HSR for the years 2030 and 2050 is calculated by using the GDP per capita estimations of the Vienna Institute for International Economic Studies (WIIW) for 2030 and 2050. As shown in Table 2, the ATDP of the Ankara-Sivas HSR line is multiplied by the relevant GDP per capita quotient (GDP of Turkey/EU average GDP per capita in 2016) to find out the WTDP figure of this line.

Table 2. Weighted traffic demand potential (WTDP) of Ankara-Sivas HSR line

	GDP-Ratio: GDP per capita (year)/ EU average 2016					**WTDP = ATDP * GDP-Ratio**			
	ATDP	2030	2050 Low	2050 Medium	2050 High	2030	2050 Low	2050 Medium	2050 High
Ankara-Sivas	9,338	0,86	0,86	1,03	1,20	8,03	8,03	9,62	11,21

The resulting WTDP values for the lower scenario ("L") for 2050 and those for 2030 are equal with the assumption that from 2030 to 2050, no further growth will take place. This WTDP approach allows a simple but reasonable estimation to find out whether the future traffic demand is appropriate only for dedicated or mixed traffic. For comparison, the WTDP figures of some other HSR links are given in Table 3.

Table 3 . Weighted traffic demand potential (WTDP) of some other HSR lines

		GDP-Ratio: GDP per capita (year)/ EU average 2016				**WTDP = ATDP * GDP-Ratio**			
	ATDP	2030	2050 Low	2050 Medium	2050 High	2030	2050 Low	2050 Medium	2050 High
Edirne - Istanbul	10.105	0,86	0,86	1,03	1,20	8,69	8,69	10,41	12,13
Eskisehir -Istanbul	19.336	0,86	0,86	1,03	1,20	16,63	16,63	19,92	23,20
Polatli-Eskisehir	17.701	0,86	0,86	1,03	1,20	15,22	15,22	18,23	21,24
Cologne-Frankfurt	12.247	1,54	1,54	1,74	1,94	18,86	18,86	21,31	23,76
Paris - Lyon	11.256	1,39	1,39	1,53	1,67	15,65	15,65	17,22	18,80
Source: UNECE, 2017									

Table 3 shows that Paris-Lyon, Cologne-Frankfurt, and Polatli-Eskisehir-Istanbul HSR lines have a high enough level of traffic demand to justify the investment due to the significant number of large cities (Istanbul in particular) located at relatively close distances, and also economic growth. The WTDP of Ankara-Sivas is quite lower than other examples and high-speed on this line might not be justified by passenger traffic alone. However, prior to decision-making, a more in-depth investigation of traffic demand might be needed since the resulting WTDP figures only indicate the traffic demand in a certain link, covering all modes of transport, due to geographical conditions and population. The real exhaustion of this potential for rail depends on its competitiveness against other modes in terms of travel times and prices, as well as soft factors like the service quality of rail, etc.

2. Conclusions

Turkey has a key location along the Eurasian Middle Corridor between Europe and China, which may result in fast-growing freight transport in the future, resulting in the need for new capacities for freight. This may mean that HSR projects become viable when carrying passengers and freight together. The development of a HSR line requires

large construction and operating costs. Thus, the economic rationale for the new HSR infrastructure largely depends on the expected volume of demand. Turkey is investing a lot in HSR projects. In this study, we investigated whether the market potential of the Ankara-Sivas HSR under construction is enough to justify passenger use only, and whether there will be any spare capacity for freight operations. We have chosen the Ankara-Sivas HSR line as a case because this line is an important section of the Eurasian transit corridor between Europe and Asia. Any improvement in the transit time will contribute much to the competitiveness of the Eurasian Middle Corridor. As a result of the analysis, we have found that the traffic potential on the Ankara-Sivas HSR line might not be justified by passenger traffic alone. There is a new opportunity for express freight trains using HSR. Railways can transport freight from China quicker, cheaper, and greener, despite the need for gauge changes and border crossings. The HSR can offer a fast, reliable, and convenient way to transport high-value, low-weight goods. The negative impact on the economy and environment highlights the importance of HSR as a good alternative for express freight transport. In this study, we applied a simplified "gravitation approach" to the Ankara-Sivas HSR link to determine the "absolute traffic demand potential" (ATDP) and "weighted traffic demand potential" (WTDP). This approach allows a simple but reasonable estimation to find out the future traffic demand. However, these methods cannot replace a more in-depth investigation of traffic demand prior to decision-making. Moreover, the technical and operational limitations of using the Ankara-Sivas HSR line for freight have not been studied. These may be the subject of further studies.

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RESEARCH ARTICLE

Minimizing Solid Waste Collection Routes Using Ant Colony Algorithm: A Case Study in Gaziantep District

Katı Çöp Toplama Rotalarının Karınca Kolonisi Algoritması ile Minimizasyonu: Gaziantep'te Bir Uygulama

Serap Ulusam Seçkiner[1], **Amanuel Moges Shumye**[2], **Sena Geçer**[3]

ABSTRACT

This paper proposes an ant colony optimization algorithm for a capacitated vehicle routing problem to determine the shortest waste collection and transportation route covered by a waste collection truck in the Şahinbey municipality of Gaziantep/Turkey. The real-case problem concerns a capacity-restricted garbage compactor truck that collects and transports waste from 349 residential waste containers located in 148 collection points. Possible solutions obtained from the ant colony algorithm were compared with mixed-integer programming model solutions. The results of the proposed ant colony optimization algorithm showed that our model yields a 28% reduction in the total daily traveled distances and energy savings against existing consumption. The new solution also cuts the current annual waste collection and transportation expenditure per vehicle by 30%. It is shown that a considerably shorter route distance obtained in the algorithmic solution helps to reduce air pollution from the infamously inefficient garbage collection trucks. Eventually, the new route will considerably reduce labor costs, the high price of fuel, machinery and equipment maintenance as well as environmental pollution, because garbage compactor trucks are one of the least efficient vehicles on the road.

Keywords: Solid waste management, Route optimization, Capacitated traveling salesman problem, Ant colony optimization, Mixed-integer linear programming

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[1] **Corresponding author:** Serap Ulusam Seçkiner (Prof. Dr.), Gaziantep Üniversitesi, Mühendislik Fakültesi Endüstri Mühendisliği Bölümü, Gaziantep, Türkiye. E-mail: seckiner@gantep.edu.tr, ORCID: 0000-0002-1612-6033

[2] Amanuel Moges Shumye (Lisans öğrencisi), Gaziantep Üniversitesi, Mühendislik Fakültesi Endüstri Mühendisliği Bölümü, Gaziantep, Türkiye. ORCID: 0000-0001-6707-3560

[3] Sena Geçer (Lisans öğrencisi), Gaziantep Üniversitesi, Mühendislik Fakültesi Endüstri Mühendisliği Bölümü, Gaziantep, Türkiye. ORCID: 0000-0002-9263-171X

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1. Introduction

Strengthening waste management has vital importance for ensuring the sustainable use of natural resources and protection of the environment and human health, and it is a fundamental factor in ensuring a better quality of life for present and future generations (Bilgi 2018). Especially in developing countries such as Turkey, the development of proper waste collection and transportation systems is key to promoting growth in the long term. Being one of the fastest developing cities both in the economy and population in Turkey, Gaziantep is the 6th biggest city of Turkey with a population of 2,5 million residents on a surface area of 6819 km^2. The increase in solid waste production has started to become one of the major environmental problems in parallel with the rapid population increase, developing industrialization and changes in the social and economic status of society, and unplanned urbanization in Turkey (Gören et al. 2018). Consequently, Gaziantep is experiencing a high increase in the quantity of solid waste produced each day. However, there has not been much work done to make waste collection efficient and cost-effective.

The existing solid waste collection and transportation system in the Gaziantep metropolitan municipality has a branch of waste management that manages all waste management operations with eight environmental engineers. The solid wastes, medical wastes, waste vegetable oils, and waste batteries in the province of Gaziantep are collected without harming the environment and disposed of through joint works with local administrations, non-governmental organizations, and licensed firms in line with the regulations published by the Ministry of Environment and Urban Planning. Among the different district municipalities, Şahinbey and Şehitkamil collect and transport solid waste to the Gaziantep Metropolitan Municipality Landfill Area. Gaziantep has 2 Landfills; Central Landfill (1500 ton/day) and Nizip Landfill (200 ton/day). Central Landfill, which takes 1.5 million m^2 of the area was constructed in 1996 and has a capacity of 30 million m^3. Statistics show that 7 million tons of solid waste were stored in the Central Landfill Area between 1996-2015 (Köse et al. 2007). Güneykent is one of the most populated districts in the Şahinbey Municipality. Its solid waste is collected using metal containers each with a capacity of 400 L as well as plastic-made containers with a capacity ranging up to 770 L. The collection and transportation of solid waste in this district are carried out by using waste collection trucks of varying capacity up to 11 tons of waste operating in a single shift from 3pm to 10am daily.

1.1. Problem definition

Solid waste collection and transportation constitutes an integral part of solid waste management systems in urban areas, thus comprising the biggest share in the list of costs involved in the municipality Solid Waste Management System (SWMS) including processing, disposal, processing, and other related costs. This critical process should be performed effectively and efficiently to avoid costly expenditures and ensure environmental health. If waste is not collected properly, then nuisance may occur in the waste generation area (Hannan et al. 2017).

Many issues exist in the SWMS currently in practice in the Şahinbey municipality. In a municipality of over 900,000 residents, there is an obvious lack of an integrated SWMS that combines scientific approaches to best meet the demands of residents in the most economical way. This includes modernizing the heuristic approach followed concerning the assignment of vehicles and scheduling of waste collection activities. Moreover, the traditional judgemental methods used to anticipate the expected fill-up rate of containers, the emptying frequency of dumpsters, and locations of collection infrastructures are largely prone to inaccuracies. This, in return, leads to excessive transportation costs due to the prevalence of zero miles.

A typical waste collection and transportation routine in the Güneykent district is carried out by allocating SWC trucks to collect solid waste from open containers located in predetermined locations using routes that are flexibly determined by truck drivers solely based on their experience and judgment. This intuitive approach to route determination might improve the quality of the total collection and transportation route through time but can only achieve limited accuracy due to its dependency on personal judgment. More than sixty percent of the costs in SWMS in different countries are due to labor costs, the high price of fuel and machinery, and equipment maintenance all of which are highly dependent on the collection and transportation route was chosen (Talebbeydokhti et al. 2013). As a result, the district continues to record high expenditure related to these activities. By identifying this room for improvement, we apply a scientific approach by formulating a capacitated travel salesman problem to optimize the process of route determination in the Güneykent district.

Some research has been made in the area of solid waste collection and transportation systems using different formulation approaches. Most of these experiments have concentrated on optimizing the collection and transportation systems implemented in urban municipalities. More specifically, researchers have conducted a variety of scientific experiments in the area of optimization of municipality solid waste collection and transportation routes by applying conventional, heuristic, and meta-heuristic optimization algorithms. For example, Das and Bhattacharyya (2015) formulated mixed-integer linear programming (MILP) to a route optimization problem and then proposed a heuristic solution for an optimal waste collection and transportation system. Beijoco et al., 2010 modeled the fill-up rate and emptying frequencies of dumpsters to optimize glass waste transportation routes for time and distance by using ArcGIS network analyst software. Bhambulkar (2011) used it to optimize solid waste collection routes by taking into account essential road restrictions. However, all software applications are not up to the mark for solid waste collection optimization. Hanna et al., (2020) searched the waste collection objectives, constraints, and modeling approach for sustainable development. Mamashli and Javadian (2020) proposed a model for optimizing sustainable design modifications of the municipal waste management network. Mojtahedi et al., (2021) studied solid waste management for sustainable vehicle routing problems. Liu and Liao (2021) tackled a two-echelon collaborative waste collection routing problem from an optimization and profit perspective.

Another group of more advanced optimization methodologies are being used in this area is meta-heuristic optimization algorithms. These methods have become increasingly popular in studies conducted in recent years. One of those approaches was implemented by Hannan et al. 2017, where a modified particle swarm optimization algorithm (PSO) was used to solve a capacitated vehicle routing problem. Karadimas et al. 2007 applied the genetic algorithm to minimize solid waste collection routes, and Islam and Rahma (2012) implemented the ant colony algorithm with different constraints including time windows, driver rest periods, and multiple disposal facilities.

These studies have investigated the relative performance of different optimization techniques to formulate and optimize real-world solid waste collection and transportation routes. Among municipal waste management studies, it can be mentioned about some research. For example, Nguyen et al., (2021) compared six data-driven machine-learning methods to predict municipal solid waste generation and random forest and k-nearest neighbor were the most effective algorithms. For readers, Abdallah et al., (2020) published a review of artificial intelligence methods for solid waste management. This review provides a comprehensive analysis of the different Artificial Intelligence models and techniques applied in Support Vector Machine application, domains, and reported performance parameters.

It is impractical to find the shortest paths of a Travelling Salesman Problem (TSP) consisting of a large number of destinations, as the problem becomes exponentially difficult with increasing locations. Especially during combinatorial problems where the solution space of the existing network is vast, exact optimization techniques such as mixed integer programming fail to give reliable solutions in practical computation time. Heuristic approaches, on the other hand, have been proved, in different route optimization problems, to give near-optimal solutions within a reasonable amount of time.

1.2. Objective and constraints

This paper attempts to optimize solid waste collection and transportation routes currently in practice in the Güneykent district of Şahinbey municipality to minimize the costs associated with solid waste collection and transportation activities including labor costs, fuel consumption, and vehicle maintenance and operating costs. This reduction in fuel consumption will eventually contribute to the reduction of environmental emissions and global warming. Optimization for distance will also increase the efficiency of the SWMS as the same; even better, activities are performed at less cost and relatively less time.

Below is a more specific and detailed description of the main objectives and sub-objectives of this study:

- Determining the shortest path followed by a garbage compactor truck that collects and transports solid waste from 349 residential waste containers to a disposal ground in the Güneykent district of Şahinbey municipality,
- Testing and investigating the performance of an ant colony algorithm optimization (ACO) approach to a capacitated travel salesman problem,

- Comparing the optimized routes generated by a meta-heuristic method (ACO) with that of an exact method (mixed-integer linear programming),
- Performing performance analysis of ACO and mixed-integer programming by studying their computational time in solving small scale TSPs
- Evaluating the quality of the existing solid waste collection and transportation route by comparing it to near-optimal routes developed through ACO.

Gaziantep city has an SWMS that consists of hundreds of vehicles and tens of thousands of containers. To best understand the effectiveness of the proposed optimization methods, the area of this investigation is concentrated on a specific region in the city of Gaziantep, where a comparatively organized waste collection routine is observed. The availability of complete geographical information on the location of solid waste containers, ease of access to the required data, and the presence of fixed vehicle scheduling are some of the most important factors that are taken into account when determining the scope of this study.

The vehicle (garbage compactor truck) in our study has an important capacity constraint that hinders it from visiting all the collection nodes in a single tour. Therefore, we developed our problem as a capacitated travel salesman problem (CTSP) which is different from a typical TSP. A CTSP is a routing problem in which a vehicle has a limited capacity that prevents it from visiting all locations in one tour, thus necessitating a second return tour. Our problem has been formulated as a CTSP during which each time the garbage compactor truck visits a point of residential waste containers its capacity decreases. After it has collected waste from a fixed number of points the truck has to travel to a disposal ground to unload and then return to the remaining points to complete its tour. The vehicle in our study has a capacity of carrying garbage from 200 - 205 containers in a single tour.

2. Materials and methods

As mentioned earlier, the determination of the area of our study aimed at finding a region that will help us effectively demonstrate the performance of the ACO algorithm implemented in our study. The Güneykent district was determined to be the most suitable region for our study as it has stationary and better organized waste container locations. We have also found it comparatively easier to access information from the Şahinbey municipality than other municipalities.

Once the type of problem and the location of the study was decided, several procedures were followed to gather the necessary information needed to conduct the research. To facilitate data collection, questionnaires and interviews were prepared. Information regarding the existing solid waste collection and transportation system was mainly collected through multiple interviews with the director of waste management services at the Şahinbey Municipality and environment and the vice president of the Şahinbey municipality. Some interviews were undertaken with specific discussions on the number of containers and locations, the type, capacity, and the number of waste collection trucks used, the operation mode of the existing waste collection and transportation, etc. An important part of the data collection process was the field survey where accurate information on the location of containers was obtained.

In the following stages of the project, Google Maps was utilized to organize and integrate the qualitative, numerical, and geographical data collected. Furthermore, tasks including geographical analysis, visualization, editing, and data conversion were performed on a geographical information system software called ArcGIS. ArcMap, the main component of ArcGIS, has many toolboxes included such as conversion tools, network analysis, and data management tools. These tools were also especially helpful in generating the distance matrix and determining the current waste collection and transportation routes. A distance matrix containing the shortest driving distances between each of the containers was generated using the ArcMAP's network analyst tool.

To find a near-optimal solution to the given capacitated travel salesman problem in a reasonable amount of time, the ACO algorithm approach was used. This algorithm is preferred over exact methods to solve combinatorial routing problems since even though the latter guarantees optimal solutions, it is extremely time-consuming, especially in cases of large combinatorial problems such as ours. However, we have also tried to propose a model of a smaller version of our original CTSP using mixed-integer linear programming, and compared its performance with that implemented using the ACO algorithm.

MATLAB R2018b was employed to formulate an ACO algorithm of the capacitated travel salesman problem. Further graphical analysis, the tuning of parameters, and the evaluation of solutions were also carried out on the same platform. As a test study, the optimization modeling software LINGO was also utilized to formulate a mixed integer programming model of a lower-scale TSP with 9 stops collection. The block diagram of the proposed method is given Figure 1.

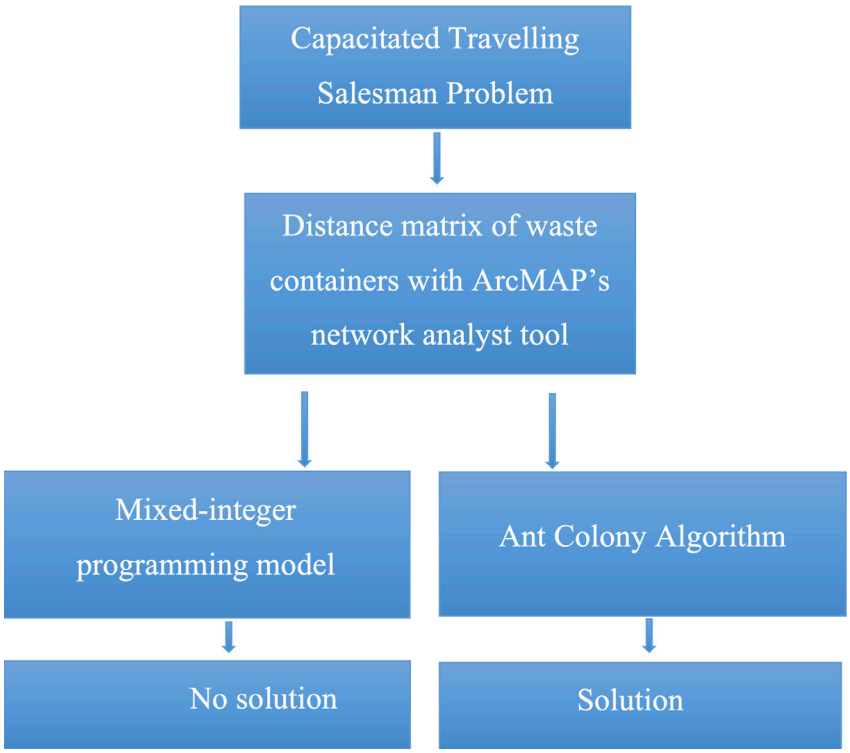

Figure 1. Block diagram of the proposed method

2.1. The Ant Colony Optimization

Ant colony optimization is a population-based metaheuristic that can be used to find approximate solutions to difficult optimization problems (Dorigo 2007, Dorigo & Stützle 2004). Artificial ants are forms of coordination that exhibit the properties of real ants but are used to model and solve complex combinatorial problems using an ant colony algorithm. Artificial ants can be considered as paths. Shortest path problems such as TSP can be modeled as a problem where an ant colony tries to determine the shortest path from its nest to a food source.

The probability of an ant colony to choose the next edge depends on two important parameters; the pheromone deposition on and the desirability of the edges attached to the current node. Pheromone deposition refers to the level of pheromone present on a given edge at the time of decision (after pheromone updating and evaporation have been carried out). This way edges that have high pheromone concentration will have a greater probability of being chosen than those with low pheromone deposition, meaning they have been visited less frequently by earlier ants. An ant colony also considers the desirability of an edge before deciding on choosing the next edge of its tour. This parameter is inversely proportional to the relative length of an edge; the shorter the path, the higher the probability of an ant choosing it and vice versa.

To express the relative weight (importance) of these two factors on decision making ACO uses two more parameters; pheromone heuristic factor (α) and expected heuristic factor (β). The pheromone heuristic factor expresses the power of pheromone that emphasizes the influence of the pheromone deposition on decision-making, whereas the expected heuristic factor expresses the relative weight of the desirability (quality) of an edge on calculating the probability of choosing a path. Optimizing these parameters helps to improve the convergence speed and global optimization ability of the algorithm (Chen 2016).

The general mathematical formulation of an Ant System (AS) for a TSP consists of three important components. We first need to simulate the concept of pheromone trails mathematically. Then, the pheromone equation should be modified to account for pheromone update and volatility (evaporation). Given that information, the probabilistic decision for constructing the solution is formulated. The roulette wheel selection procedure is then utilized to select potential solutions using the calculated probabilities.

Given an ant *k* in a colony of ants, the pheromone laid by ant *k* on the path between nodes *i* and *j* is given by (see Eq.1):

$$\Delta \tau_{i,j}^{k} = \begin{cases} \frac{1}{L_K}, if\ the\ kth\ ant\ travels\ on\ the\ edge\ i,j \\ \end{cases} \quad (1)$$

where L_k is the length of the tour of the k^{th} ant

0, otherwise

The pheromone deposited by all ants on the edge *i, j* before the effect of evaporation is expressed as in Equation 2:

$$\tau_{i,j}^{k} = \sum_{k=1}^{m} \Delta \tau_{i,j}^{k} \quad (2)$$

where $\Delta \tau_{i,j}^{k}$ is the amount of pheromone deposited by ant k on the edge *i, j*

m is the number of ants

The previous equation can also be adjusted to include the effect of evaporation on the pheromone concentration of each edge (see Equation 3):

$$\tau_{i,j}^{k} = (1-\rho)\ \tau_{i,j}^{k} + \sum_{k=1}^{m} \Delta \tau_{i,j}^{k}, \qquad 0 \leq \rho \leq 1 \quad (3)$$

where ρ is the rate of evaporation

Whenever an ant *k* reaches certain node *i*, the decision of choosing the next edge of its tour *(i, j)* is given by the following probability (see Equation 4):

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha} (\eta_{i,j})^{\beta}}{\sum (\tau_{i,j})^{\alpha} (\eta_{i,j})^{\beta}}, \quad \eta_{i,j} = \frac{1}{L_{ij}} \quad (4)$$

Where $\eta_{i,j}$ indicates the desirability of the edge *i, j*

The roulette wheel selection procedure assigns the next point of the tour based on calculated cumulative sums and random number generation. The process has three main steps:

- Calculate the cumulative sum for each of the *n* candidate edges using their probabilities
- Generate a random number *r* ($0 \leq r \leq 1$)
- Use the calculated cumulative sums as upper and lower limits to divide *r* into *n* intervals
- The next edge is the edge whose cumulative sum is the upper limit of the interval in which the random number *r* falls

3. Case study

A geographical analysis of the spatial data has been carried out to generate inputs that would feed the algorithm, including location coordinates and a distance matrix. Our problem has been formulated as a CTSP during which each time the garbage compactor truck visits a point of residential waste containers, its capacity decreases. After it has collected waste from a fixed number of points the truck has to travel to a disposal ground to unload and then return to the remaining points to complete its tour. The garbage carrying capacity of the vehicle has been determined to be 200-205 containers on a single tour. Therefore, the algorithm had to be developed by considering this capacity constraint.

3.1. Geographical analysis

As a result of the field survey, the total number of residential waste containers in the area of study has been determined to be 349. To facilitate effective analysis of the routing problem, the container system has been divided into 148 points of a collection each containing

varying numbers of residential waste containers ranging from 1 to 12 depending on the location of the point. A geographical view of the location of residential waste containers in the Güneykent district is given in Figure 2 scale as 1:12,500.

Figure 2. A geographical view of the location of residential waste containers in Güneykent district

Once the required data on the location of residential waste containers were gathered, it was integrated with other qualitative, numerical, and geographical data using ArcMAP. Primarily, the location of each point has been converted from geographical to cartesian (x,y) coordinates to ease the implementation of the ACO algorithm (see Table 1). Another important part of this analysis was the determination of a distance matrix by calculating the shortest driving distance between each of the 148 points including the disposal ground (see Table 2).

Table 1. A portion of the coordinates and the number of containers of each collection point

Collection point	Point_*x*	Point_*y*	Number of containers
1	4154499	4442535	2
2	4154542	4442643	2
3	4154648	4442849	1
4	4154466	4442937	2
5	4154433	4442983	11
6	4154337	4442777	2
7	4154325	4442692	1
8	4154156	4442895	4
9	4154223	4442994	2
10	4154237	4443017	2
11	4154092	4443080	5
12	4154268	4443099	1
13	4154293	4443080	2
14	4154262	4442920	1

Table 2. A portion of the distance matrix between collection points

Input_fid	Near_fid	Distance (Meters)
1	2	116.24543
1	3	347.5586281
1	4	403.3522034
1	5	452.835511
1	6	291.2181313
1	7	234.3608329
1	8	497.2413901
1	9	535.5903285
1	10	548.6055049
1	11	680.2014408
1	12	609.4727229
1	13	582.6328175
1	14	452.0995466
1	15	541.1811157

3.2. Implementation of the ACO Algorithm

The process of applying the ACO algorithm on our CTSP problem is made of several coding procedures including determining the initial parameters, creating ant colonies, applying the roulette wheel, calculating the fitness function, finding the best ant, updating the pheromone matrix, performing an evaporation and visualization of the results. The algorithm codes were written on MATLAB R2018b and computation was carried out on a computer that has an Intel(R) Core(TM) @2.20 GHz processor with 8Gb RAM. Initializing the ACO parameters is the first and probably the most important stage of implementing the algorithm. These parameters to be set are a number of ants (A), the number of iterations (T), initial pheromone level (τ_o), rate of evaporation (ρ), pheromone heuristic factor (α) and expected heuristic factor (β).

Because the number of ants can reasonably be set to the number of destinations in the given TSP (Gaertner & Clark, 2005). We set as 148 ants in our case. Concerning the heuristic factors and the rate of evaporation, ACO is too complex to allow for an analytical approach to the problem of optimizing parameter settings (Siemiński 2013). Several experiments have been performed in the past in an attempt to determine the values of α and β that produce the lowest cost. Gaertner and Clark, 2005 [15] have emphasized the importance of avoiding extreme values for α and β, which would affect the global searching ability and the searching speed of the algorithm. Accordingly, based on the parameter evaluation examples and simulations performed by Gaertner and Clark, 2005 [15] α is recommended to be in the interval [1.0, 3.0], β is set in the range [2.0, 4.0], whereas ρ falls in the interval [0.5, 0.8]. We have set $\alpha = 1.0$, $\beta = 2.0$ and $\rho = 0.5$.

The initial pheromone concentration, on the other hand, has been calculated using the following Equation 5.

$$\tau_O = \frac{10}{\sum_{i=1}^{n}\sum_{j=2}^{n} dij}\ (n-1) \tag{5}$$

where n is the number of nodes

d_{ij} is the distance between node i and node j

The number of nodes (collection points and a disposal ground) in our problem is 148, and given the distance matrix, we have calculated the initial pheromone concentration τ_o to be 1.42 * 10e-6. To achieve a solution as close to the optimal value as possible, we have performed 1041 iterations, thus setting $T = 1041$.

The next step in the implementation of the ACO algorithm is the creation of a colony of ants that will tour the graph looking for the shortest route possible. The pseudo-code in Figure 3 illustrates the process used to create ant colonies for our study:

```
% CREATE A COLONY OF ANTS
FUNCTION [ ] = create_colony ( )
  container_limit = 205
    FOR ( for all ants)
      FOR (for all nodes)
                  prob. of choosing the next node = P_i,j
                  prob. of choosing visited nodes = 0
                  prob. of choosing the disposal ground =0
                   next_node = roulette_wheel(P)
    IF (total_containerNo < container_limit)
                              next_destination = next_node
                          CONTINUE
                           ELSE
                    next_node = disposal_ground
                                FOR (the rest of the nodes)
                      prob. of choosing the next node = P_i,j
                     prob. of choosing visited nodes = 0
                         next_node = roulette_wheel(P)
                                    next_destination = next_node
            END FOR
          END IF
      BREAK FOR
    END FOR
  END FOR
END FUNCTION
```

Figure 3. Pseudo-code for creating a colony of ants

Whenever an ant k completes a tour visiting all the collection points, the length of its tour (L_k), the sum of the length of the edges traveled by the ant, and the sequence of the collection points visited (the tour of ant k) are saved in the fitness function. A fitness value corresponding to ant k represents the length of its tour (L_k). In each iteration, the fitness values of all ants are compared with each other, and the smallest fitness value is stored as '*the best fitness*'. The tour corresponding to the ant with the smallest fitness value will also be stored as '*the best tour*'. These values are updated whenever a new fitness function is created in every iteration. The process of updating the pheromone levels of the '*good solutions*' is also carried out using the values obtained from the fitness function. If ant k used the edge i,j in its route, the pheromone concentration of edge i,j would be improved by an amount equal to the reciprocal of the fitness value of ant k, (as given in Equation 1). The pheromone updating step in each iteration is preceded by evaporation (see Eq. 3) corresponding to a rate $\rho = 0.5$, meaning half of the pheromone

level in the '*bad solutions'* will be destroyed. The following flow chart given in Figure 4 that summarizes the steps followed while implementing the ACO algorithm:

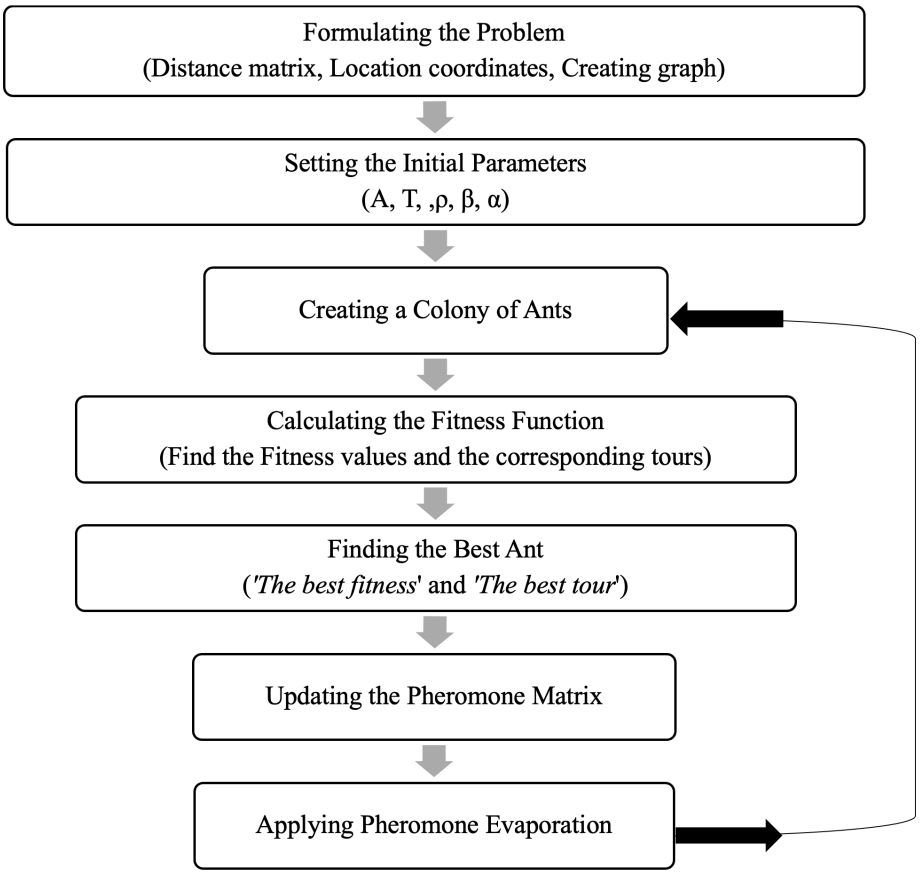

Figure 4. Procedure for implementing ACO algorithm

3.3. Computational analysis of the pilot problem

To demonstrate the computational performance and feasibility of the ACO algorithm and MILP, a pilot case problem is extracted from our original case. 9 of the 148 collection points have been modeled as a TSP to demonstrate the feasibility and computational time of the ACO algorithm and MILP. We began by finding the sub-solution of the TSP using MILP. First, a 9×9 matrix was selected to show the distance relationship between the collection points. The distance matrix is shown in Table 3.

Table 3. The distance matrix for the pilot problem.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	0	116,2454	347,5586	403,3522	452,8355	291,2181	234,3608	497,2414	535,5903
2	116,2454	0	231,6722	303,6643	357,0448	244,9102	222,4635	460,9772	474,3016
3	347,5586	231,6722	0	202,1584	253,3397	319,2256	359,1351	494,1457	449,0546
4	403,3522	303,6643	202,1584	0	56,61272	205,5262	282,6765	312,8322	249,5957
5	452,8355	357,0448	253,3397	56,61272	0	227,2708	310,3949	290,6424	210,2879
6	291,2181	244,9102	319,2256	205,5262	227,2708	0	85,84288	216,0671	245,1224
7	234,3608	222,4635	359,1351	282,6765	310,3949	85,84288	0	264,1401	318,7601
8	497,2414	460,9772	494,1457	312,8322	290,6424	216,0671	264,1401	0	119,5408
9	535,5903	474,3016	449,0546	249,5957	210,2879	245,1224	318,7601	119,5408	0

The codes were then written on LINGO Extended Version and computation was carried out on a computer with Intel(R) Core(TM) @2.20 GHz processor with 8Gb RAM. The proposed MILP model is suitable for small TSP problems such as our pilot problem.

The optimal sequence of the collection points of pilot problem is also shown as below;

1 → 2 → 3 → 4 → 5 → 9 → 8 → 6 → 7 → 1

In the second stage, the ACO algorithm was applied to the same set of collection points modeled as a TSP. 500 iterations are performed and the number of ants is now set at $A = 9$ to account for the change in the number of locations. The remaining parameters are used as determined in Section 3.2. Figure 5 shows the solution space of the pilot problem:

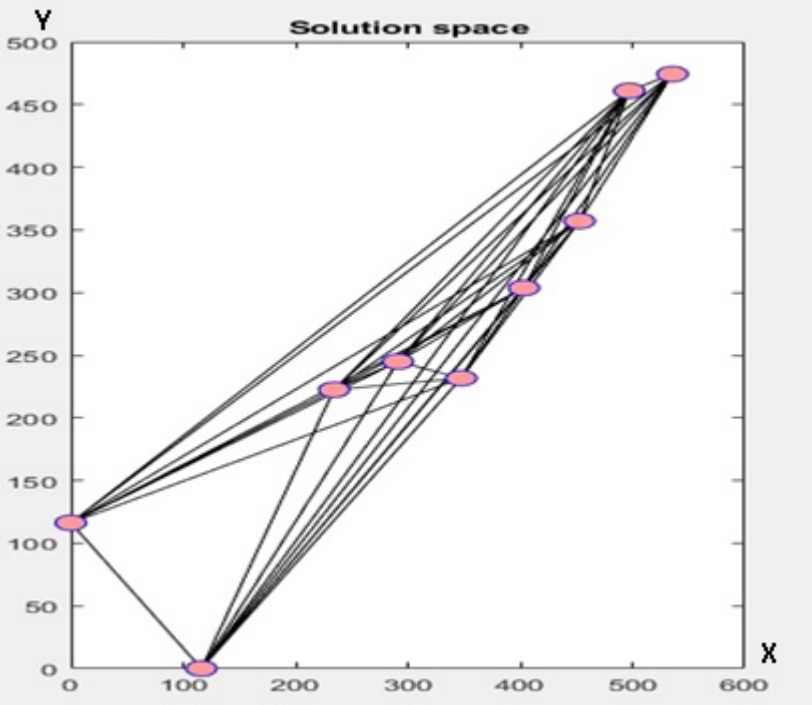

Figure 5. Solution space of the pilot problem with 9 collection stops

The algorithm was coded to undergo several iterations; the tour of the best ant and the distribution of the pheromone trails are illustrated. Figure 6 portrays the graphical results after 4 iterations and it gives a good visualization of what the pheromone distribution looks like in the early stages of the optimization algorithm. On the other hand, in the pheromone trail graph of Figure 7, it can be observed that after a series of pheromone updating and evaporation procedures, all the pheromone remains are concentrated on the tour of the best ant. This phenomenon shows the importance of updating pheromones to promote good solutions, while evaporation gradually destroys bad solutions.

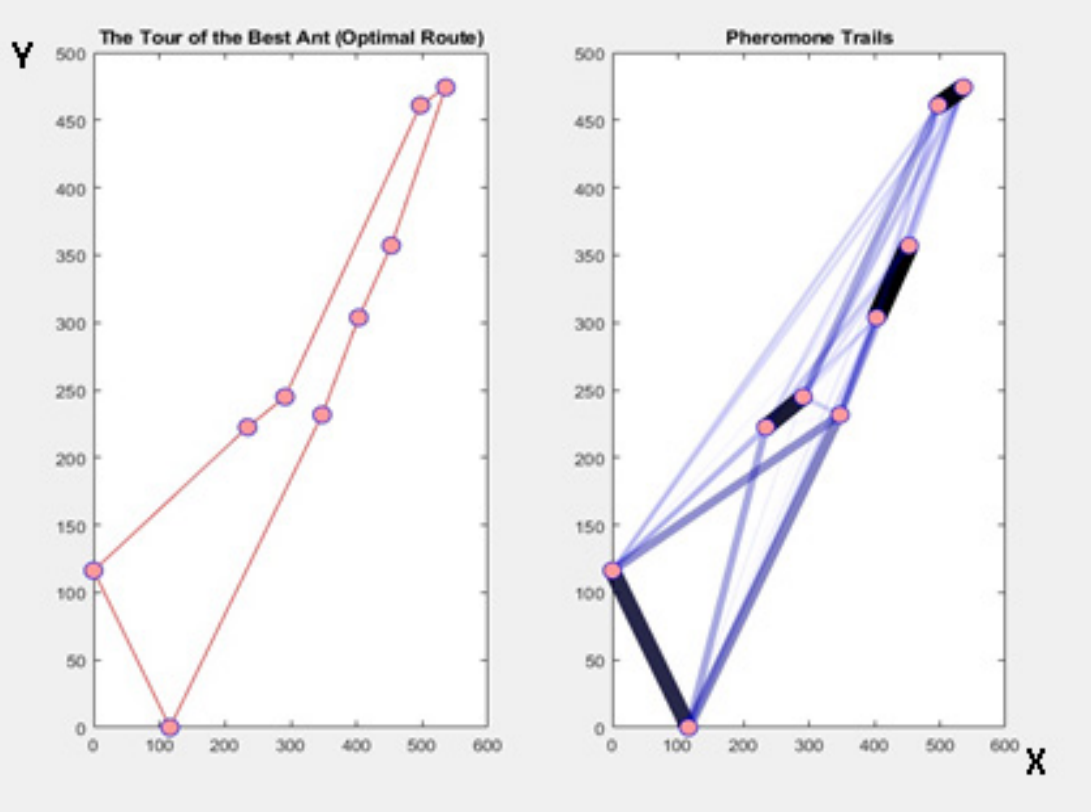

Figure 6. Visualization of the ACO solution after 4 iterations

The shortest path at the highest iteration has been determined to be 1472.7882 meters approximately 1.5 Km, which agrees with the global optimal solution obtained using MILP. Thus, the shortest path provided by the ACO algorithm is also the optimal route of the pilot TSP. It is also observed from Figure 6 that it took the algorithm only 4 iterations to reach the global optimal solution obtained using LINGO's MILP. This can be explained by the fact that the solution space of the problem is too small when compared to the performance of the algorithm. In this case, ant colonies have a high probability of narrowing the solution space quickly by following pheromone trails concentrated on comparatively shorter paths that get visited more frequently than their longer counterparts due to their higher desirability and quality. The total computational time after 500 iterations for the father function (AntColonyAlg) that executes all the other child functions is observed to be 2.78 minutes, which is poor when compared to the total elapsed time of 0.13 seconds consumed during MILP. This emphasizes the performance superiority of linear programming over heuristic methods for solving small-scale problems. The optimal route and the pheromone trail distribution for the pilot problem have been shown in Figure 7.

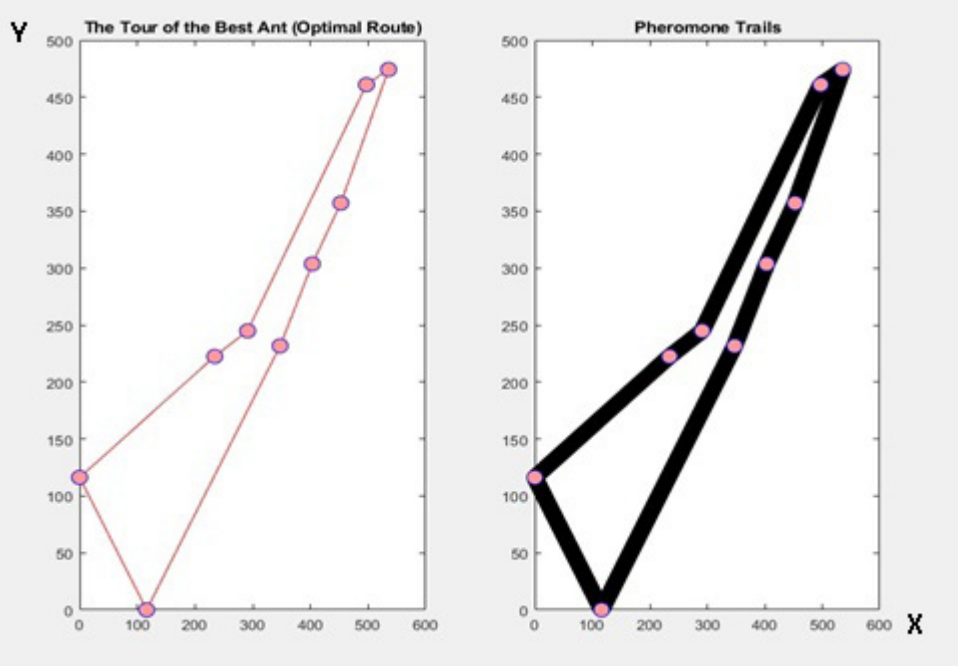

Figure 7. The optimal route and the pheromone trail distribution in the pilot problem

3.4 Computational analysis for the real case problem

The original CTSP is made up of 349 residential waste containers divided into 148 collection points. As mentioned in Section 2, the ACO algorithm to this CTSP problem has been written taking the capacity constraint into account. Once the garbage compactor vehicle has collected waste from a maximum of 200 containers, it travels to the disposal ground, unloads, and then returns to the remaining collection points. This phenomenon is effectively modeled and illustrated in Fig. 9. The parameters of the ACO algorithm in this study are $T = 1041$, $\tau_o = 1.42 * 10e\text{-}6$, $\alpha = 1.0$, $\beta = 2.0$ and $\rho = 0.5$. Based on the procedure set in Figure 4, the ACO algorithm was written on MATLAB R2018b, and computation was carried out on a computer, which has an Intel(R) Core(TM) @2.20 GHz processor with 8Gb RAM. This NP-Hard problem has an extremely large solution space due to the existence of a large number of locations with 148 collection points. By the way, the solution space consists of 148 factorial combinations. The shortest distance traveled by the best ant in the early, middle and final iterations show a decent reduction in value thus indicating an increase in the quality of the solution as the iteration proceeds. In the first 9 iterations of the algorithm, the shortest route has seen a 35% improvement dropping to just below 31 km from an initial value of over 47 km in the first iteration. However, this reduction in the shortest route doesn't show a significant decline in the remaining iterations. The algorithm reached its near-optimal distance of roughly 29.5 km at the 169th iteration and remained unchanged until the 1041st iteration. This early arrival to the near-optimal solution and inability to improve in the late iterations can be attributed to the relative proximity of the waste containers to each other, thus creating a condition where the possibility of finding a better solution than achieved after some point becomes difficult or is accompanied by insignificant changes.

Using the ACO algorithm the optimal route of the CTSP is presented in Table 4:

Table 4. The results of the capaciated travelling salesman problem for the148 containers

111➔110➔108➔109➔126➔1➔127➔148➔93➔94➔28➔31➔29➔30➔7➔102➔6➔101➔100➔104➔128➔2➔103➔4➔5➔14➔9➔10➔13➔12➔89➔88➔77➔76➔75➔71➔70➔17➔51➔69➔50➔49➔48➔47➔46➔53➔54➔57➔40➔41➔42➔45➔44➔43➔38➔37➔35➔25➔36➔34➔33➔32➔27➔26➔96➔95➔97➔98➔99➔90➔91➔125➔124➔123➔122➔120➔119➔118➔116➔117➔121➔114➔115➔112➔113➔92➔105➔107➔106➔3➔147➔146➔145➔144➔143➔142➔141➔140➔139➔137➔136➔135➔132➔133➔134➔129➔130➔131➔138➔87➔79➔86➔80➔85➔81➔82➔84➔83➔65➔64➔66➔67➔73➔74➔78➔72➔68➔60➔59➔62➔63➔61➔11➔16➔8➔15➔24➔23➔22➔21➔20➔19➔56➔55➔39➔58➔52➔18 =29.5 km (optimized total travelling distance)

The solution time for the functions implemented in the proposed ACO algorithm is shown in Table 5. The computational time is just over 10 hours (37,177 sec). However, the computational time it took the ACO algorithm to find the shortest route should be significantly lower than the current termination time as the algorithm reached its near-optimal value much earlier (in the 169th iteration).

Table 5. The computational time of the ACO algorithm

Summary Function name	**Calls**	**Total Time**	**Self Time***
drawPheromone	1041	28048.507 s	20018.750 s
AntColonyAlg	1	37177.325 s	4611.319 s
gobjects	23592375	2242.759 s	2242.752 s
newplot	11796187	6267.129 s	1986.235 s
Graphics/private/clo	2082	1927.782 s	1927.782 s
newplotwrapper	11796187	7842.138 s	1575.009 s
Newplot>ObserveAxesNextPlot	11796187	1409.440 s	1409.440 s
Title	2083	788.923 s	788.313 s
CreateColony	1042	1091.923 s	723.212 s
Newplot>ObserveFigureNextPlot	11796187	628.709 s	628.709 s
drawBestTour	1041	1183.553 s	453.360 s
rouletteWheel	22655199	175.738 s	175.738 s
updatePheromone	1041	165.027 s	165.027 s
iofun/private/openExcelWorkbook	1044	124.951 s	116.004 s
Hold	156151	138.773 s	89.489 s
Graphics/private/claNotify	2082	80.629 s	80.361 s
markFigure	162397	30.929 s	30.929 s

4. Discussion and Conclusion

This paper has successfully demonstrated the performance of the meta-heuristic ant colony optimization algorithm to a capacitated travel salesman problem of a solid waste collection vehicle in the Güneykent district. A pilot problem extracted from the original CTSP has also been modeled as a TSP to assess the performance and feasibility of the proposed ACO algorithm and compare its solution to that of an exact optimization method namely the MILP model.

Such as particle swarm optimization, firefly algorithm, ant colony optimization, and bat algorithm have gained much popularity and they have successfully tackled various test suites of benchmark functions and real-world problems. It was inevitable to use ant colony or similar algorithms to solve our combinatorial problem. Based on our existing experience on ACO algorithm, it was able to approximate promising solutions with good convergence and diversity maintenance for most of the optimization problems.

It has been observed that the ACO algorithm has delivered the same solution as the global optimal solution provided by the MILP on LINGO. The computational time on LINGO (0.13 sec) was, however, significantly lower than the termination time of the ACO algorithm (2.78 min) implemented in MATLAB, emphasizing the superiority of exact models and linear solvers over heuristic methods in optimizing small scale TSPs.

The application of the proposed ACO algorithm on the original CTSP has shown satisfactory results. The shortest possible route (near-optimal distance) was determined to be 29.5 km. As per the solution obtained, the garbage compactor truck will visit 84 of the 148 collection points before heading to the disposal ground to unload, during which 196 of the 349 residential solid waste containers will be visited, thus satisfying the capacity constraint. The remaining collection points will then be visited in the second round. In spite of the 10 hours termination time to complete around a thousand iterations, the algorithm has managed to reach the near-optimal solution in the 169th iteration, on which the shortest route was 29.5 km.

The length of the current solid waste collection and transportation route followed by the garbage compactor truck understudy in the Güneykent district was 41 km. As a result, the near-optimal solution obtained as a result of the ACO algorithm (29.5 km) is found to be a significant improvement. There exists a daily reduction of 11.5 km (28% reduction) of driving distances in the new solution. In practice, waste collection vehicles operate daily using the same route. So, these statistics reach 345 km per month and a further 4,197.5 km saving every year from just a single truck. Eventually, the new route will considerably reduce labor costs, the high price of fuel, machinery and equipment maintenance as well as environmental pollution. Because garbage compactor trucks are one of the least efficient vehicles on the road, a quick calculation of the reduction in fuel costs introduced by the new route shows that with the current fuel price averaging 6 ₺ per liter and given the fact that the truck understudy consumes 1 liter of diesel fuel for every 1.5 km of waste collection and transportation, the optimized route would bring about a saving of 16,790 ₺ per year per vehicle. This lends a considerable economic benefit when compared to the current expenditure of the district reaching 58,400 ₺ per year per vehicle. The saving accounts to close to 30% of the current expenditure.

The potential future benefit of this study can be easily anticipated when because the SWMS in Şahinbey Municipality has over 50 garbage compactor trucks operating in the much longer and complicated collection and transportation routes and routines in different districts of the municipality every day. Thus, a deep study and analysis of the existing routing system, as well as the application of meta-heuristic or other heuristic optimization

techniques to optimize waste collection and transportation routes, is key to promoting significant cost reductions and improving the efficiency of the SWMS in general.

Due to their low efficiency and consumption of diesel fuel, garbage compactor tracks are also highly pollutant, thus making every mile reduction valuable. A reduction of 4,197.5km per year per vehicle brought about by the new route will provide a considerable decline in the amount of carbon dioxide emitted to the environment. This study can also be adapted and/or modified to include other districts in the municipality to be able to experience more significant and visible economic and environmental changes. It can also be studied under integrated SWMS along with other study areas including optimal container location, collection schedule, and vehicle assignment.

Capacitated garbage collection management problem is a combinatorial problem. For example; if there are three waste containers, there will be possible three factorial routes to visit. As the number of waste containers increases, the number of problem variables increases exponentially. In addition, other constraints that make it difficult, especially capacity constraints, do not allow the collection of waste with unlimited time and unlimited storage. The insolvency of the problem with mathematics depends on the variables of the problem. Therefore, it can take days to months to obtain the optimal solution. The difficulty of the problem will increase with new constraints. If the working hours, experiences, special requests and work of the employees are taken, the problem may become unsolvable. While we always move towards solving more realistic problems, the endless buffers follow each other because the dynamics of work and life do this in the future. This is why our model is built on an important problem of garbage collection as a vehicle routing problem. The problem is very clear and its purpose is very simple. In future studies, it is necessary to make new simple and realistic additions to this problem, whose goal is clear. For example, the types of waste collected, sorting facilities, waste collection priorities; neighborhood or route priorities can be added. This increases the importance of the problem even more, and if it is made more dynamic, more beneficial results will result.

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RESEARCH ARTICLE

Tarım-Gıda Tedarik Zincirinde Ağ Tasarımı ve Optimizasyonu: Bir Meyve Suyu İşletmesi Örneği

Network Design and Optimization in the Agri-Food Supply Chain: A Juice Business Example

Belkız Torğul[1], Enes Demiralay[2], Turan Paksoy[3]

ÖZ

Tarımsal gıdalara ulaşamamak günümüzde yaygınlaşmaya başlayan büyük bir sorun haline gelmiştir. Tarımsal gıda tedarik zincirleri, gıda güvenliği ve halk sağlığı ile ilgili sorunlar nedeniyle son yıllarda tüketiciler, firmalar, devlet kurumları ve araştırmacıların daha fazla ilgisini çekmektedir. İnsanların yaşamını sağlıklı bir şekilde devam ettirebilmesi için en önemli ihtiyacı olan tarımsal gıdaların tedarik süreci çerçevesinde son yıllarda tüm dünyanın ilgisini çeken sürdürülebilirlik konusuna da yer verilmelidir. Bir tarımsal gıda tedarik zincirinin sürdürülebilirliğini etkileyen en kritik faktörlerden biri ağ tasarımıdır. Bu yüzden, tarımsal tedarik zincirlerinin tasarımı ve işletilmesi daha sıkı düzenlemelere tabi olmalıdır. Bu çalışmada, gıda tedarik zincirlerinin tasarımı için öncelikle operasyonel araştırma yöntemlerinin bir literatür incelemesi verilmiş ardından şeftali suyu ürünlerinin tedarik zinciri sürdürülebilirliği için yeni bir kapalı döngü ağ tasarımı uygulaması sunulmuştur. Şeftali suyu tedarik zinciri ağ tasarım modeli, karma tamsayılı doğrusal programlamaya dayalı olarak kârı maksimize etmek üzere formüle edilmiş ve sayısal bir örnek yardımıyla GAMS programında çözülerek doğrulanmıştır. Önerilen model, çiftçi-tedarikçi seçimi, taşıma ve dağıtım sorunlarını ele alırken geri dönüşüm süreci ile maliyet düşürme, çevrenin korunması ve atıkların ekonomiye kazandırılması faaliyetlerini ön plana çıkarmaktadır. Modelin çözüm sonuçları, ele alınan gıda- tedarik zincirinde en fazla mali giderlerin satın alma kalemi olduğunu ortaya koymuştur. Yapılan duyarlılık analizi ile çiftçilerden yeterli arz sağlanması yoluyla daha kısa tedarik zinciri oluşturmanın işletmeye hem ekonomik hem de çevresel olarak katkı sağlayacağı sonucuna varılmıştır.

Anahtar Kelimeler: Ağ Tasarımı, Geri Dönüşüm, Karma Tamsayılı Doğrusal Programlama, Tarım-Gıda Tedarik Zinciri

ABSTRACT

Lack of access to agriculture-based food has become a major problem that is becoming increasingly widespread. Agri-food supply chains have attracted growing attention from consumers, companies, government agencies, and researchers in recent years due to problems with food safety and related public health issues. Sustainability, which has attracted global attention in recent years, should also be included within the optimal framework of the process of supplying agricultural food, which is among the most important needs people face in order to live healthy lives. One of the most critical factors affecting the agri-food supply chain's sustainability is network design. Therefore, the design and operation of agri-food supply chains should be subject to stricter regulations. In this study, we conduct a literature review of operational research methods used in the design of agricultural food supply chains, and present a new, closed-loop network design application for supply chain sustainability of peach juice products. The peach juice supply chain network design model was formulated using linear programming to maximize profit and was verified using the GAMS program with the help of a numerical example. The proposed model framework highlights cost reduction activities within the recycling process, protecting the environment, and recovery the waste to the economy while addressing farmer–supplier selection, transportation, and distribution problems.

Keywords: Network Design, Mixed Integer Linear Programming, Recycling, Agri-Food Supply Chain

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[1] **Sorumlu yazar/Corresponding author:** Belkız Torğul (Arş. Gör.), Konya Teknik Üniversitesi, Mühendislik ve Doğa Bilimleri Fakültesi, Endüstri Mühendisliği Bölümü, Konya, Türkiye E-mail: belkistorgul@gmail.com ORCID: 0000-0002-7341-9334

2 Enes Demiralay (Arş. Gör.), Konya Teknik Üniversitesi, Mühendislik ve Doğa Bilimleri Fakültesi, Endüstri Mühendisliği Bölümü, Konya, Türkiye E-mail: edemiralay@ktun.edu.tr ORCID: 0000-0003-1383-3645

3 Turan Paksoy (Prof. Dr.), Necmettin Erbakan Üniversitesi, Havacılık ve Uzay Bilimleri Fakültesi, Havacılık Yönetimi Bölümü, Konya, Türkiye E-mail: tpaksoy@yahoo.com ORCID: 0000-0001-8051-8560

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EXTENDED ABSTRACT

Globalization and an increase in exports are playing a progressively important role in expanding supply chains (SCs) over wide areas. In addition, Supply Chain Management (SCM) has been gaining strategic importance in terms of its impact on the success of companies that have become business partners and/or competitors across different geographic areas. Suppliers, production facilities, distribution facilities, storage facilities, and collection and recovery facilities are members of the SC, and SCs are dynamic processes involving a continuous flow of materials, funds, and information within and between these members across multiple functional areas. SCM determines and oversees the number of entities, locations, capacities, and flows between SC members. The dynamics of SCM have changed over the years, as new paradigms have developed in order to respond to increasing environmental concerns and customer pressures. Lack of access to agricultural food has become a major problem. Agri-food SCs are attracting more attention from consumers, companies, government agencies, and researchers due to problems with food safety and related public health concerns. Sustainability, which has attracted global attention in recent years, should also be included within the framework of supplying agricultural food, which is the most important need for people to live healthy lives. Increasing environmental concerns, the impacts of climate change, social-environmental awareness, legal regulations of governments, declining resources and profit margins have increased the need and importance of sustainability. By collecting used products from end-users as part of the supply process, SCs have become cyclical and sustainable structures. Based on this transformed structure, the concept of "Closed-Loop SCM" (CLSC) or "Sustainable SCM" has emerged. One of the most critical factors affecting agri-food supply chain sustainability is network design. Therefore, we propose that the design and operation of agri-food supply chains, including network design, should be subject to stricter regulations.

In this study, we first provide a literature review of operational research methods regarding the design of agricultural food SCs. Then, we present a new closed-loop network design application for a sustainable supply chain for peach juice products. In the processed peach products supply chain farmers are the main suppliers of raw materials. In addition to buying from farmers, producers sometimes obtain raw materials from large traders (second-tier suppliers). In these cases, the supply chain is extended as raw materials are not purchased directly from the farmers. Distributors distribute peach juice from the manufacturer to retailers or consumers, but retailers are the preferred distribution channel for manufacturers in marketing their peach juice products, as peach juice consumers consist of local consumers living in various regions. The manufacturer processes the peaches, which are procured from farmers or second-tier suppliers in June, July, and August, in their production center. Peach juice is delivered to the distribution and collection center, and from there it is forwarded to retailers, who are the customers. The company works in cooperation with the glass bottle supplier and packaging facilities to package their final products. In addition, it produces their products in accordance with environment friendly, sustainable agriculture food sector practices by selling the pulp produced during the production phase to be turned into organic fertilizer, and by collecting at least some

of the used glass bottles from customers. The collected glass bottles that are suitable are then disinfected and reused in the production center, and the others are sold to a recycling center and then to the glass bottle supplier for reprocessing.

The model developed to analyze the problem of optimizing the agri-food supply chain network design was formulated based on mixed integer linear programming with the objective function of maximizing profit, and was verified by solving it in the GAMS program using a numerical example. The model framework presented in this study highlights the cost reduction activities within the recycling process, protecting the environment, and recovering the manufacturing waste into the economy while addressing farmer–supplier selection, transportation, and distribution problems. It also provides examples of how to overcome problems that often arise in agri-food systems, offering guidance to practitioners on key issues to be included in network design of agri-food supply chains. This peach juice production process implementation study serves as an example for presenting these modeling and optimization strategies and can be applied to a wide variety of agri-food SCs with similar characteristics.

1. Giriş

Günümüzde küreselleşme ve ihracattaki artış ile işletmelerin Tedarik Zinciri (TZ) geniş bir alana dağılmış ve farklı coğrafyalarda iş ortağı ve/veya rakip haline gelen işletmelerin arasında artan rekabet TZ'nin stratejik bir önem kazanmasına neden olmuştur. Tedarikçiler, üretim tesisleri, dağıtım tesisleri, depolama tesisleri, toplama ve geri kazanım tesisleri TZ'yi oluşturan üyelerdir ve TZ bu üyeler içinde ve arasında çok sayıda işlevsel alanda sürekli malzeme, fon ve bilgi akışını içeren dinamik bir süreçtir (Jain vd., 2009). TZ üyelerinin sayısının, yerinin, kapasitesinin ve aralarındaki akışların belirlenmesine Tedarik Zinciri Yönetimi (TZY) adı verilir. TZY'nin dinamikleri yıllar içinde değişmiş, artan çevresel kaygılar ve müşteri baskılarına cevap verebilmek için yeni paradigmalar TZY'ye eklenmiştir.

Artan çevresel kaygılar, iklim değişiklilerinin artan etkisi, toplumsal çevre bilincinin artması, hükümetlerin yasal düzenlemeleri, azalan kaynaklar ve kâr marjları sürdürülebilirliğe olan ihtiyacı ve önemi arttırmıştır. Bu süreçte son kullanıcılardan kullanılmış ürünlerin toplanmasıyla TZ döngüsel ve sürdürülebilir bir yapıya dönüşmüştür. Bu dönüşmüş yapıyla birlikte "Kapalı Döngü Tedarik Zinciri Yönetimi" (KDTZ) veya "Sürdürülebilir Tedarik Zinciri Yönetimi" kavramı ortaya çıkmıştır. Artmakta olan çevresel bilinç ve sürdürülebilirliğin önemi nedeniyle, Sürdürülebilir TZY akademisyenlerden ve uygulayıcılardan daha fazla ilgi görmeye başlamıştır. Literatürde Sürdürülebilirlik, Üçlü Kârlılık Yaklaşımı (Triple Bottomline-TBL Approach) adı verilen bu yapı üç ana sütun üzerinde tanımlanmaktadır; ekonomik, çevresel ve sosyal faktörler. Son araştırmalar, sürdürülebilir araç ve yöntemlerin entegre kullanımının kuruluşlarda bir sinerji yarattığını ve aynı anda hem operasyonel hem de çevresel performansı artırdığını göstermektedir (Paksoy vd., 2019). Bu aslında çok şaşırtıcı değildir. Çünkü sürekli iyileştirme için kullanılan en popüler ekonomik paradigmalardan biri olan Yalın Üretimin temel amaçlarından israfların yani mudaların azaltılması (malzeme, su, enerji vb.), doğrudan yeşil felsefe ile de örtüşmektedir.

19. yüzyılın ikinci yarısından beri, gıda sistemi küreselleşme olgusundan güçlü bir şekilde etkilenmiştir. Çiftçiler ve tüketiciler arasındaki doğrudan ilişkilerin yerini, çeşitli aracıları içeren karmaşık bir aktörler sistemi almıştır (Dunne vd., 2011). Büyük toptancılar ve süpermarket zincirlerinden oluşan bir pazara giriş, küçük çiftçilerin aleyhine rekabeti artırmıştır (Renting vd., 2003). Üretilen toplam gıdanın yaklaşık %30-35'i, yetersiz altyapı ve etkisiz TZ nedeniyle her yıl israf edilmektedir (Parwez, 2014). Küreselleşme ayrıca biyolojik çeşitlilik ve ekosistemlerde bir çöküşe, obeziteye ve gıda yoksulluğunun artmasına ve tüketicilerin gıda kaynağı ve kalitesi hakkında yeterli bilgiye sahip olmasının imkansızlığına neden olmuştur (Pulker vd., 2018; Qaim, 2017). Bununla birlikte, günümüzde tüketiciler, küreselleşmiş bir gıda sisteminin olumsuz etkilerine giderek daha fazla farkına varmaktadır ve çiftçilerle yeniden doğrudan bir bağlantı kurmaya, yerel toplulukları desteklemeye, sağlıklı gıda tüketmeye isteklidirler (Duram ve Cawley, 2012). Ayrıca, küresel gıda talebinin 2030 yılına kadar %50 artacağı tahmin ediliyor ve bu da üretim ve ulaşım için kaynak talebinin artmasına yol açıyor (Allaoui vd., 2018). Planlayıcılar, paydaşlar ve araştırmacılar, gelecekte yeterince sağlıklı gıdaya ulaşıp ulaşamayacağımızı ve ne pahasına olacağını merak ediyorlar.

Bu sebeple, özellikle gıda tedarik zincirleri (GTZ)'de firmaların, müşteri beklentilerini karşılamak için rakiplerinden daha hızlı ve daha esnek olmasının yanı sıra sürdürülebilir paradigmaları uygulamaları da gerekmektedir. Tüm bu koşullar göz önünde alındığı zaman GTZ'de hammaddelerin çiftçilerden doğrudan alınarak, aracılardan ortadan kalkmasıyla hem üreticiler hem de çiftçiler ekonomik fayda sağlamış olacaktır. Çiftçiden direk alınmış taze ve doğal hammaddeler sayesinde, ürünlerin insan sağlığına olan zararlarında azalma sağlanacaktır. Son müşteriden kullanılmış ürünler geri toplanarak, atıkların çevreye zarar vermesi önlenmiş hem de ürünlerin geri dönüşümü ile ekonomik fayda sağlanmış olacaktır.

Son yıllardaki değişimler ve gelişmeler ışığında, sürdürülebilir paradigmalar GTZ ağ tasarımı için büyük önem arz etmektedir. Bu kapsamda, bu çalışmada gıda sektöründe faaliyet gösteren bir meyve suyu firmasının TZ ağ tasarımı oluşturulmuştur. Çiftçiden satın alınan şeftalilerin, son müşteriye cam şişede meyve suyu olarak ulaşana kadar ki ve son müşterideki kullanılmış ürünlerin geri dönüşümüne kadar geçen tüm süreçler için GTZ ağ tasarımı yapılmıştır.

2. Kavramsal Çerçeve

Bu bölümde GTZ ağ tasarımına ilişkin kapsamlı bir literatür taramasına yer verilmiştir. Eleştirel bir bakış açısı sağlamak amacıyla Tablo 1'de literatür matrisi oluşturulmuştur.

Apaiah ve Hendrix (2005), Hollanda'daki yeni proteinli gıdaların tedarik ağını optimize eden doğrusal bir model önermiştir. Gong vd. (2007), taze tarımsal ürünlerin toplam envanter taşıma maliyetini ve TZ'deki atıkları en aza indirmek için, GTZ ağ tasarımı için bir envanter konum tahsis modeli geliştirmiştir. Çözümün kalitesini artırmak için, bir yerel arama Parçacık Sürüsü Optimizasyonu (PSO) algoritmasına yerleştirilmiştir. Sonuçlar, algoritmanın farklı maliyetler arasındaki çatışmayı etkili bir şekilde çözebileceğini ve Pekin'in çabuk bozulan gıda dağıtım merkezleriyle ilgili geliştirme kararlarını iyileştirebileceğini göstermektedir. Jiang vd. (2009), bir et-gıda TZ'de tedarik kesintileri meydana geldikten sonra TZ ağının hayatta kalma ve dayanıklılığını arttırmak için çoklu tedarikçiye dayalı esnek bir ağ tasarımı için karışık tam sayılı stokastik bir model geliştirmiştir. Önerilen modeli çözmek için Benders ayrıştırma algoritması kullanılmıştır. Modelin uygulanabilirliği ve doğruluğu için vaka çalışması yapılmıştır. Akkerman vd. (2010), gıda dağıtım yönetimine yönelik nicel operasyon yönetimi yaklaşımlarını ve sektörün karşılaştığı gıda dağıtım yönetimiyle ilgili zorlukları araştırmıştır. Literatürün gıda kalitesi, gıda güvenliği ve sürdürülebilirlik olmak üzere üç yönüne, üç karar seviyesinde odaklanılmıştır: stratejik ağ tasarımı, taktik ağ planlaması ve operasyonel ulaşım planlaması. Zhao ve Lv (2011), tarımsal GTZ'de tesis konumu ve üretim kapasitesi seçimini işlemek için karma tamsayı model geliştirmiştir. Çok kademeli ve çok ürünlü TZ için tasarım probleminin karmaşıklığından dolayı, PSO algoritması önerilmiştir. Hasani vd. (2012), aralıklı veri belirsizliği altında stratejik KDTZ ağı tasarımı için genel kapsamlı bir model önermiştir. Ogier vd. (2013), tedarikin mevsimselliği, ürünler için aktarmaların sınırlandırılması ve ardışık dönemler arasında depolama imkânı olmaması sebebiyle taze GTZ ağ tasarımı için karma tam sayılı model geliştirmiştir. Govindan vd. (2014), sürdürülebilirliği, bozulabilir bir GTZ ağında dağıtım konusunda karar verme sürecine entegre ederek çok amaçlı bir optimizasyon modeli

önermiştir. Sürdürülebilir TZ ağ tasarımı ve bozulabilir bir gıda TZ'de ekonomik ve çevresel hedefleri optimize etmek için zaman pencereli iki kademeli konum yönlendirme problemi kullanılmıştır. Soysal vd. (2014), genel bir sığır lojistik ağı probleminde toplam lojistik maliyetini en aza indirmek ve nakliye operasyonlarından kaynaklanan toplam sera gazı emisyonu miktarını en aza indirmek için çok amaçlı bir doğrusal programlama modeli geliştirmiştir. Validi vd. (2014), İrlanda'da sütün dağıtımında yer alan iki katmanlı bir TZ için kapasiteli bir dağıtım ağının tasarımına yönelik sağlam bir çözüm yaklaşımı önermiştir. Cascini vd. (2014), taze GTZ'de hem küresel maliyeti hem de çevresel etkiyi en aza indirgemek için çok amaçlı, çok ürünlü, çok katmanlı, çok dönemli bir karmaşık tam sayılı doğrusal model geliştirmiştir. Önerilen modelin uygulanabilirliği ve doğruluğu için bir GTZ ağ tasarımı vaka çalışması ile gösterilmiştir. TZ ağlarında hasat sonrası kaybı (PHL) azaltmak için, Nourbakhsh vd. (2016), yeni ön işleme tesisleri için en uygun yerleri belirleyerek ve karayolu / demiryolu kapasite genişlemesini optimize ederek tahıl nakliyesi ve altyapı yatırımı için optimum lojistiği belirleyen bir matematiksel model önermiştir. Marco Bortolini vd. (2016), işletim maliyeti, karbon ayak izi ve teslimat süresi hedefleri göz önünde bulundurularak taze gıda dağıtım ağlarının taktiksel optimizasyonunun üstesinden gelmek için üç hedefli bir TZ ağı önermiştir. Uygulanabilirliği doğrulamak için bir dizi İtalyan üreticiden birkaç Avrupalı perakendeciye taze meyve ve sebzelerin dağıtımını ele alan gerçek bir vaka çalışması kullanılmıştır. Colicchia vd. (2016), hem verimli hem de ekolojik olarak sağlam olan bir TZ ağı tasarımı için çok amaçlı matematiksel model geliştirilmiştir. Önerilen modelin uygulanabilirliği ve doğruluğu için Lindt & Sprüngli firmasının çikolata ürünlerinin dağıtımı vaka çalışması ile gösterilmiştir. Sonuçlar, maliyet odaklı ağ optimizasyonunun çevre için yararlı etkilere yol açabileceğini ve dağıtım maliyetlerindeki küçük bir artışın, çevresel performanstaki büyük bir iyileştirmeyle dengelenebileceğini göstermektedir. Mohammed vd. (2017a), ilk olarak helal et ürünlerinin bütünlüğünün izlenebilirliğini artırmak için önerilen bir RFID tabanlı yönetim sistemi tarafından izlenen üç kademeli bir helal et tedarik zinciri (HMSC) ağının ekonomik fizibilitesini araştırmak için deterministik çok amaçlı karışık tamsayı doğrusal programlama modeli geliştirmiş ve önerilen RFID tabanlı HMSC ağını, şu hedeflere dayalı olarak optimize etmek için kullanmıştır; 1- Helal et ürünlerinin ortalama bütünlük sayısını en üst düzeye çıkarmak, 2- yatırım getirisini (ROI) en üst düzeye çıkarmak, 3- tesislerin kapasite kullanımını en üst düzeye çıkarmak ve 4- önerilen RFID izleme sisteminin toplam yatırım maliyetini en aza indirmek. İkinci olarak, bütünlük yüzdesinin değerini değiştirerek Helal et ürünlerinin sayısı üzerindeki etkisini incelemek için bir stokastik programlama modeli geliştirmiştir. Geliştirilen modellerin gerçek bir vaka çalışması kullanılarak uygulanabilirliğini gösterilmiştir. Mohammed ve Wang (2017), toplam nakliye maliyetini, nakliye araçlarının sayısını ve et ürünlerinin teslim süresini en aza indirmeyi amaçlayan uygun maliyetli et TZ ağı tasarımı için çok amaçlı olasılıklı bir model geliştirmiştir. Geliştirilen çok amaçlı modelin ve önerilen çözüm yöntemlerinin etkililiği ve uygulanabilirliği bir vaka çalışmasıyla gösterilmiştir. Mohammed vd. (2017b), helal et ürünlerinin bütünlüğünün izlenebilirliğini artırmak için bir Helal et TZ ağı tasarımı için RFID özellikli bir izleme sistemi geliştirmiştir. Önerilen RFID destekli izleme sisteminin ekonomik fizibilitesini araştırmak için çok amaçlı bir model geliştirmiştir. Geliştirilen matematiksel modelin uygulanabilirliği ve doğruluğu için bir vaka çalışması

yapılmıştır. Miranda-Ackerman vd. (2017), tedarikçi, üretim ve pazar seviyelerinden oluşan üç aşamalı bir yeşil TZ ağının çok amaçlı optimizasyonu modellemiştir. Modelin uygulanabilirliği ve doğruluğu bir portakal suyu TZ vaka çalışmasıyla gösterilmiştir. Mohammed vd. (2017c), toplam uygulama ve operasyon maliyetinin en aza indirilmesi ve müşteri memnuniyetinin ve ürün kalitesinin en üst düzeye çıkarılması açısından bir et TZ ağı için uygun maliyetli bir ağ tasarımı elde etmeyi amaçlayan çok kriterli optimizasyon modeli geliştirmiştir. Modelin uygulanabilirliğini ve önerilen çözüm yaklaşımlarının performansını incelemek için bir vaka çalışması yapılmıştır. Gholamian ve Taghanzadeh (2017), uzun vadeli tedarikçi seçimi kararlarını, yeni siloları yerleştirmeyi, buğdayın ve ürünlerinin orta vadeli atama ve dağıtım kararlarını içeren entegre buğday ürünleri TZ ağ tasarımı için bir model geliştirmiştir. Allaoui vd. (2018), ilk aşamada Analitik Hiyerarşi Süreci (AHP) yöntemine ve Sıralı Ağırlıklı Ortalama (OWA) toplama yöntemine dayalı melez çok kriterli karar verme yöntemi kullanarak paydaş seçimi yapmıştır, ikinci aşamada TZ'yi optimize etmek için ilk aşamada elde edilen sonuçları kullanarak çok amaçlı bir matematiksel model geliştirmiştir. Modelin uygulanabilirliğini ve verimliliğini bir tarım-gıda şirketinin vakası ile gösterilmiştir. M. Bortolini vd. (2018), sürdürülebilirliği artırmak amacıyla tek kullanımlık ve yeniden kullanılabilir olmak üzere iki farklı paketleme kabı kullanmıştır. Bu ambalaj kaplarının maliyetleri ve emisyonları doğal olarak farlıdır. Paketleme kabı en iyi seçimi, depolama / işleme düğüm lokasyonu ve akış dağıtımını belirlemek amacıyla taze meyve ve sebze dağıtımı zinciri ağ tasarımı için çift amaçlı karışık tam sayılı doğrusal programlama modeli geliştirmiştir. Modelin uygulanabilirliği İtalya'nın Emilia-Romogna bölgesinden gerçek bir vaka ile gösterilmiştir. Barsing vd. (2018), GTZ'de kısa raf ömrü ve yüksek çeşitlilik sebebiyle oluşan belirsizlik, öngörülemezlik ve karmaşıklık seviyesini azaltmak ve ortadan kaldırmak için çapraz yerleştirme merkezi kullanmıştır. Paydaşlar arasında malzeme veya bilgi akışına dayanarak n tane çapraz yerleştirme tesisinden birini seçmek için yeni bir yaklaşım geliştirmiştir. Das (2019), önemli miktarda atık ve emisyon üreten mevcut GTZ uygulamalarının sınırlarının üstesinden gelmek ve performanslarını iyileştirmek için esneklik kriterlerini, yalın ve yeşil tabanlı uygulamaları bütünleştiren sürdürülebilir bir GTZ ağı tasarım modeli geliştirmiştir. Modelin uygulanabilirliği örnek bir eyaletin şebeke ağı ile gösterilmiştir. Rohmer vd. (2019), küresel GTZ bağlamında sürdürülebilirlik konularını ele alan yeni bir ağ tasarımı geliştirmiştir. Alternatif üretim ve tüketim senaryolarının yanı sıra birbirleriyle çelişen hedefler arasındaki ödünleşmeleri, beslenmeyle ilgili bir vaka çalışmasıyla göstermiştir. Darestani ve Hemmati (2019), bozulmalarla ilgili belirsizlikleri dikkate alırken, çabuk bozulan mallar için bir TZ ağı modeli önermiştir. Önerilen model toplam şebeke maliyetlerini en aza indirmek ve sera gazı emisyonlarını en aza indirmek üzere iki alt amaç içermektedir. İki amaçlı modeli çözmek için genel ağırlıklandırma yöntemi ve Torabi-Hassini yöntemi kullanılmıştır. Ghanbari ve Bashiri (2019), esnek tarımsal GTZ tasarlamak için hem tedarikçiler hem de dağıtım merkezleri için kesinti senaryolarını dikkate alan iki aşamalı stokastik model geliştirmiştir. Yıkıcı olaylara rağmen hızlı tepki verebilmek için şu üç stratejiyle esnek bir model oluşturmuştur; 1- Yedekleme tesisini tedarikçilere ve dağıtım merkezlerine ayırmak, 2- tedarikçiler ve dağıtım merkezlerinde çoklu kaynak kullanımı, 3- Tedarikçiler için kesinti olasılığını azaltmak için azaltma stratejileri. Sonuçlar, TZ için esnek stratejilerin uygulanmasının

daha fazla kar elde edeceğini ve maliyetlerden tasarruf sağlayacağını kanıtlamıştır. Pourmohammadi vd., (2020), İran'da buğday TZ'nin yeniden tasarlanması ve planlanması için uzun vadeli ve kısa vadeli depolama tesisleri ile buğday kalitesi arasındaki farkları dikkate alan karma tam sayılı doğrusal matematiksel bir model geliştirmiştir. Mohammadi vd. (2020), işlenmiş gıda endüstrisindeki TZ'yi sabit raf ömürlü ürünlerle tasarlamak için çok amaçlı bir model önermiştir. Ekonomik bir endeks olarak kâr maksimizasyonu ile ekonomik, imalat sektöründe karbondioksit emisyonları ve atık su arıtma endeksi ile çevresel ve sosyal bir endeks olarak yaratılan iş sayısını en üst düzeye çıkarma modelin hedefleri arasında bulunmaktadır. Biuki vd. (2020), sürdürülebilirliğin üç boyutunu TZ uygulamalarına dâhil etmek için iki aşamalı bir yaklaşım önermiştir. İlk aşamada, sürdürülebilir bir TZ'nin planlanmasına yardımcı olmak için çok amaçlı bir Karışık Tam Sayı Programlama modeli tasarlamıştır. İkinci aşamada, problemi çözmek için Genetik Algoritma (GA) ve PSO algoritması paralel ve seri kombinasyonları olarak iki melez metasezgisel yöntem kullanılmıştır. Mogale vd. (2020), sürdürülebilir gıda tahıl TZ için iki taraflı, maliyeti ve karbondioksit emisyonunu aynı anda en aza indirmeyi amaçlayan karar destek modeli geliştirmiştir. Model, çok kademeli, çok dönemli, çok modlu taşımacılık, çoklu kaynak bulma ve dağıtım, çeşitli nedenlerden kaynaklanan emisyonlar, heterojen kapasiteli araçlar ve sınırlı kullanılabilirlik ve kapasiteli depolar gibi birçok sorun özelliğini kapsamaktadır. Jouzdani ve Govindan (2021), bozulabilir gıda ürünleri TZ'de maliyet, enerji tüketimi ve trafik sıkışıklığını optimize etmek için sürdürülebilirliğin TBL yaklaşımını dikkate alarak çok amaçlı bir matematiksel model geliştirmiştir. Ürün ömür belirsizliği bir Weibull rastgele değişkeni olarak modellenmiş ve gıda bozulabilirliğinin bir karar değişkeni olarak kabul edilen araç buzdolabı kullanımından etkilendiği varsayılmıştır. Çalışmada %15'lik bir ekonomik uzlaşma, tedarik zinciri ağı tasarımının sürdürülebilirliğini %150 oranında artırabilir sonucuna varılmıştır.

3. Yöntem ve Model Çerçevesi

Bu çalışmada şeftali suyu üretimi üzerine bir sürdürülebilir kapalı döngü tarım gıda tedarik zinciri ağı yapısı incelenmiştir. İşlenmiş şeftali ürünlerinin tedarik zinciri sisteminde, çiftçiler ana hammadde tedarikçileridir. Çiftçilere ek olarak, üreticiler bazen hammaddeleri büyük tüccarlardan (2. Kademe Tedarikçiler) da temin etmektedir. Bu durumda, doğrudan çiftçilerden hammadde alınmaması nedeniyle tedarik zinciri daha uzun olabilmektedir. Distribütörler, şeftali suyunu üreticiden perakendecilere veya tüketicilere dağıtır. Perakendeciler, üreticilerin şeftali suyu ürünlerini pazarlamak için en çok tercih ettikleri alternatiftir. Şeftali suyu tüketicileri, farklı bölgelerde yaşayan yerel tüketicilerden oluşmaktadır.

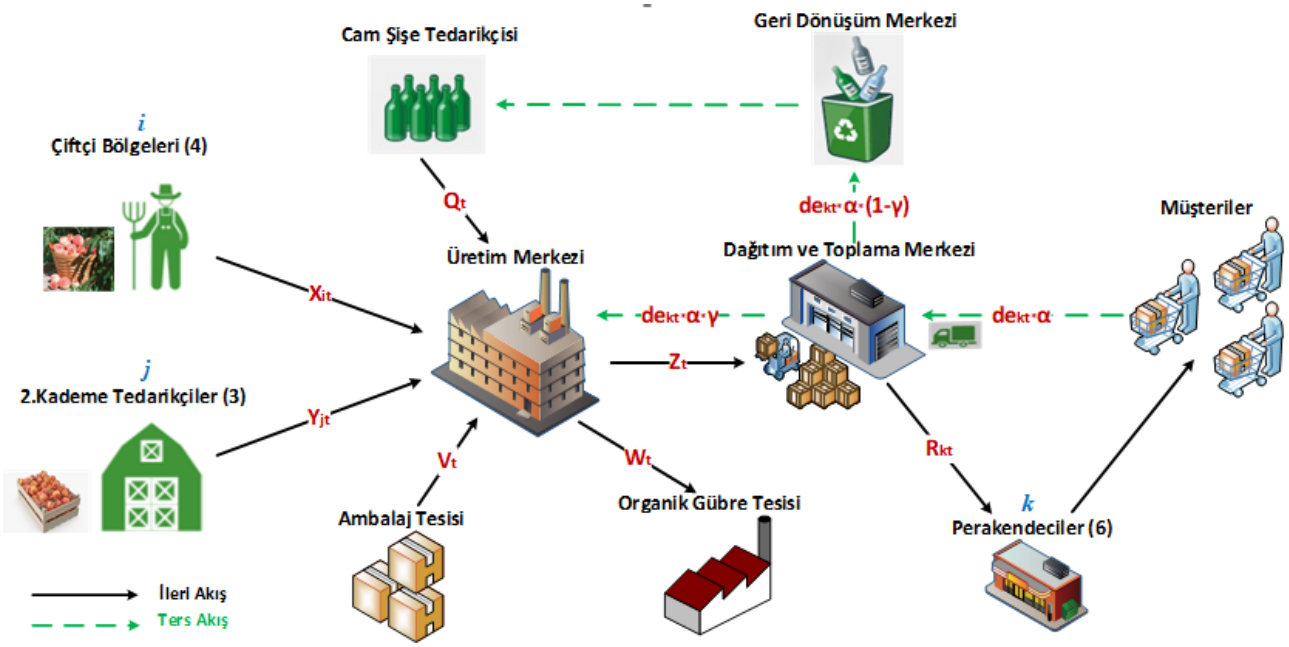
Şeftali suyu tedarik zinciri konfigürasyonu Şekil 1›de sunulmuştur. Firma, haziran, temmuz ve ağustos aylarında çiftçiler veya 2. kademe tedarikçilerden temin ettiği şeftalileri üretim merkezinde işleyerek şeftali suyu nihai ürünü şeklinde dağıtım ve toplama merkezine oradan da müşterisi konumundaki perakendecilere ulaştırır. Elde ettiği nihai ürünlerin ambalaj ve paketlenmesi için cam şişe tedarikçisi ve ambalaj tesisleri ile işbirliği içerisinde olan firma, ayrıca üretim aşamasında ortaya çıkan posayı organik gübreye dönüştürmek üzere satarak ve müşterilerden kullanılmış cam şişeleri belli oranda geri toplayarak da

çevreye duyarlı sürdürülebilir tarım gıda sektörüne uygun üretim yapmaktadır. Toplanan cam şişelerden uygun olanlar dezenfekte edilip üretim merkezinde yeniden kullanılırken kalan kısım ise yeniden işlenmek üzere geri dönüşüm merkezine oradan da tekrar cam şişe tedarikçisine satılmaktadır.

Tablo 1. Tarım-Gıda Tedarik Zinciri Literatür Matrisi

Yazar	*Geleneksel Ağ Tasarımı*	*Kapalı Döngü Ağ Tasarımı*	*Sürdürülebilirlik*	*Gıda Türü*	*Çözüm Yöntemi*
Apaiah ve Hendrix (2005)	✓			Proteinli Gıda	LP
Gong vd. (2007)	✓			Bozulabilir Gıda	PSO
Jiang vd. (2009)	✓			Et	MISP
Zhao ve Lv (2011)	✓			Elma	PSO
Hasani vd. (2012)		✓		Bozulabilir Gıda	MILP
Ogier vd. (2013)	✓			Taze Gıda	BD, DSSP
Govindan vd. (2014)		✓	✓	Bozulabilir Gıda	MOPSO, AMOVNS
Soysal vd. (2014)		✓	✓	Et	MOLP
Validi vd. (2014)	✓		✓	Mandıra	TOPSIS, MOGA-II, NSGA-II
Cascini vd. (2014)		✓		Sebze	MILP
Nourbakhsh vd. (2016)	✓			Tahıl	MILP
Bortolini vd. (2016)	✓		✓	Taze Gıda	TOLP
Colicchia vd. (2016)	✓			Çikolata	MOMP
Mohammed vd. (2017a)	✓			Helal Et	MOMILP
Mohammed ve Wang (2017)	✓			Et	MOPP
Mohammed vd. (2017b)	✓			Helal Gıda	POS
Miranda-Ackerman vd. (2017)	✓		✓	Portakal Meyve Suyu	LCA, GA, TOPSIS
Mohammed vd. (2017c)	✓			Et	MCOM
Gholamian ve Taghanzadeh (2017)	✓			Buğday	MILP
Allaoui vd. (2018)	✓		✓	Genel Gıda	HDMM, MOMP
Bortolini vd. (2018)		✓		Taze Gıda	BOMILP
Barsing vd. (2018)	✓			Hazır Yemek	SNA
Das (2019)	✓		✓	Genel Gıda	Mathematical Programming
Rohmer vd. (2019)	✓		✓	Besleyici Gıda	MOLP
Darestani ve Hemmati (2019)		✓		Bozulabilir Gıda	CCM, WSM, THM
Ghanbari ve Bashiri (2019)	✓			Genel Gıda	TSSP
Pourmohammadi vd. (2020)	✓			Buğday	SBSP
Mohammadi vd. (2020)	✓		✓	Genel Gıda	AUGMECON
Biuki vd. (2020)	✓		✓	Bozulabilir Gıda	PSO, GA
Mogale vd. (2020)	✓			Tahıl	MOPSO, NSGA-II
Jouzdani ve Govindan (2021)	✓		✓	Bozulabilir Gıda	RMCGP
Bu Çalışma		✓	✓	Şeftali Meyve Suyu	MILP

LP: Linear Programming, PSO: Particle Swarm Optimization, MISP: Mixed Integer Stochastic Programming, MILP: Mixed Integer Linear Programming, MOPSO: Multi-Objective Particle Swarm Optimization, AMOVNS: Adapted Multi-Objective Variable Neighborhood Search, MOLP: Multi-Objective Linear Programming, BD: Benders Decomposition, DSSP: Dynamic Slope Scaling Procedure, TOPSIS, MOGA-II: Multi-Objective GA of kind II, NSGA-II: Non-Dominated Sorting GA of kind II, TOLP: Three Objective Linear Programming, MOMP: Multi-Objective Mathematical Programming, MOMILP: Multi-Objective Mixed Integer Linear Programming, MOPP: Multi-Objective Possibilistic Programming, POS: Pareto Optimal Solution, LCA: Life Cycle Assessment, GA: Genetic Algorithm, MCOM: Multi-Criteria Optimization Method, HDMM: Hybrid Decision-Making Method, BOMILP: Bi-Objective Mixed Integer Linear Programming, SNA: Social Network Analysis, CCM: Comprehensive Criteria Method, WSM: Weighted Sum Method, THM: Torabi-Hassini Method, TSSP: Two-Stage Stochastic Programming, SBSP: Scenario-based Stochastic Programming, AUGMECON, RMCGP: Revised Multi-Choice Goal Programming



Şekil 1. Şeftali Suyu Üretimi için Temsili Kapalı Döngü Tarım-Gıda Tedarik Zinciri Ağı

Probleme ilişkin bazı varsayımlar:

1) Tek tip bir nihai ürün (1 lt'lik şeftali suyu) üretilmektedir.
2) Yeni bir cam şişe ile yıkanıp dezenfekte edilen veya geri dönüştürülen bir cam şişe arasında hiçbir fark yoktur.
3) Üretim kapasitesi tüm nihai ürün gereksinimi için yeterlidir.
4) Tüm maliyet ve satış fiyatı bilgileri bilinmektedir.
5) Her bir dönem için müşterilerin (perakendeciler) talebi kesin olup tümüyle karşılanmaktadır.
6) Yok satma olmadığı varsayılmıştır.

3.1. Matematiksel Model

Model, yukarıdaki varsayımlara dayanarak talebi karşılamak üzere kârı en büyüklemeye çalışmaktadır.

İndisler

i : *Çiftçi Bölgeleri (i=1, 2, …, I)*

j : *2. Kademe Tedarikçiler (j=1, 2, …, J)*

k : *Perakendeciler (k=1, 2, …, K)*

t : *Periyot (t=1, 2, …, T)*

Parametreler

pc_{it} : *i. çiftçi bölgesinden t periyodunda şeftali satın alma maliyeti (₺)*

pt_{jt} : *j. 2. kademe tedarikçisinden t periyodunda şeftali satın alma maliyeti(₺)*

dc_i : *i. çiftçi bölgesi ile üretim merkezi arasındaki mesafe(km)*

dt_j : *j. 2. kademe tedarikçisi ile üretim merkezi arasındaki mesafe(km)*

dd : *Üretim merkezi ile dağıtım ve toplama merkezi arasındaki mesafe(km)*

dp_k : *Dağıtım ve toplama merkezi ile k. perakendeci arasındaki mesafe(km)*

Cc_i : *i. çiftçi bölgesinin şeftali üretim kapasitesi(ton)*

Ct_j : *j. 2. kademe tedarikçinin şeftali üretim kapasitesi(ton)*

de_{kt} : *k. perakendecinin(müşterinin) t dönemindeki şeftali suyu talebi(lt)*

a : *Üretim merkezinin şeftali işleme maliyeti (₺/ton)*

sa : *Bir koli şeftali suyu satış fiyatı(₺/g lt)*

sb : *Organik gübre tesisine şeftali posası satış fiyatı(₺/ton)*

sc : *Geri dönüşüm merkezine kullanılmış cam şişe satış fiyatı(₺/adet)*

ta : *Birim şeftali taşıma maliyeti (ton)*

tb : *Birim şeftali suyu taşıma maliyeti (lt)*

ps : *Cam şişe tedarikçisinden 1 litrelik cam şişe satın alma maliyeti (₺/adet)*

pk : *Ambalaj tesisinden karton kutu satın alma maliyeti (₺/adet)*

α :*Müşterilerden dağıtım ve toplama merkezine geri dönen cam şişe yüzdesi (%)*

β :*İşlenmiş şeftaliden açığa çıkan posa yüzdesi (%)*

γ :*Yeniden kullanılacak cam şişe yüzdesi (%)*

g :*Karton kutu hacmi (alabildiği 1 lt'lik şişe sayısı)*

f : *1 lt şeftali suyunun ağırlığı (ton)*

h : *Şeftali suyunun stok maliyeti (₺/lt)*

Karar Değişkenleri

X_{it} : *t periyodunda i çiftçisinden üretim merkezine taşınan şeftali miktarı (ton)*

Y_{jt} : *t periyodunda j 2. kademe tedarikçidem üretim merkezine taşınan şeftali miktarı (ton)*

Z_t : *t periyodunda üretim merkezinden dağıtım ve toplama merkezine taşınan şeftali suyu miktarı (lt)*

Q_t : *t periyodunda cam şişe tedarikçisinden üretim merkezine gelen cam şişe miktarı (adet)*

V_t : *t periyodunda ambalaj tesisinden üretim merkezine gelen karton kutu miktarı (adet)*

W_t : *t periyodunda üretim merkezinden organik gübre tesisine gönderilen şeftali posası miktarı (ton)*

R_{kt} : *t periyodunda dağıtım ve toplama merkezinden k perakendecisine gönderilen şeftali suyu miktarı (lt)*

I_t : *t periyodunda dağıtım ve toplama merkezinde bulunan şeftali suyu stok miktarı (lt)*

Amaç Fonksiyonları

Amaç fonksiyonu, toplam kârı maksimize etmektir. Yani model, toplam geliri maksimize ederken toplam maliyeti minimize eder. Bu nedenle amaç fonksiyonu toplam gelirin (TG), toplam maliyete (TM) olan farkı şeklinde hesaplanmaktadır. İki kısımdan oluşan amaç fonksiyonu aşağıdaki gibidir:

$$Z = TG\text{-}TM \tag{1}$$

1) Toplam Gelir (TG): Firma, şeftali suyu nihai ürünü başta olmak üzere, şeftali posası ve geri dönüştürülecek cam şişe satışı gerçekleştirmektedir. Bu yüzden TG aşağıdaki gibi üç kısımdan oluşmaktadır.

$$TG = \sum_k \sum_t R_{kt}.\left(\frac{sa}{g}\right) + \sum_t W_t.sb + \sum_k \sum_t de_{kt}.\alpha.(1-\gamma).sc \tag{2}$$

2) Toplam Maliyet (TM): Firma, toplam satın alma maliyeti (TSM), toplam üretim maliyeti (TÜM), toplam taşıma maliyeti (TTM) ve şeftali suyu stok maliyeti (SM) olmak üzere dört farklı maliyete katlanmaktadır. Bu yüzden TM aşağıdaki gibi formülize edilmiştir.

$$TM = TSM + TÜM + TTM + SM \tag{3}$$

2.1) Toplam satın alma maliyeti (TSM): TSM'nin ilk kısmı, üretim merkezinin şeftali talebini karşılamak üzere çiftçilerden ve 2. kademe tedarikçilerinden yapılan satın alma maliyetlerini, ikinci kısım şeftali sularını ambalajlamak için kullanılan cam şişe satın alma maliyetini ve üçüncü kısımda cam şişeleri paketlemek üzere kullanılan karton kutu satın alma maliyetini göstermektedir.

$$TSM = \left(\sum_i \sum_t X_{it}.pc_{it} + \sum_j \sum_t Y_{jt}.pt_{jt}\right) + \left(\sum_t Q_t.ps\right) + \left(\sum_t V_t.pk\right) \tag{4}$$

2.2) Toplam üretim maliyeti (TÜM): Üretim maliyeti; fabrikada şeftalinin işlenmesi için tüketilen kaynakların (elektrik, su, makine, işçilik vb.) toplam maliyetleri hesaplanarak tek kalem şeklinde *(a)* aşağıdaki gibi hesaplanmıştır.

$$TÜM = a.\left(\sum_i \sum_t X_{it} + \sum_j \sum_t Y_{jt}\right) \tag{5}$$

2.3) Toplam taşıma maliyeti (TTM): Modelde taşıma hammadde ve nihai ürün bazında ele alınmıştır. Çiftçilerden ve 2. kademe tedarikçilerinden üretim merkezine yapılan şeftali (hammadde) birim taşıma maliyetleri *(ta)* eşit kabul edilmiştir. Ayrıca, üretim merkezinden

dağıtım ve toplama merkezine ve dağıtım ve toplama merkezinden perakendecilere olan şeftali suyu (nihai ürün) taşıma maliyetlerinin *(tb)* de eşit olduğu kabul edilmiştir. Buna göre toplam taşıma maliyeti aşağıdaki gibi hesaplanmaktadır.

$$\text{TTM}= ta.\left(\sum_i \sum_t X_{it}.\,dc_i + \sum_j \sum_t Y_{jt}.\,dt_j\right) + tb.\left(\sum_t Z_t\,.\,dd + \sum_k \sum_t R_{kt}\,.\,dp_k\right) \quad (6)$$

2.4) Stok maliyeti (SM): Fabrikada üretilen şeftali sularının tümü dağıtım ve toplama merkezine gönderilmektedir. Buradaki şeftali suları talep miktarınca perakendecilere iletilirken, kalan kısım ise sonraki dönemlerde satılmak üzere stoklanır ve maliyeti aşağıdaki gibi hesaplanır.

$$\text{SM}= \sum_t I_t\,.\,h \quad (7)$$

Kısıtlar

$$\left(\sum_i X_{it} + \sum_j Y_{jt}\right) - (Z_t.f + W_t) = 0\ , \qquad \forall t \quad (8)$$

$$Z_t - \left(Q_t + \sum_k de_{k(t-1)}\,.\,\alpha.\gamma\right) = 0\ , \qquad \forall t \quad (9)$$

$$\frac{\left(Q_t+\sum_k de_{k(t-1)}.\alpha.\gamma\right)}{g} - V_t = 0\ , \qquad \forall t \quad (10)$$

$$\beta.\left(\sum_i X_{it} + \sum_j Y_{jt}\right) - (W_t) = 0\ , \qquad \forall t \quad (11)$$

$$(Z_t + I_{t-1}) - (\sum_k R_{kt} + I_t) = 0\,, \qquad \forall t \quad (12)$$

$$R_{kt} = de_{kt}\ , \qquad \forall k,\ t \quad (13)$$

$$X_{it} \le Cc_i\ , \qquad \forall i,\ t \quad (14)$$

$$Y_{jt} \le Ct_j\ , \qquad \forall j,\ t \quad (15)$$

$$X_{it}, Y_{jt}, W_t\ \ge\ 0\,, \qquad \forall i,\ j,\ t \quad (16)$$

$$Z_t, Q_t, V_t, R_{kt}, I_t\ \ge\ 0\,, tamsayı \qquad \forall k,\ t \quad (17)$$

Kısıt (8)-(12)-*Denge Kısıtlarıdır*-İlki, üretim merkezine gelen şeftali miktarının, çıkan şeftali suyu ve posası miktarına eşit olmasını sağlar; ikincisi, yine üretim merkezine gelen şişe miktarının üretilen şeftali suyunu şişelemek için gerekli olan şişe miktarı kadar olmalıdır. Yani gelen şişe miktarı üretim merkezinden dağıtım ve toplama merkezine gönderilen nihai ürün şişe ihtiyacını karşılamalıdır; üçüncüsü, satın alınacak karton kutu miktarını belirler, üretim merkezine gelen şişe miktarı karton kutu hacmine *(g)* bölünerek paketleme için gerekli olan karton kutu miktarı bulunur; dördüncüsü, işlenmiş şeftaliden açığa çıkacak posa miktarını belirler; son denge kısıtı ise dağıtım ve toplama merkezine giren ve çıkan ürün miktarını eşitler. Kısıt (13)-*Talep Kısıtı*- perakendecilere gönderilen şeftali sularının talebi karşılaması gerektiğini; Kısıt (14), (15)-*Kapasite Kısıtları*- sırasıyla çiftçilerden ve 2. kademe tedarikçilerinden üretim merkezine taşınan şeftali miktarının ilgili çiftçi ve tedarikçinin kapasitesinden fazla olamayacağını; Kısıt (16) ve (17) -*İşaret Kısıtları*- ise karar değişkenlerinin negatif olmaması ve tamsayı olması gerektiğini göstermektedir.

3.2. Sayısal Örnek ve Bulgular

Bu bölümde, Türkiye'de faaliyet gösteren X meyve suyu üreticisinin şeftali suyu-gıda tedarik zinciri ağ tasarımı problemi, önerilen sürdürülebilir modelin uygulanabilirliğini

göstermek için kullanılmıştır. 1995 yılında yerli sermaye ile ticari hayatına başlayan X şirketi, %100 meyve suyu üreten sektörün önde gelen firmalarından biri olarak hizmet vermektedir. Anonim şirketinin gizlilik politikası nedeniyle, şirketin adı ve vaka çalışmasındaki bazı veriler buradan değiştirilerek rapor edilmiştir. Modelin planlaması 3 periyot üzerinden yapılmıştır. Çiftçilerin olduğu 4 ayrı bölge, 3 ayrı 2. kademe tedarikçi, 6 perakendeci ve 1'er üretim merkezi, cam şişe tedarikçisi, ambalaj tesisi, organik gübre tesisi, dağıtım ve toplama merkezi, geri dönüşüm merkezi ve çok sayıda müşteri bulunmaktadır. Üretim merkezinin müşterisi perakendecilerdir ve perakendeciler ile müşteriler arasındaki alış veriş dikkate alınmamaktadır. Ton başına şeftali işleme maliyeti ***(a)*** 500₺ taşıma maliyeti ***(ta)*** 0,03₺ iken litre başına şeftali suyu taşıma maliyeti 0,0005₺ dir. Nihai ürün (12 litre şeftali suyu kolisi) satış fiyatı ***(sa)*** 40₺, organik gübre merkezine ton başına şeftali posası satış fiyatı ***(sb)*** 60₺, geri dönüşüm merkezine kullanılmış birim cam şişe satış fiyatı ***(sc)*** 0,10₺ olarak ele alınmıştır. 1 litrelik cam şişe satın alma maliyeti ***(ps)*** 0,20₺ iken birim karton kutu hacmi ***(g)*** 12 adet 1 litrelik şişe büyüklüğünde ve satın alma maliyeti ise ***(pk)*** 0,15₺'dır. 1 litre şeftali suyunun ağırlığı ***(f)*** 0.0013 ton ve stok maliyeti ise ***(h)*** 0.03₺'dır. İşlenmiş şeftaliden açığa çıkan posa yüzdesi ***(β)*** 0.20, geri dönen şişe yüzdesi ***(α)*** 0.40 ve yeniden kullanılacak şişe yüzdesi ***(γ)*** 0.17'dir. Ürün talebi her zaman birimi için 7 adettir. Üretim merkezi ile dağıtım ve toplama merkezi arasındaki mesafe ***(dd)*** 1500 km'dir. Diğer parametreler aşağıda Tablo 2, Tablo 3 ve Tablo 4'de verilmiştir.

Tablo 2. Şeftali satın alma maliyetleri *(₺)*

		Periyot		
		1	**2**	**3**
Çiftçi bölgeleri	**1**	500	450	520
	2	550	500	570
	3	530	480	550
	4	515	460	565
		1	**2**	**3**
2. kademe tedarikçiler	**1**	590	510	600
	2	630	560	650
	3	620	550	630

Tablo 3. Tedarik zinciri üyeleri arasındaki mesafeler *(km)* ve kapasiteler *(ton)*

	1	**2**	**3**	**4**	**5**	**6**
dc_i	3000	3020	3015	2980		
dt_j	200	185	160			
dp_k	100	120	200	210	178	150
Cc_i	98	80	75	150		
Ct_j	60	70	75			

Tablo 4. Müşteri talepleri *(lt)*

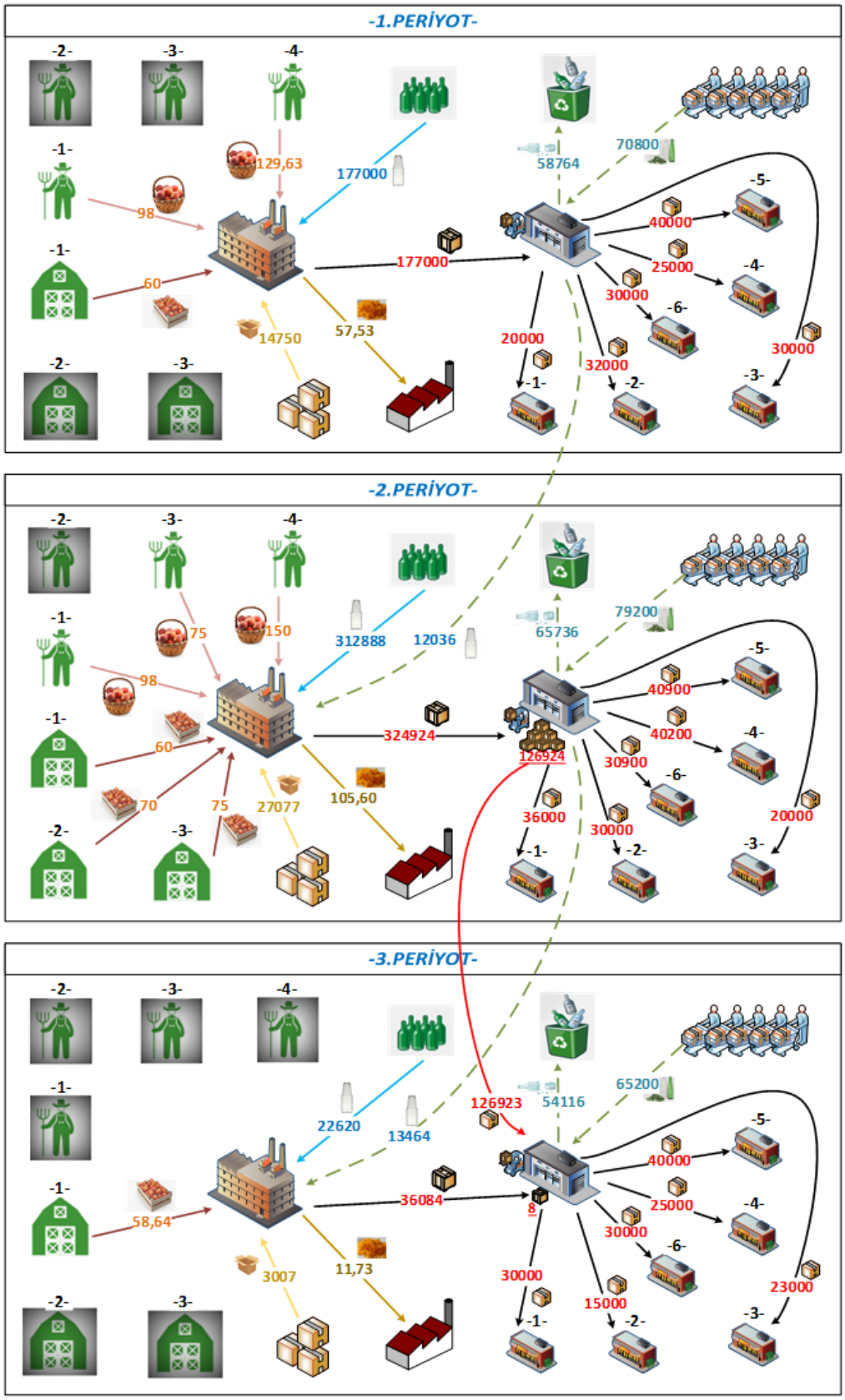
		Periyot		
		1	**2**	**3**
Perakendeciler	**1**	20000	36000	30000
	2	32000	30000	15000
	3	30000	20000	23000
	4	25000	40200	25000
	5	40000	40900	40000
	6	30000	30900	30000

Geliştirilen karma tam sayılı doğrusal programlama modeli bu veriler doğrultusunda, *Windows 10* işletim sistemi üzerinde çalışan *16 GB RAM'li 2.20 GHz Intel® Core™ i7-8750H CPU* işlemciye sahip bir bilgisayarda *GAMS 24.0.1/CPLEX* paket programı kullanılarak 1 saniyeden kısa bir sürede çözülmüş ve aşağıdaki sonuçlar elde edilmiştir (Tablo 5).

Tablo 5. Optimal amaç fonksiyonu değeri *(₺)*

Amaç Fonksiyonu	**Değeri**
TG	1821686.09
TM	1494672.96
TSM	555716.23
TÜM	437131.50
TTM	498017.28
SM	3807.96
Z	**327013.12**

Çözüm sonuçlarına göre toplam gelir 1821686.09₺, toplam maliyet 1494672.96₺, karı maksimize eden optimum amaç fonksiyonu değeri ise 327013.12₺'dir. Firma için mali giderler olarak en fazla satın alma sonrasında sırasıyla taşıma, üretim ve stok kalemleri gelmektedir. Tüm dönemlerin optimal akışı Şekil 2'de gösterilmektedir.



Şekil 2. Optimal Akış

4. Tartışma

Bu bölümünde çözüm sonucu elde edilen bulgular Şekil 2 üzerinden açıklanmıştır. Burada kara kutu içerisinde gösterilen çiftçi ve 2. kademe tedarikçileri, ilgili dönemde aktif olmayan, herhangi bir satış gerçekleştirmeyen elemanları resmetmektedir. Düz çizgili oklar ileri, kesikli çizgiler tersine akışları göstermektedir. Çizgilerin üzerindeki sayılar akış miktarını, oklar ise akış yönünü belirtmektedir. Buna göre; Firma ilk dönem satın alma maliyetleri daha düşük olan 1 ve 4 numaralı bölgelerde bulunan çiftçilerden ve 1 numaralı 2. kademe tedarikçisinden şeftali temin ederek üretimi gerçekleştirmiştir. İkinci dönem ise şeftali maliyetlerinin düşüşüyle birlikte 2 numaralı bölgede bulunan çiftçiler dışında tüm çiftçi ve tedarikçilerden mümkün olduğunca şeftali temin ederek hem 2. dönemin talebini hem de sonraki dönem talebinin büyük kısmını karşılayacak şekilde üretim yapmıştır. Böylece dağıtım ve toplama merkezinde fazla şeftali suyu stoku tutarak bir sonraki dönemde beklenen hammadde fiyat artışı sebebiyle oluşacak zararın önüne geçmiştir. Ayrıca, üretilen şeftali suyunu şişelemek için bir önceki dönem toplanan cam şişelerden uygun olanlar dezenfekte edilip kullanılmış kalan kısım ise cam şişe tedarikçisinden satın alınarak karşılanmıştır. Son dönem ise kalan talebi karşılamak için sadece 1 numaralı tedarikçiden şeftali temin edilerek üretim gerçekleştirilmiş, kalan kısım dağıtım ve toplama merkezindeki stoktan karşılanmıştır. Yine şişelemek için hem önceki dönem toplanıp dezenfekte edilen hem de satın alınan yeni şişeler kullanılmıştır.

Geliştirilen modele ait çözüm sonuçlarının işletmenin karını artırmak üzerine iyileştirilmesi için, duyarlılık analizi yapılacak ve elde edilen bulgular genişletilecektir. İşletme için mali giderler bazında satın alma kalemi en fazla olduğundan, bir sonraki aşamada çiftçi ve 2. kademe tedarikçilerin tedarik zincirine ektisi üzerine bir analiz gerçekleştirilecektir.

4.1. Duyarlılık Analizi

Bu bölümde oluşturulan model için Çiftçi ve 2. Kademe tedarikçi kapasite parametreleri değerlerindeki değişimin, problemin amaç fonksiyonu değeri ve ağ tasarımı üzerine olan etkileri incelenmiştir. Tablo 6'deki sonuçlara göre çiftçi kapasiteleri artıkça amaç fonksiyonu değeri de genel olarak artmaktadır. Çiftçi kapasiteleri %25, %50, %75 ve %100 arttırıldığında toplam kâr sırasıyla %0.8, %1.3, %1.8 ve %2.1'lik bir artış göstermiştir. Ayrıca Tablo 6'den elde edilen verilere göre tüm senaryolarda 1. Çiftçiden ilk iki dönem, 4. Çiftçiden ise sadece ikinci dönem (şeftali fiyatlarının düştüğü sezon) ful kapasite ürün satın alınmıştır. Çiftçi kapasiteleri artırıldıkça firma öncelikle bu tedarikçilerden ürün almaya yöneldiğinden 3 numaralı çiftçiden ilk senaryodan sonra 2 numaralı çiftçiden ise hiçbir senaryoda ürün satın alınmamıştır.

Tablo 7'daki sonuçlara göre 2. Kademe tedarikçi kapasiteleri artıkça yine amaç fonksiyonu değeri de genel olarak artmaktadır. 2. Kademe tedarikçi kapasiteleri %25, %50, %75 ve %100 arttırıldığında toplam kâr sırasıyla %0.6, %1, %1.3 ve %1.7'lik bir artış göstermiştir. Ayrıca Tablo 7'dan elde edilen verilere göre tüm senaryolarda 1. tedarikçiden ilk iki dönem, 3. tedarikçiden ise sadece ikinci dönem ful kapasite ürün satın alınmıştır. Yine, 2. Tedarikçiden 2. dönem ilk iki senaryoda ful kapasite sonraki senaryolarda ise firma öncelikle 1 ve 3 numaralı tedarikçilerden ürün almaya yöneldiğinden kapasitesinin altında ürün satın alınmıştır.

Buradan hareketle, çiftçi ve tedarikçilerin etkinliği üzerine yapılan duyarlılık analizleri sonucunda, doğru (en uygun) çiftçileri tarlalarını daha verimli hale getirmeleri üzerine teşvik ederek daha fazla miktarda ürün çıkmasını sağlamak; yine doğru tedarikçileri de satın alma sözü üzerine hasat zamanı daha fazla ürün temin etmeleri konusunda teşvik etmek, firmanın satın alma maliyetlerini büyük ölçüde düşürecek ve kârı en büyükleme amacına dair büyük avantaj kazandıracaktır. Bu açıdan, Tablo 6 ve 7 da sunulan duyarlılık analizleri sonucuna göre; Firmanın daha fazla kâr elde etmek için öncelikli olarak kendisi için en uygun olan 1 numaralı çiftçi ve tedarikçi ile sonrasında gerekirse 4 numaralı çiftçi ve 3 numaralı tedarikçi ile bir anlaşma yoluna gitmesi önerilir.

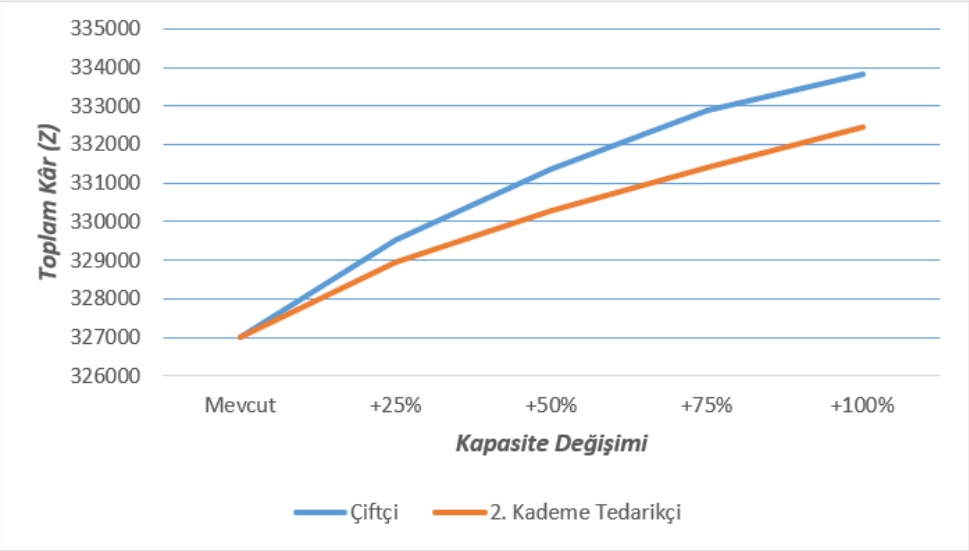
Tablo 6. Senaryo analizi sonucu çiftçilerden ürün akışı ve amaç fonksiyonu performans değerleri

	Çiftçi kapasitelerinin değişimi				
Performanslar	**Mevcut**	**+%25**	**+%50**	**+%75**	**+%100**
***Cc*$_1$**	**98**	**122.5**	**147**	**171.5**	**196**
X_{11}	98	122.5	147	171.5	196
X_{12}	98	122.5	147	171.5	196
X_{13}	0	0	0	0	0
***Cc*$_2$**	**80**	**100**	**120**	**140**	**160**
X_{21}	0	0	0	0	0
X_{22}	0	0	0	0	0
X_{23}	0	0	0	0	0
***Cc*$_3$**	**75**	**93.75**	**112.5**	**131.25**	**150**
X_{31}	0	0	0	0	0
X_{32}	75	49.76	0	0	0
X_{33}	0	0	0	0	0
***Cc*$_4$**	**150**	**187.5**	**225**	**262.5**	**300**
X_{41}	129.63	105.13	80.63	56.13	31.62
X_{42}	150	187.5	225	262.5	300
X_{43}	0	0	0	0	0
Z	**327013.12**	**329529.48**	**331357.70**	**332896.51**	**333814.41**

Tablo 7. Senaryo analizi sonucu 2. kademe tedarikçi ürün akışı ve amaç fonksiyonu performans değerleri.

	2. Kademe tedarikçi kapasitelerinin değişimi				
Performanslar	**Mevcut**	**+%25**	**+%50**	**+%75**	**+%100**
***Ct*$_1$**	**60**	**75**	**90**	**105**	**120**
Y_{11}	60	75	90	105	120
Y_{12}	60	75	90	105	120
Y_{13}	58.64	21.88	21.88	21.88	21.88
***Ct*$_2$**	**70**	**87.5**	**105**	**122.5**	**140**
Y_{21}	0	0	0	0	0
Y_{22}	70	87.5	105	80.51	46.76
Y_{23}	0	0	0	0	0
***Ct*$_3$**	**75**	**93.75**	**112.5**	**131.25**	**150**
Y_{31}	0	0	0	0	0
Y_{32}	75	93.75	112.5	131.25	150
Y_{33}	0	0	0	0	0
Z	**327013.12**	**328963.22**	**330285.16**	**331401.34**	**332472.15**

Bunun yanında çiftçi ve 2. Kademe tedarikçi kapasite değerleriyle yapılan duyarlılık analizlerinin amaç fonksiyonuna ektileri üzerindeki fark Şekil 3'de daha açık bir şekilde gösterilmiştir. Buna göre, çiftçi kapasiteleri üzerine yapılan değişiklikler kâr üzerinde, 2. Kademe tedarikçilerine oranla daha büyük artışlara neden olmuştur. Bu da gösteriyor ki önerilen model, çiftçi kapasitesi parametre değişikliklerine daha duyarlıdır.



Şekil 2. Duyarlılık analizi sonucu amaç fonksiyonundaki performans değişimi

5. SONUÇ

Gıda, günlük yaşamın hayati bir bileşenidir, ancak mevcut tüketim ve üretim kalıpları çevre ve gelecek nesillerin gıda güvenliği için bir tehdit oluşturmaktadır. Üretilen tarımsal gıda ürünleri, yetersiz altyapı ve verimsiz TZ ağları nedeniyle israf edilmektedir. Bu nedenle, çevresel sorumlulukların ve toplumsal farkındalığın artmasıyla birlikte, gıda tedarik sistemini yeniden gözden geçirmenin zamanı gelmiştir (Rohmer vd., 2019). Firmaların, mevcut yaklaşımlarıyla birlikte sürdürülebilir paradigmaları da uygulamaları rakiplerine karşı avantaj sağlamaktadır. Bu doğrultuda, Gıda sektöründe faaliyet gösteren bir meyve suyu firması için yeni bir TZ ağ tasarımı oluşturulmuştur. Yapılan duyarlılık analizi ile uygun çiftçi ve tedarikçilerden yeterli arz sağlanmasının, maliyet artışının önüne geçeceği ve meyve suyu üretim sürecine daha yüksek kâr kazandıracağı sonucuna varılmıştır.

Meyve Suyu Endüstrisi Derneği 2020 yılı şubat ayında Türkiye'deki yıllık meyve suyu tüketiminin 1 milyar litre olduğunu açıklamıştır. Bu çalışma, mevcut yayınlardan farklı olarak meyve suyu tedarik zincirinde geri dönüşüme yeterli önemi vermesi ve sürdürülebilir bir ağ tasarımı oluşturması bakımından literatüre katkı sağlamaktadır. Çalışmanın pratik hayata katkısı ise önerilen modelin uygulanması halinde meyve suyu üretim sürecinin daha verimli ve sürdürülebilir biçimde planlanacağı, hem çiftçilerin hem de firmanın çevresel ve ekonomik kazanım elde edeceği sonucudur.

Bu çalışmada sunulan model çerçevesi, uygulayıcılara tarım-gıda tedarik zincirinde ağ tasarımı modelleme ve tasarım sürecine dâhil edilmesi gereken temel konularda rehberlik etmek için geliştirilmiştir. Ayrıca tarımsal gıda sistemlerinde sıklıkla ortaya

çıkan durumların nasıl üstesinden gelineceğine dair örnekler sunmaktadır. Şeftali suyu üretim süreci uygulama çalışması, sunulan modelleme ve optimizasyon stratejileri için örnek bir vaka işlevi görür ve benzer özelliklere sahip çok çeşitli tarımsal gıda tedarik zincirlerine uygulanabilir.

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RESEARCH ARTICLE

Kshal: A Web-Based Innovative Software Alternative for Maritime Logistics Companies

Kshal: Deniz Lojistiği Firmalari İçin Web Tabanli Bir Yazilim Alternatifi

Kerem Şahinboy[1]

ABSTRACT

The 20th Century was a milestone of evolutionary jumps in critical changes in the business world. Technological innovations have been sparkled into our daily lives and triggered the rise of intelligent systems integrating production systems, supply chains, customs authorities, b2b, c2c commercial activities, etc. The boost of change occurred within companies by the push of intelligent technological systems. The internet made this jump more visible and widespread while providing new challenges and opportunities together. Dull software systems evolved into mobile or web-based, fully integrated multilingual assets that helped companies to become new winners, or by another name, "record breakers" in the world markets. This paper aims to enlighten the necessity of shifting companies to upgrade their software infrastructure into web-based, lightweight, budget-wise, feasible, innovative platforms that can create sustainable profitability while simplifying complex organisational problems in the maritime industry. KSHAL is a web-based ERP program designed for small and medium-sized freight forwarders, shipping companies and maritime logistics organisations. KSHAL is capable of handling container shipments, container trading activities, freight quotations, and customer relations successfully. KSHAL Project as a web-based maritime software alternative will be the focal point of this article as an excellent example of planning, designing, coding, deploying and commercialising the whole software development process in one go. The paper also aims to illuminate the advantages of the SaaS (Software as a Service) based ERP systems for freight forwarding companies and merchants in the container trading industry.

Keywords: Software, Logistics, Innovation, Development, Maritime

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[1] **Corresponding author:** Kerem Şahinboy (Ph.D Candidate), Yeditepe University Logistics Dept, İstanbul, Turkey
E-mail: kerem.sahinboy@std.yeditepe.edu.tr ORCID: 0000-0001-7403-6979

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1. Introduction

This article aims to study the steps of building a web-based software alternative from drafts up to commercialising the final product by selling it to corporate level buyers in the maritime industry. The paper will try to obtain findings on the possibilities of bringing a creative, economical and straightforward software solution as a final product without compromising the building of an extensive data handling structure that provides a complete web-based IT system for maritime companies, particularly freight forwarders and container trading merchants. The article will also display a full-scale production process from blueprints to taking the completed and deployed software "live" and more. This study is a part of the first author's PhD dissertation.

2. Research Problems and Theoretical Approach

There are three major problems this research focuses on. These three problems form the basis of the text and provide us with a reliable guideline on creating a beneficial application. The first problem is allocated for the group of smaller issues related to the developer's end. In this cluster, we will group questions or issues related to Start-Up Mentality, budgeting, human resources, design, development, creating differences while not burying the ideas under chunks of occupying "dead" decisions. Simply, "How to develop an industry-specific software without sacrificing the quality and operability."

The second cluster is a base for several smaller problems related to innovation and market trends. Innovation, or General Product Innovation (GPI), shapes upmarket trends while market trends pull or push innovative technologies. Hence, a GPI provides a substantial improvement in product functionality (where products can be physical goods or non-physical services) while drawing on an established set of technical principles. GPI commonly occurs within product lines (for simplicity, we will refer to the organisational unit responsible for a product line as a "business" while noting that some businesses may offer multiple product lines), which tend to draw on common pools of knowledge. For instance, consider applications software. Identifying the distinction between GPI and minor changes typically depends on criteria relevant to a particular industry and technical settings. The empirical section of the paper uses a multi-dimensional approach to identifying GPIs that are appropriate in our analytic setting [1].

The final cluster of problems is classified as customers'/users' end. No matter how much an investor ever believed in his/her product, the success is justified by the customers' decision. All our efforts, struggles and achievements are crowned, praised or trashed by those who experience our product and decide if it works or not. What is the correlation between available IT solutions and complaints of customers? How may we reconceptualise enhancing end-user satisfaction through our technology? How advanced is our target audience when taking tech, IT, software, ERP topics into consideration? How simple should our screens and task flows be designed, as many efforts languish as they become a control mechanism over the sales force, sales personnel do not enter the necessary data into the program, or the information is not used for the intended purpose [2]?

Good research is grounded in theory. Theories consist thus of plausible relationships produced among concepts and set of concepts, providing both a framework for critically understanding a phenomenon and a basis for considering how what is unknown can be organized [3]. This paper cites Porter's Value Chain Strategy. This theory can be taken as a peerless management tool that is often used in the logistics industry to get into details of individual departments or activities of companies by splitting their functions into pieces. Value chain analysis describes the activities within and around an organisation and relates them to analysing its competitive strength. Therefore, it evaluates which value each particular activity adds to the organisations' products or services. This idea was built upon the insight that an organisation is more than a random compilation of machinery, equipment, people and money. Only if these things are arranged into systems, and systematic activities will it become possible to produce something for which customers are willing to pay the price Porter argues that the ability to perform particular activities and manage the linkages between these activities is a source of competitive advantage [4].

As the second theoretical reference, this paper adjusts Time in Transit Theory to its narrative content. This theory was introduced by the Japanese academic Kiyoyasu Tanaka in 2010 by delivering a contemporary approach that analyses freight and distance alternatives. Distance as a variable derivative has a significant influence on freight. Tanaka concentrates his argument around the trade-off issue between freight- cost-time and timely delivery to build this model. Using the Japanese Census of Logistics, his paper examines the cost influence of distance and time across shipping modes. Tanaka states that he found the results puzzling because business enterprises are likely to pay more for short-distance shipments by truck, ship and railroad transportation. Tanaka's statement is in itself puzzling because the effect of short distances on rates, as per-mile freight rates, tends to decline with distance as the ratio decreases [5].

The third theory that this paper is scholarly influenced by is The Theory of Constraints (TOC). TOC is a method for identifying the most important limiting factor (i.e., constraint) that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor. In manufacturing, the constraint is often referred to as a bottleneck [6]. Constraints can be observed or experienced in all divisions of maritime companies, and software is there to take an incentive initiative to mitigate the congestion that drains our customers' profitability, effectiveness, and competitive superiority in the maritime industry for customers who have bought or will buy KSHAL. A lean, simple to use, easy to learn, and powerful software is one of the key players challenging constraints at companies, especially in shipping entities where data is a major player of the operational flow.

3. Methodology

Building up software from drafts has three project stages: before the project starts, the development phase, and the aftermaths of the deployment. Analytical Hierarchy Process (AHP) is a popular and effective method for deciding between numerous alternatives by weighting their importance levels. We will be seeking answers to our questions on which database platform, coding language, deployment environment and pricing technique

is best for our software named KSHAL. This study will use the Critical Path Method (CPM) for scheduling the project steps and Project Evaluation and Review Technique (PERT) in conjunction with CPM to visualise the budget aspect of software development. CPM requires us to compile all the activities needed to accomplish the KSHAL project and assign each station its unique time requirements. When developing software, there are multiple serial and parallel activities. Developing DB relations, setting up a coding environment, distributing project segments between the developers and data analysts, creating the GUI, connecting back-end and front-end buses are all important stations that run simultaneously or by sequence. While CPM has a deterministic approach, PERT runs in a probabilistic way. DEA will measure KSHAL's benefits at multiple hubs. This paper will evaluate how effective and efficient the software is at three different companies in two countries: Turkey and Ukraine. Medium-sized maritime logistics companies have used the program in their shipping, container storage, container sales, CRM, and documentation operations for over a year. DEA is an efficiency analysis that compares participating units' relative efficiency level, such as similar-sized companies that work in the same business field and different company branches. The participating teams must have the same or similar inputs and generate the same or similar outputs.

4. Statistical Comparison of Two ERP Programs

It is necessary to benchmark two software platforms, particularly an ERP that works on a local computer network and another one that works on the web to observe the benefits or inefficiencies of these systems. Company "A" is a participant freight-forwarding corporation with over 15 years of experience in container shipping, air cargo and truck transportation services, located in Istanbul, Turkey. Company A used these two different ERP platforms over the years. Our case study will reveal the substantial meaningful relations, if any, between these two ERP platforms as each has significant differences technologically and cost-wise.

This research used IBM's SPSS program to interpret the data collected from company A. The data was acquired from the company directly by visiting them at their workplace and studying the raw data for five working days. Table 1 gives us an insight into ERP1, which the company used from 2010 to 2014, and the Table 2 shows us the details of ERP2, which was in use from 2015 to 2019. The benchmark data has been segmented into three measurement units: as USD currency, as quantity and as minutes for 41 different criteria as subjects of the comparison study. ERP1 is software that runs locally as an installed program. The primary DB is stored on a server, and CALs (Certified App License) connect to the mainframe as clients. It does not have access for third-party applicants unless otherwise permitted by company A. ERP1 does not require an Internet connection to function except a typical WAN structure, which allows CALs to log in through a LAN. ERP2 is a web-based platform that needs an Internet connection to access it. ERP2 is not an installed product; it does not require any applets or plug-ins to be installed to use it. It runs on a cloud environment and is accessible by web browsers. ERP1 does not provide DB protection or a backup service. Company A protects its data and monitors it with a daily backup process performed by the company's personnel.

ERP1 is an older software than ERP2, and cost-wise it is the one with a higher sales price. ERP1 uses Progress DB, and ERP2 uses MS SQL DB. As a result, the start-up cost of ERP1 is higher than ERP2. ERP1 requires two in-house servers, one dedicated for the program's core and one for hosting the DB. In addition to this, ERP1 only runs on Microsoft Server operating system. The client is asked to purchase Microsoft's Server Operating system twice, once for the server that runs the program and the other for the server that hosts the DB files. ERP2 runs on a virtual server environment that does not ask clients to invest in hardware items such as servers or additional operating system licenses. In this respect, it is relatively simple to kick-start the ERP2 project for maritime companies willing to switch their old ERP or have a brand new one from zero ground.

ERP1 has fewer modules, and broader skills to cover the major needs of shipping companies. Most importantly, ERP1 has an integrated accounting module that comes with the program while ERP2 works with third-party accounting programs. On the other hand, ERP2 shows signs of openness and more flexibility for third-party integration possibilities. ERP1 has a policy that they produce all that is needed and supply their customers with their licensed products. ERP1 needs two to three weeks to get the program customised and running correctly for each new client, while ERP2 needs a week to set it all up and get ready, including custom-designed documents.

As seen below, ERP1 was used for five years at company A. Company A had a 3.5 million USD turnover in the first year when ERP1 was set in use. When it was replaced by ERP2 in 2014, company A had 3427 TEU (Twenty Feet Equivalent Unit) sea shipments, 404 air cargo parcels and 1012 truckloads per annum. The data table shows that 1089 Bill of Ladings were issued for 3296 TEUs in 2013. Therefore, it can be interpreted that an average B/L had 3.02 TEUs assigned to it as it is possible to ship multiple containers under one B/L coverage.

The company A, as it is their preference in business, has only air cargo parcel exports; that is why there is an equal number of air cargo exports and MAWBs (Master Airway Bill). Table 1 shows that company A's marketing department has sent 1561 freight quotations to local and international customers and gained 3296 TEUs out of these efforts. Comparing that ratio, the trucking department has half of that efficiency which the sea freight department had in 2013, and they have sent 1311 freight quotations and gained only 927 shipments as a result. We can also observe that company A continuously increased their international partners from 9 to 14 in those five years. International partners are considered big-scale customers in the maritime business. They provide shipment volumes as both service buyers and sellers at the same time.

Table 1. ERP1 Dataset (A Locally Installed Program)

ERP 1 (COMPANY A)	UNIT	2010	2011	2012	2013	2014
Turnover (Mil)	USD	3.5	3.8	4.2	5.1	5.3
Net Profits (Mil)	USD	0.32	0.34	0.39	0.46	0.49
Sea Shipments (TEUs)	Quantity	2342.0	2520.0	2711.0	3296.0	3427.0
Air Shipments (Parcel)	Quantity	132.0	244.0	296.0	371.0	404.0
Road Shipments (Truck)	Quantity	721.0	826.0	899.0	927.0	1012.0
Sea B/L Issued	Quantity	834.0	681.0	777.0	1089.0	911.0
Air B/L Issued	Quantity	132.0	244.0	296.0	371.0	404.0
Road Cmr Issued	Quantity	721.0	826.0	899.0	927.0	1012.0
Freight Invoice Issued - Sea	Quantity	2006.0	2114.0	2645.0	3010.0	3127.0
Freight Invoice Issued - Air	Quantity	132.0	244.0	296.0	371.0	404.0
Freight Invoice Issued - Road	Quantity	701.0	808.0	890.0	894.0	997.0
Error(s) Reported	Quantity	44.0	52.0	31.0	27.0	24.0
Integration Demanded	Quantity	0.0	0.0	1.0	0.0	1.0
Annual Maintenance Fees	USD	2382.0	4248.0	5310.0	6018.0	7788.0
Av. Profit Per Shipment	USD	100.2	94.7	99.84	100.1	101.2
Av. Profit Per Shipment Sea	USD	92.2	90.8	104.0	105.0	93.2
Av. Profit Per Shipment Air	USD	110.1	97.7	98.8	97.1	91.3
Av. Profit Per Shipment Road	USD	98.2	95.6	96.7	98.2	119.1
Time for Submitting a B/L	Minute	5	5	5	6	6
Average Amount of Reports	Quantity	4	4	5	5	6
Active CALs	Quantity	10	13	13	15	16
Program Crash Reports / Annual	Quantity	3	2	0	0	1
Training Time	Minute	40	52	55	68	78
Training Time per CAL	Minute	4	4	4.23	4.53	4.87
Training Costs	USD	1200	1560	1650	2040	2340
Training Costs per CAL	USD	120	120	126.92	136	146.25
Freight Quotations Made	Quantity	2576	2747	2741	3179	3893
Freight Quotes. Made Sea	Quantity	1104	1310	1098	1561	2080
Freight Quotes. Made Air	Quantity	410	328	366	307	384
Freight Quotes. Made Road	Quantity	1062	1109	1277	1311	1154
Average Time to Make Offers	Quantity	7	7	8	8	7
Visit Reports Submitted	Quantity	378	432	842	1040	1092
Acquired Orders After Quotes	Quantity	695	906	1014	1208	1479
Lost Customers	Quantity	27	24	18	32	19
Acquired Customers	Quantity	32	22	27	28	33
Reclaimed Customers	Quantity	4	0	2	1	1
Quantity of International Partners	Quantity	9	11	12	15	14
Quantity of Domestic Partners	Quantity	17	22	26	35	33
Amount of Integrations	Quantity	0	0	0	1	1
Integrated 3rd Party Apps	Quantity	0	0	0	1	1
Average Screen Time per CAL per Day	Minute	178	181	202	216	209
Amount of Complaint Tickets (CALs)	Quantity	32	27	38	41	45

Table 2. ERP2 Dataset (A Web-Based Program)

ERP 2 (COMPANY A)	UNIT	2015	2016	2017	2018	2019
Turnover (Mil)	USD	5.9	6.4	6.8	7.2	8.1
Net Profits (Mil)	USD	0.58	0.63	0.65	0.64	0.77
Sea Shipments (TEUs)	Quantity	3948.0	4314.0	4608.0	4983.0	4764.0
Air Shipments (Parcel)	Quantity	425.0	471.0	518.0	615.0	552.0
Road Shipments (Truck)	Quantity	1107.0	1184.0	1213.0	1340.0	1205.0
Sea B/L Issued	Quantity	842.0	922.0	1221.0	1422.0	1385.0
Air B/L Issued	Quantity	425.0	471.0	518.0	615.0	552.0
Road Cmr Issued	Quantity	1107.0	1184.0	1213.0	1340.0	1205.0
Freight Invoice Issued - Sea	Quantity	3801.0	3926.0	4107.0	4048.0	4513.0
Freight Invoice Issued - Air	Quantity	425.0	471.0	518.0	615.0	552.0
Freight Invoice Issued - Road	Quantity	1096.0	1091.0	1175.0	1213.0	1106.0
Error(s) Reported	Quantity	29.0	16.0	10.0	14.0	9.0
Integration Demanded	Quantity	2.0	0.0	0.0	1.0	1.0
Annual Maintenance Fees	USD	1416.0	1289.0	1154.0	1080.0	928.0
Av. Profit Per Shipment	USD	105.8	105.5	102.5	92.2	118.1
Av. Profit Per Shipment Sea	USD	111.3	106.1	101.5	94.6	124.8
Av. Profit Per Shipment Air	USD	102.0	107.2	98.4	87.9	108.8
Av. Profit Per Shipment Road	USD	104.2	103.3	107.7	94.0	120.7
Time for Submitting a B/L	Minute	5	5	4	4	3
Average Amount of Reports	Quantity	6	6	7	8	9
Active CALs	Quantity	15	16	16	19	22
Program Crash Reports / Annual	Quantity	3	0	1	0	2
Training Time	Minute	120	72	64	86	96
Training Time per CAL	Minute	8	4.5	4	4.52	4.36
Training Costs	USD	1200	720	640	860	960
Training Costs per CAL	USD	80	45	40	45.26	43.63
Freight Quotations Made	Quantity	3925	3841	4190	3433	4211
Freight Quotes. Made Sea	Quantity	2810	2706	2971	2522	2885
Freight Quotes. Made Air	Quantity	505	248	303	201	286
Freight Quotes. Made Road	Quantity	610	887	916	710	1040
Average Time to Make Offers	Quantity	5	5	5	5	4
Visit Reports Submitted	Quantity	921	1183	1320	1408	1560
Acquired Orders After Quotes	Quantity	1570	1728	1718	1510	1588
Lost Customers	Quantity	23	14	25	16	12
Acquired Customers	Quantity	21	7	32	29	31
Reclaimed Customers	Quantity	2	0	3	4	5
Quantity of International Partners	Quantity	18	18	19	19	19
Quantity of Domestic Partners	Quantity	29	42	44	45	44
Amount of Integrations	Quantity	2	0	0	3	4
Integrated 3rd Party Apps	Quantity	2	0	0	3	5
Average Screen Time per CAL per Day	Minute	217	234	242	252	268
Amount of Complaint Tickets (CALs)	Quantity	8	11	5	7	7

It is possible to observe that due to several upgrades and changes in ERP1, the time of submitting a BL (Bill of Loading) and the average time of sending a quotation have increased by one minute per record. In the maritime industry, particularly in the freight forwarding business, response punctuality on the customer's demands means a big

win. Whoever sends the offers first makes a significant and positive impression on the customer's side. Moreover, punctuality is equal to expertise in a specific type of service or geographical area served. Thus, the average time spent for a quotation is a measured parameter at maritime companies.

At this step, to take our study up to a more concrete scale and have it materialise, it is necessary to propose a simple hypothesis as follows:

- H0: ERP2 is not significantly better than ERP1, and ERP2 does not bring a remarkable dynamism to company A.
- H1(A): ERP2 is significantly better than ERP1, and ERP2 brings more dynamism to company A.

Table 3. Results of Different Statistical Analyses

Variables	Mean Rank		Mann-Whitney U	Wilcoxon W	Chi-Square	P-value	Correlation Coefficient Category of ERP	P-value
Turnover Mil	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Net Profits Mil	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Sea Shipments TEUs	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Air Shipments Parcel	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Road Shipments Truck	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Sea B/L Issued	ERP1	3.6	3,000	18,000	3,938	**0.047**	0.661	**0.037**
	ERP2	7.4						
Air B/L Issued	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Road Cmr Issued	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Freight Invoice Issued Sea	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Freight Invoice Issued Air	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Freight Invoice Issued Road	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Errors Reported	ERP1	7.6	2,000	17,000	4,811	**0.028**	-0.731	**0.016**
	ERP2	3.4						
Integration Demanded	ERP1	4.4	7,000	22,000	1,729	0.189	0.438	0.205
	ERP2	6.6						
Annual Maintenance Fees	ERP1	8	.000	15,000	6,818	**0.009**	-0.870	**0.001**
	ERP2	3						

Av Profit Per Shipment	ERP1	4	5,000	20,000	2,455	0.117	0.522	0.122
	ERP2	7						
Av Profit Per Shipment Sea	ERP1	3.8	4,000	19,000	3,153	0.076	0.592	0.071
	ERP2	7.2						
Av Profit Per Shipment Air	ERP1	5	10,000	25,000	.273	0.602	0.174	0.631
	ERP2	6						
Av Profit Per Shipment Road	ERP1	4.6	8,000	23,000	.889	0.346	0.314	0.376
	ERP2	6.4						
Time for Submitting a BL	ERP1	7.4	3,000	18,000	4,544	**0.033**	-0.711	**0.021**
	ERP2	3.6						
Average Amount of Reports	ERP1	3.2	1,000	16,000	5,989	**0.014**	0.816	**0.004**
	ERP2	7.8						
Active CALs	ERP1	3.5	2,500	17,500	4,528	**0.033**	0.709	**0.022**
	ERP2	7.5						
Program Crash Reports Annual	ERP1	5.5	12,500	27,500	.000	1,000	0.00	1.00
	ERP2	5.5						
Training Time	ERP1	3.6	3,000	18,000	3,938	**0.047**	0.661	**0.037**
	ERP2	7.4						
Training Time per CAL	ERP1	5	10,000	25,000	.280	0.597	0.176	0.626
	ERP2	6						
Training Costs	ERP1	7.9	.500	15,500	6,322	**0.012**	-0.838	**0.002**
	ERP2	3.1						
Training Costs per CAL	ERP1	8	.000	15,000	6,860	**0.009**	-0.873	**0.001**
	ERP2	3						
Freight Quotations Made	ERP1	3.4	2,000	17,000	4,811	**0.028**	0.731	**0.016**
	ERP2	7.6						
Freight Quotes Made Sea	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Freight Quotes Made Air	ERP1	7	5,000	20,000	2,455	0.117	-0.522	0.122
	ERP2	4						
Freight Quotes Made Road	ERP1	8	.000	15,000	6,818	**0.009**	-0.870	**0.001**
	ERP2	3						
Average Time to Make Offers	ERP1	3.4	.000	15,000	7,500	**0.006**	-0.913	**0.000**
	ERP2	7.6						
Visit Reports Submitted	ERP1	3	2,000	17,000	4,811	**0.028**	0.731	**0.016**
	ERP2	8						
Acquired Orders After Quotes	ERP1	7	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	4						
Lost Customers	ERP1	6.1	5,000	20,000	2,455	0.117	-0.522	0.122
	ERP2	4.9						
Acquired Customers	ERP1	6.1	9,500	24,500	.395	0.530	-0.210	0.561
	ERP2	4.9						
Reclaimed Customers	ERP1	4.5	7,500	22,500	1,118	0.290	0.352	0.318
	ERP2	6.5						
Quantity of International Partners	ERP1	3	.000	15,000	7,031	**0.008**	0.884	**0.001**
	ERP2	8						
Quantity of Domestic Partners	ERP1	3.4	2,000	17,000	4,840	**0.028**	0.733	**0.016**
	ERP2	7.6						

Amount of Integrations	ERP1	4.4	7,000	22,000	1,513	0.219	0.410	0.239
	ERP2	6.6						
Integrated 3rd Party Apps	ERP1	4.4	7,000	22,000	1,513	0.219	0.410	0.239
	ERP2	6.6						
Average Screen Time per CAL per Day	ERP1	3	.000	15,000	6,818	**0.009**	0.870	**0.001**
	ERP2	8						
Amount of Complaint Tickets CALs	ERP1	8	.000	15,000	6,860	**0.009**	-0.873	**0.001**
	ERP2	3						

A normality test applied for all the variables is reported in Table 3. The test was conducted to determine whether to use parametric or non-parametric inferential tests to examine the variables and interpret the results. As the first step, it was checked if the variables were normally distributed. The following variables: integration demanded, annual maintenance fees, program crash reports, training time per CAL, training costs per CAL, acquired (new) customers, amount of integrations and integrated third-party apps were not normally distributed ($p < .05$). On the other hand, the rest of the variables were normally distributed ($p > .05$). Those variables that were normally distributed had an independent t-Test (a parametric test) applied to examine them, while those variables that were not normally distributed had a Mann-Whitney u-test (non-parametric test) conducted.

In conclusion, the Independent Samples t-Test is a parametric statistical tool favoured when the frequency count is more than 30. This is a more powerful tool to determine significant differences. Mann-Whitney U is a non-parametric equivalent of the t-Test that is not bound by the frequency count rule; therefore, Mann-Whitney U can be used for quick statistical inferences. For this study, both of their results mirror each other except for the category Sea B/L Issued, since the differences are pretty minimal. Some categories are significantly higher for ERP 2 and others that are considerably lower for ERP 2.

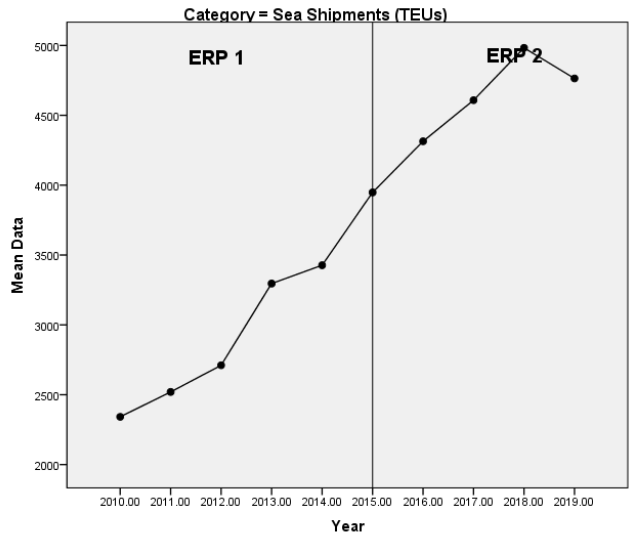


Figure 1. Container Shipments (TEUs)

Overall, the results show us that ERP2 as a web-based platform is a more effective and efficient tool than ERP1, is locally installed and comes with hardware investment requirements. Therefore, H1 appears to be a significant proposal.

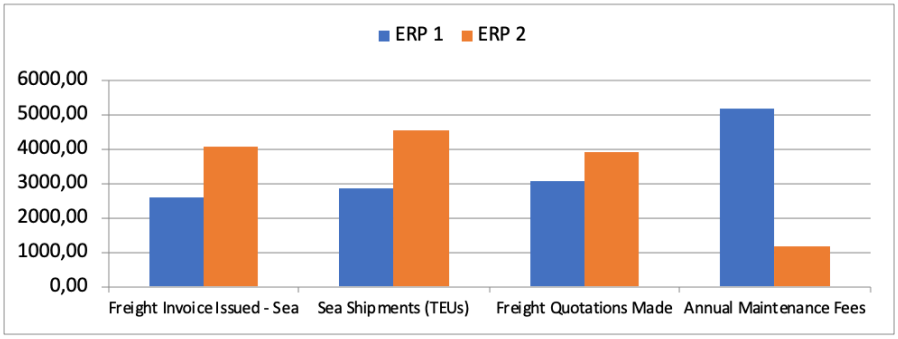


Figure 2. Bar Chart of Mean Values of Different Categories Compared by ERP

From this point of view, our benchmark showed that ERP platforms that run on the cloud environment run on less expensive, less limiting but more flexible database structures and will have a brighter future than those that run on local computers and use relatively weak DB tools.

5. KSHAL Project

This section is the kernel of our research that reveals the significant steps illuminating the software development process from blueprints to the final deployment stage. Why did we design the screens in such a way? How has the pricing structure been built? How do we promote and sell the program? How do we handle customer feedback data through the software? How secure is the system? How economical is such a system for companies to use? How effective is KSHAL as a web-based ERP alternative for the maritime industry? Answers and solutions to these questions, some of which have come from our hypotheses, will be sought in this section.

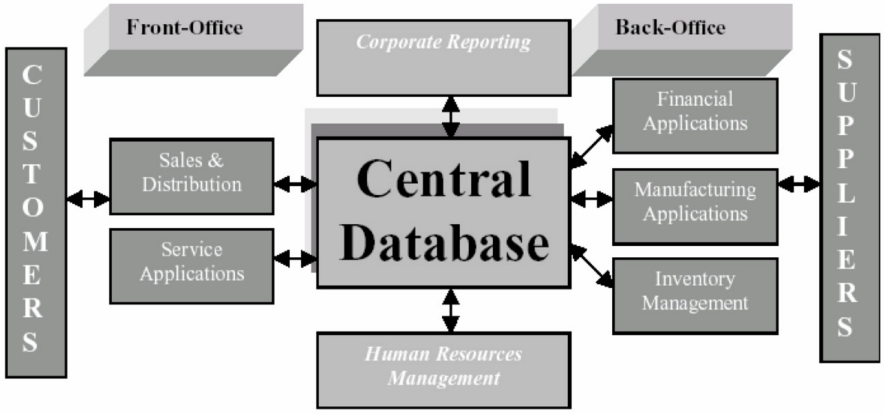


Figure 3. Web-Based ERP Model (eiilmuniversity.ac.in)

KSHAL is structured on the Microsoft SQL Server DB system, a powerful, relational database management system. This DB system is actively used by developers when building up an ERP solution such as ours. KSHAL was developed using C# coding

language. It is an object-oriented, mid-level programming language invented by Anders Hejlsberg in response to its rival, Java for Microsoft, back in 2000. C# is a multipurpose, multiparadigm coding language that can be considered a hybrid of C++ and Java. However, it is owned and strongly supported by Microsoft, and it works in harmony with other MS products, such as the MS SQL Server DB management system. KSHAL, briefly, is coded using C# on Visual Studio, it uses MS SQL Server as DB and gets hosted by Microsoft's Azure VPS service. It runs on .Net and includes ASP at the front-end of the program. So, it is possible to name KSHAL as a compilation and a result of the Microsoft stack software. KSHAL is a practical simulation of what we do during routine shipping operations in our daily life. It deliberately aims to simplify logistic operations by its database model, screens and menu structure.

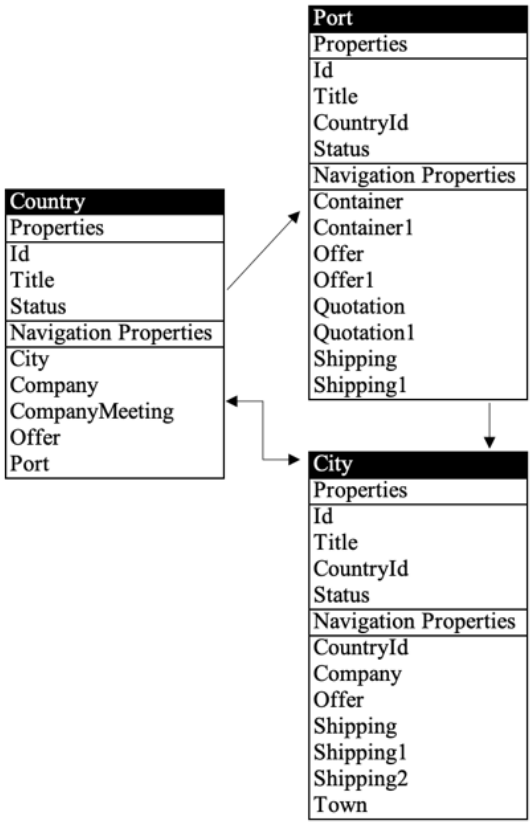


Figure 4. Data Tables Relation Model Detail

User experience (UX) encompasses all aspects of the end-user interaction with its services and products [7]. In the IT industry, particularly while developing an ERP for the maritime industry, UX design is the process that developers apply to create software solutions that deliver meaningful and performance-boosting features to users. This process includes the design of the entire workflow, screens, and menus of the program while simultaneously considering branding, usability, functionality, and simplicity. While building up an ERP for the shipping industry, a lean user experience powered by a simple design can assist customers in achieving their goals more effectively than the opposite ones with a complex screen flow and difficult navigation. The word simplicity does not equate to primitiveness

for ERP programmes, on the contrary, it is a difficult task to achieve. It requires deep know-how in supply chain management and software development to offer a platform that handles heavy duties but has a lean design. KSHAL's UX was designed by focusing on simplicity, which led the project into a clean and sleek design with a robust back-end interaction with a purposeful front-end build.

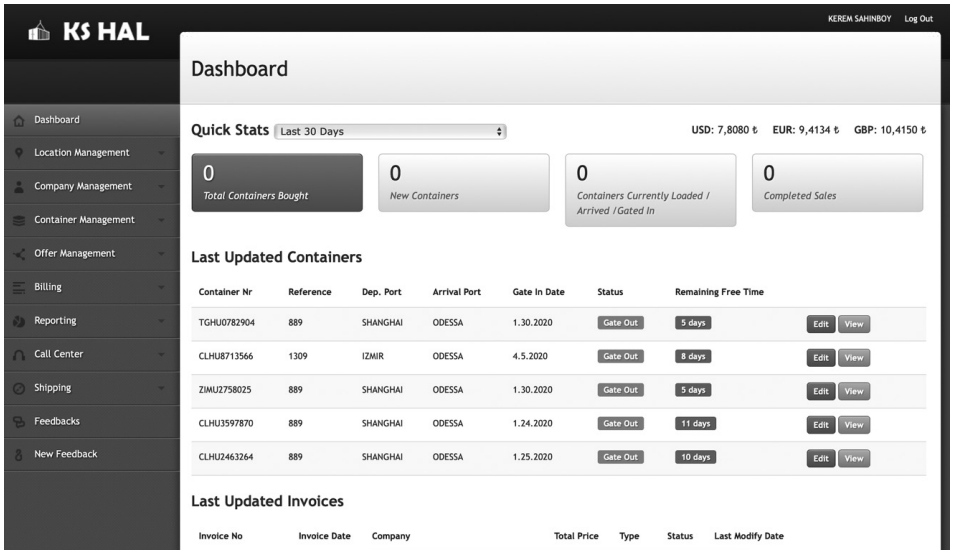


Figure 5. KSHAL's Dashboard

Since we have analysed the alternatives and decided which DB management system and coding language to use for KSHAL, it was necessary to merge these technical aspects with practical applications and needs, which have become the foundation of our UX designing process. The UX of KSHAL is the purified expression of converting particular know-how into code, as no software engineer will know container shipping better than an expert experienced in this field. So, we acknowledge that KSHAL is the first and only ERP platform designed by shipping and maritime experts in Turkey. The container management module (CMM) is the flagship of KSHAL. It is used to buy and sell all types of used or brand-new containers, set them for lease, calculate profits/losses, warehousing expenses, agency fees, demurrage incomes and costs, and track all sorts of demographic and operational information correlated to containers in the inventory list. CMM was designed for merchants, dealers, forwarders, exporters and importers to provide automation in container procurement and selling activities. It is a unique tool that utilises several complex processes, such as container tracking, storage and demurrage calculations in the container trading business. When the number of containers in stock reaches up to hundreds of units and is circulated between tens of different depots, these tasks may become troubling responsibilities. In our UX, KSHAL positions the container merchant at the centre of the operations.

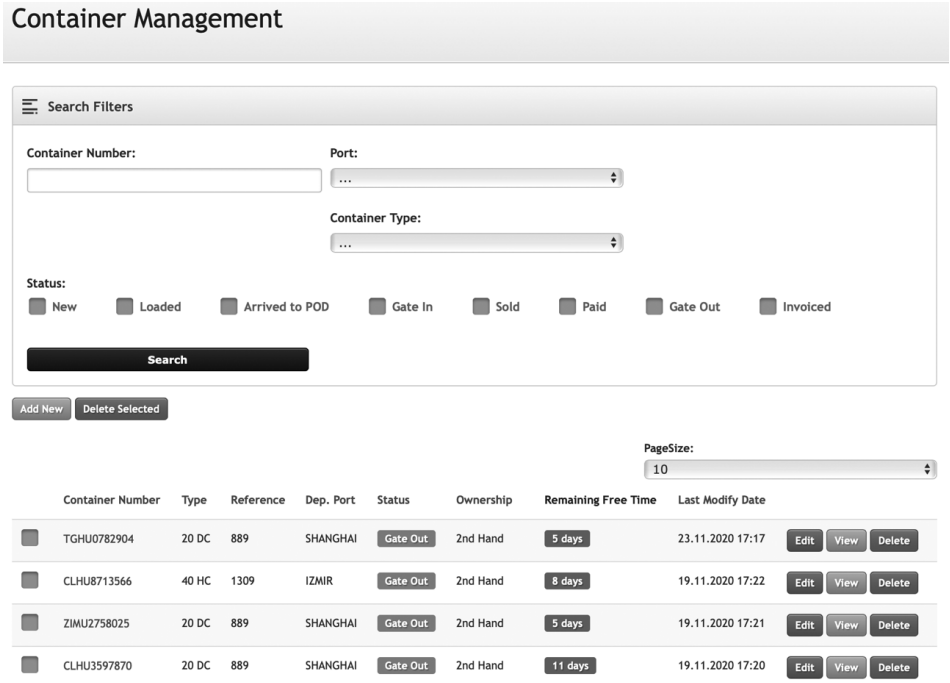


Figure 6. Container Management Module Dashboard

The container module of KSHAL fulfils all buying, selling, cost-profit recording, status checking, and shipping automation requirements. It is a one of a kind by adding third parties into the core of the business. Our agents may log in and update gate-in, gate-out dates of the containers associated with their accounts. Our container buyers may log in and purchase whichever equipment is available in our stocks as long as they have paid the deposit as shown on KSHAL. KSHAL operators can issue income invoices and also register cost invoices. The bulk update feature assists us in modifying records of containers in large quantities at once with ease. It is a simple, robust, consistent, shipshape software alternative for maritime logistics companies. Freight quotations are the face of marketing departments and most likely the face of companies in the SCM industry. A freight quotation should be as simple, as understandable, and as intact as possible. It must be lean and informative. Along the way, when shipping lines, trucking companies and air cargo carriers grow, freight quotations also become complex documents to understand by end customers. Surcharges, cited laws, seasonal fees, warnings, restrictions, and liability reminders have turned freight quotations into hard to read and difficult to acknowledge documents. There must be a balance between appeal and functionality. Therefore, freight quotations are gateways between transport companies and their potential customers. KSHAL's pricing module is concentrated on container shipping services. It manages costs and generates sales prices based on a number of selections. KSHAL's pricing module is based on proper cost recording features. KSHAL generates sales prices via available and valid costs by applying a flat profit rate or a percentage. Both of these options can also be modified manually. The pricing module is titled Offer Module on KSHAL. The costs link takes users to dashboard where they can search through sea freight or trucking costs. The trucking costs department of KSHAL involves domestic container haulage services but not international trucking business. On the cost dashboard, users have a list

of fees that have been retrieved from various container shipping lines in default order that shows most recent records as first in line.

PageSize: 10

	Company	Departure Port	Destination Port	20 DC	40 DC	40 HC	Othc	Vgm	Seal Fee	Ens	Tlx	Validity	Created On	
☐	MSC	AMBARLI	ST.PETERSBURG	745,00 €	1.205,00 €	1.205,00 €	350,00 €	25,00 €	5,00 €	25,00 €	50,00 €	30.04.2020	10.09.2019 11:50	Edit Delete
☐	MSC	AMBARLI	KLAIPEDA	631,00 €	807,00 €	807,00 €	350,00 €	25,00 €	5,00 €	25,00 €	50,00 €	31.10.2019	10.09.2019 11:47	Edit Delete
☐	MSC	AMBARLI	RIGA	591,00 €	1.107,00 €	1.107,00 €	350,00 €	25,00 €	5,00 €	25,00 €	50,00 €	30.09.2019	10.09.2019 11:43	Edit Delete
☐	OOCL	AMBARLI	RIGA	586,00 €	747,00 €	747,00 €	310,00 €	25,00 €	5,00 €	25,00 €	25,00 €	31.12.2019	9.09.2019 16:50	Edit Delete
☐	COSCO	IZMIT	KLAIPEDA	725,00 €	550,00 €	550,00 €	315,00 €	25,00 €	5,00 €	25,00 €	25,00 €	30.09.2019	9.09.2019 15:31	Edit Delete
☐	COSCO	IZMIT	RIGA	900,00 €	1.000,00 €	1.000,00 €	315,00 €	25,00 €	5,00 €	25,00 €	35,00 €	30.09.2019	9.09.2019 15:30	Edit Delete
☐	COSCO	IZMIT	ST.PETERSBURG	575,00 €	700,00 €	700,00 €	315,00 €	25,00 €	5,00 €	25,00 €	25,00 €	30.09.2019	9.09.2019 15:16	Edit Delete

Figure 7. KSHAL Cost Module Dashboard

Each column's title is a clickable link that, once clicked, sorts the whole column either alphabetically or numerically in ascending order. We can search active (valid) and deactivated (invalid) tariffs here on this page. Invalid rates are also shown on the software to give users a glimpse of the historical evolution and change of the freight levels. We can see the name of the container line, port of departure, port of destination, BAS based on various types of containers and surcharges such as OTHC, Vgm, Seal Fee, Ens, and Telex Release Fee. We can see the validity of the cost and the date it was created. KSHAL can assign two major currency types, such as USD and EUR, to all expense items. KSHAL produces freight quotations in PDF file format by using NRECO technology of .NET. NRECO (.Net REusable COmponents) is a productive tool when some file formats are converted into other types of output files without compromising the purpose and content. Due to security reasons, freight quotation files are generated in PDF file format on KSHAL.

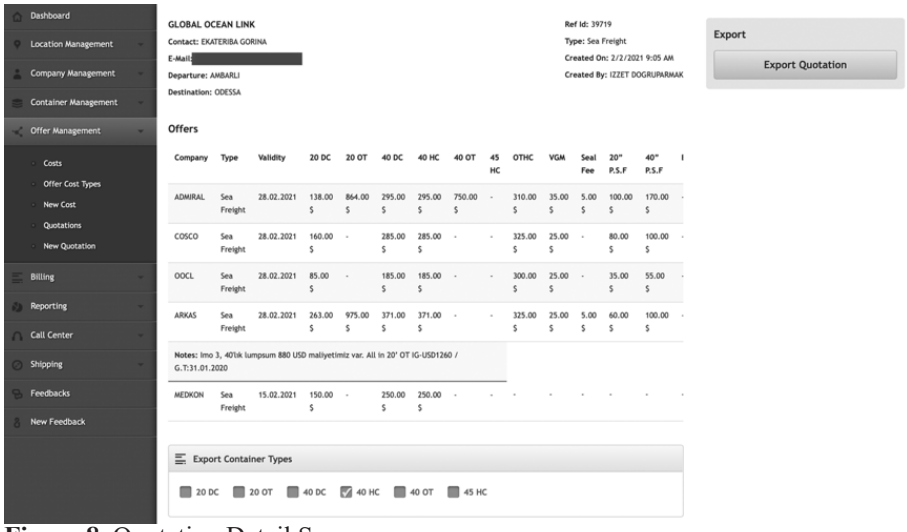


Figure 8. Quotation Detail Screen

The Offer Management Module of KSHAL is an all-embracing, ambidextrous and comprehensive tool for recording costs, comparing alternatives, creating freight quotations and tracking them on dashboards. Offer Management Module also prevents unnecessarily repeated jobs such as asking for the same quotations from container lines on different working days. Two or more sales operators with no tool such as KSHAL may accidentally request the same route from the same shipping line. End customers may ask for rates via phone, email or fax. They may send their freight quotation requests to a different number of salespeople of the same company. Responding to the same request over and over is also a sign of ineffective usage of company sources. It is not a luxury but an obligatory need to monitor which customer(s) asked how many freight quotations, in which period and how many of these price offers have been realised as concrete shipping orders. Hence, transport companies are commercial bodies for sustainable profits, and these activities must be actively observed via ERP platforms such as KSHAL. Hereby, we may acknowledge that KSHAL's price quotation module models the container shipping industry's needs accurately and responds to those who want to simplify these tasks on a budget.

The shipping module menu has only two buttons on the left navigation panel. The records link takes users to the dashboard and the new record link takes users into a new shipping record screen. This is purposely designed as lean as possible to keep the philosophy of KSHAL's simplicity approach. However, there is no concession of sleek design while applying the rules of simplicity. On the shipping module dashboard, we display columns such as Booking No, Ref No, M B/L No, From, To, Line, Vessel, Voyage, D/D, A/D, and Created on (date).

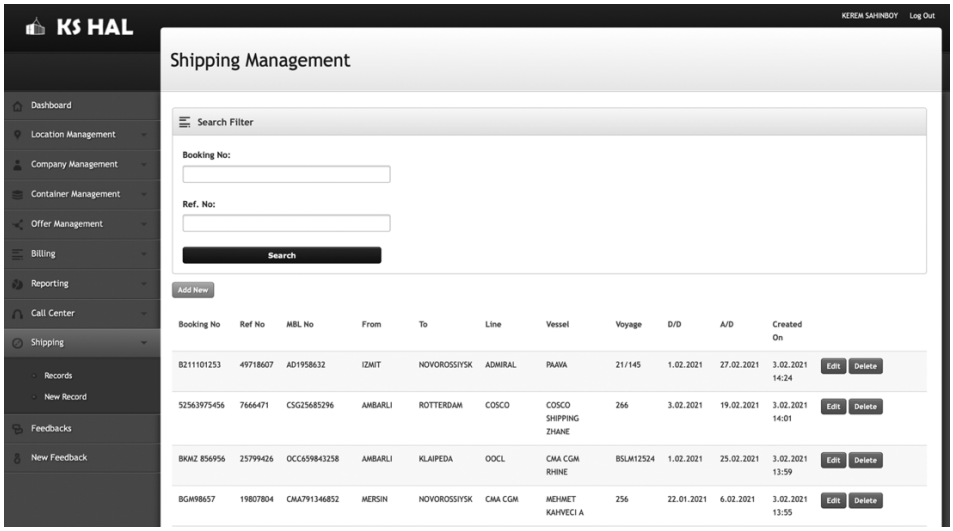


Figure 9. Shipping Management Module

The shipping module of KSHAL is a consistent and hardwearing part that delivers technological facilities and is an easy to adapt and learn container shipping operations model. As well as the other modules of the program, it is fully customisable, responsive, lean, and simple to utilise. KSHAL's parametric system structure is used to define the flexibility, which the program can offer. This flexibility represents dynamism. Any ERP program with fixed navigation panels, static components and complicated screen design

is outdated. Contemporary ERP alternatives are semi-designed platforms that get their final shapes and running forms after being customised to fit their end customers' business models. It is not too daring to say that maritime logistics ERP alternatives are evolving from fixed, rigid pocket programs to tailor-made products, which are open for further adjustments. There is no dispute or controversial discussions between staying loyal to our UX while providing the utmost flexibility to our users since this approach is an inseparable part of our user experience design from day one. Supplying a flexible, dynamic and parametric software as a strategic approach was embedded into KSHAL's unique UX from the beginning. Therefore, it is a coherent strategy.

KSHAL's call centre module is designed for marketing activities fulfilled by outcalls, incalls and active sales campaigns by visiting potential or already acquired customers. In the maritime logistics industry, companies sell services so, for promoting their services, they use an almost endless number of options that are available, such as email campaigns, advertising on a wide array of media sources, hot calls or customer visits at their premises.

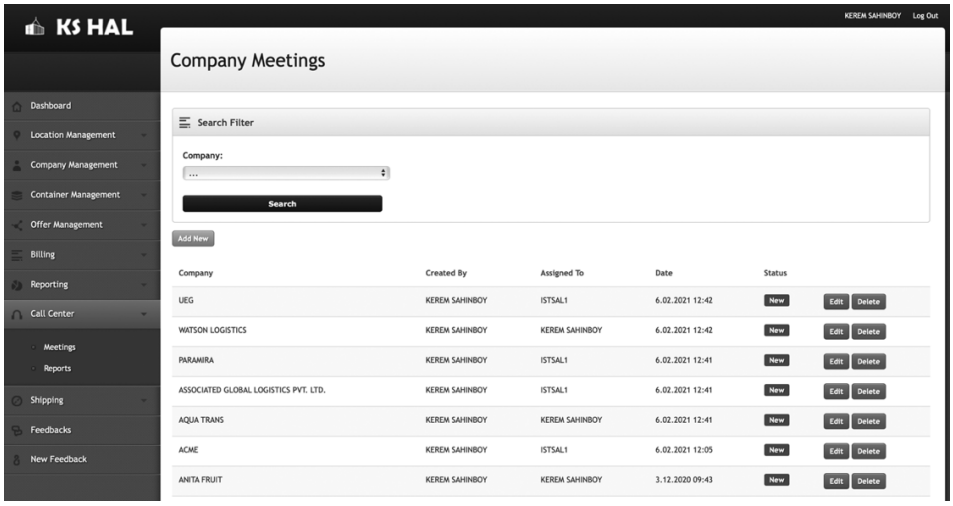


Figure 10. Call Centre Module

On the Reports page, Super Admin may obtain activity reports of each user's outcalls and customer meetings in defined terms. KSHAL's call centre module has a narrowed activity field comparing CRM programs. The call centre module does not have bulk email sending or newsletter apps designed within the panel because those methods' negative impact is easily visible in the market. Nevertheless, it has complete call centre activities, meeting reporting features, a comments section, and an activity reporting section. Moreover, it works with the offer management module in harmony under the same roof of KSHAL. This approach is a simple, practical and valuable tool that helps maritime companies coordinate their sales and marketing activities through the same platform.

The billing task is an inseparable part of the whole operations performed on KSHAL. Therefore, the development process is decided to position the billing section as an independent module. One of the reasons why KSHAL has a built-in, separate billing module is the probability of issuing invoices unassociated with shipping or container trading activities.

	Invoice No	Invoice Date	Company	Total Price	Type	Status
☐	ASA2019000000380	24.05.2019	CONTAINER TRADE	4.600,00 $	Income	Paid
☐	EAR2019000001204	15.11.2019	CONTAINER TRADE	2.300,00 $	Income	Paid
☐	059252	3.05.2017	EXPRESS CARGO LTD.	1.850,00 $	Income	Paid
☐	488676	7.05.2018	CONTAINER TRADE	3.000,00 $	Income	Paid
☐	489046	25.06.2018	SPD TIMOSHENKO PAVEL VIKTOROVICH	2.300,00 $	Income	Paid
☐	481941	31.01.2018	CONTAINER TRADE	2.250,00 $	Income	Paid
☐	060204	25.08.2017	EXPRESS CARGO LTD.	1.950,00 $	Income	Paid
☐	488380	26.03.2018	CONTAINER TRADE	2.250,00 $	Income	Paid
☐	ASA2019000000489	13.06.2019	EXPRESS CARGO LTD.	2.300,00 $	Income	Paid
☐	259514	27.08.2018	CONTAINER TRADE	2.300,00 $	Income	Paid

1 2 3 4 5 6 7 8 9 10 ...

Figure 11. Billing Module Dashboard

The billing module is not an "all-inclusive" accounting portal. Still, it works as a simple and effective component of KSHAL for issuing invoices, registering cost invoices and controlling cancelled invoices. It is directly linked to all other modules. It allows users to perform pre-accounting tasks such as generating income invoices and recording payments or cost invoices without leaving the software.

Feedback

Search Filter

Name / Surname:

Status:

☑ Unread ☑ Read ☑ In Process ☑ Completed

Search

Ticket Nr.	Member	Create Date	Subject	Status	
1007	KEREM SAHINBOY	13.02.2021 10:52	SMS MODULE FOR CONTAINER MANAGEMENT	Unread	View
1006	KEREM SAHINBOY	13.02.2021 10:40	PDF SCREEN ERROR MESSAGE	Unread	View
1005	KEREM SAHINBOY	13.02.2021 10:38	DASHBOARD SUGGESTION	Completed	View
1004	KEREM SAHINBOY	7.02.2021 17:40	test	Unread	View
1003	KEREM SAHINBOY	3.12.2020 09:56	TEST	In Process	View
1002	KEREM SAHINBOY	3.12.2020 09:53	NEW IDEA	Completed	View
1001	KEREM SAHINBOY	3.12.2020 09:52	PLEASE ADD OUR NEW BL TEMPLATE	Unread	View
1000	KEREM SAHINBOY	26.10.2020 10:04	Test Feedback	Completed	View

Figure 12. Error & Feedback Module

KSHAL's error and feedback handling module establish a direct connection between the developers and the program users. It is an instant messaging and ticketing feature that ranks all feedback messages in four stages: 'Unread', 'Read', 'In Process' and 'Completed'. These stages show how each feedback is queued and processed. When a customer has a question, suggestion, complaint, error report or a request, click on the New Feedback button. The user submits the title of the message and the details of the message in a free text format into the form. Once the customer submits a feedback message, KSHAL

triggers an auto email to the project leader of the developing team and also the same ticket gets shown on the dashboard of the module. The super admin (user) assigns the tasks to whoever is capable of handling the issues properly. The dashboard shows ticket numbers, the name of the KSHAL user who submitted the ticket, date, subject of the ticket and status of the issue, as shown in Figure 12.

KSHAL is a comprehensive, web-based, industry-specific, innovative ERP program that delivers customised, effective IT solutions to small and mid-sized freight forwarders, container trading merchants, and maritime logistics companies. The program has a container management module that container traders use. KSHAL has a shipping module used by freight forwarders. KSHAL has the Parametric System Management Module, Billing Module, CRM Module, Error and Feedback Module, Offer Management Module, and Reporting Module. It is sold for affordable prices. Freight forwarders can subscribe to KSHAL to have their fully functional, turnkey ERP solution in seconds. Overall, KSHAL is an excellent example of how SaaS (Software as a Service) platforms should be built. Besides KSHAL's innovative business models, especially for container trading jobs, it has been proven that the program has a commercial value as it has been contracted to three freight forwarding companies. In conclusion, we have a fully functional, self-proven, commercialised, innovative, industry-specific, new model proposing, dynamic, affordable ERP alternative program named KSHAL that serves small and medium-sized maritime logistics, freight forwarding, and shipping companies in complete competence, at the end of this research.

6. Determining Software Components with Analytical Hierarchy Process

The AHP model was constructed based on four main criteria that shaped our decision to start building up the KSHAL project: the type of database, coding language, working platform, and pricing methodology.

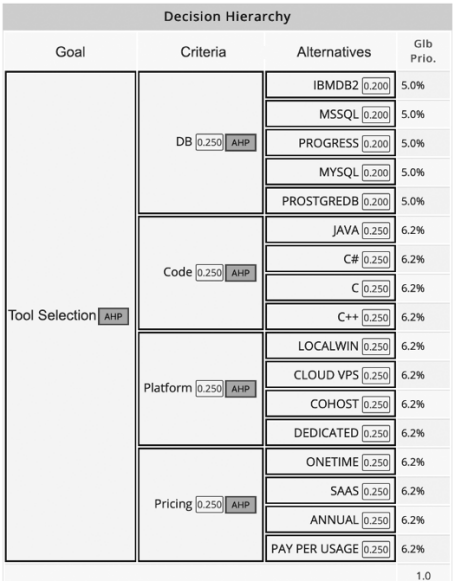


Figure 13. The Decision Tree

AHP analysis questions were sent to twenty different members of the Universal Carriers' Alliance Network [8]. The purpose of collecting deterministic opinions from different geographies and companies enriched the compiled findings of the decision-making process. UNICA is a freight forwarders' network founded in 2008 by the joint initiative of five mid-sized international freight companies. As of today, it has 68 countries covered by 84 member companies that have 244 offices combined. Our study aimed to send our questionnaire to companies of similar size, which employ between 25 to 40 staff members in one hub. In addition to this, the participants were selected from different continents of the world. The following companies have contributed to this study:

	Company Name	Location
1	Brightway Ltd	Vietnam
2	Fast Forward Freight	Belgium
3	All in One Services S.A.	Mexico
4	Transconsult	Czechia
5	Noble Cargo Care	Egypt
6	RIM Logistics	Germany
7	Saba Marine Services	Iraq
8	Ojs Swift Ventures	Nigeria
9	Bin Qutab International	Pakistan
10	Translogistics Solution S.A.C.	Peru
11	Kw Speed Logistics Ltd	Ghana
12	Best Express	Saudi Arabia
13	Smart Logistics	Ukraine
14	Asgard Transport Llc	Turkey
15	East Logistics A/S	Denmark
16	1 Triple A Logistics	Israel
17	Dahnay Logistics	India
18	Avits Ltd	Russia
19	Atlantic Overseas Express	the USA
20	Multitrans Logistics	Uzbekistan

Figure 14. AHP Participants

As a conclusion and as a result of this section, Microsoft SQL Server was selected as the database of the software build. Microsoft SQL Server is a dynamic, robust, feasible and reliable solution capable of responding to our relational database needs when designing a web-based alternative software solution for maritime logistics companies in Turkey.

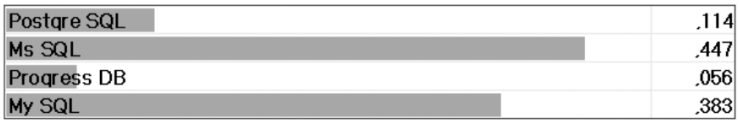


Figure 15. DB Choice Result (Expert Choice Output)

It was critically important to decide on which coding language will be used for our software. Each of these languages is strong, reliable, sophisticated and able to respond to our needs. However, they come with their strong and weak points. C# is far more effective for KSHAL as a coding language as it is backed up by a strong company, Microsoft.

Figure 16. AHP Result Screen For Coding Language

As the result of our AHP analysis, we picked up Cloud VPS alternative as a place where we deployed KSHAL and put it in use for our potential customers. The cloud environment was both our development periphery and the digital habitat where KSHAL would be available for customers to log in and use as a web-based ERP solution. These correlated decisions automatically identified KSHAL as a turnkey solution for maritime logistics companies.

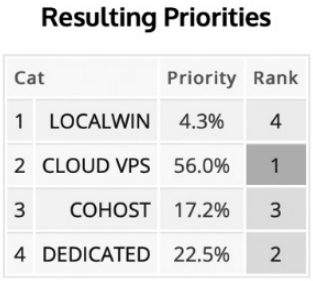


Figure 17. KSHAL's Deployment Platform

In conclusion, we decided to use MS SQL as our database infrastructure, C# as our coding language, CLOUD VPS as our deployment environment, SaaS as our service, and pricing commitment while developing KSHAL. Among these four criteria, the choice of coding

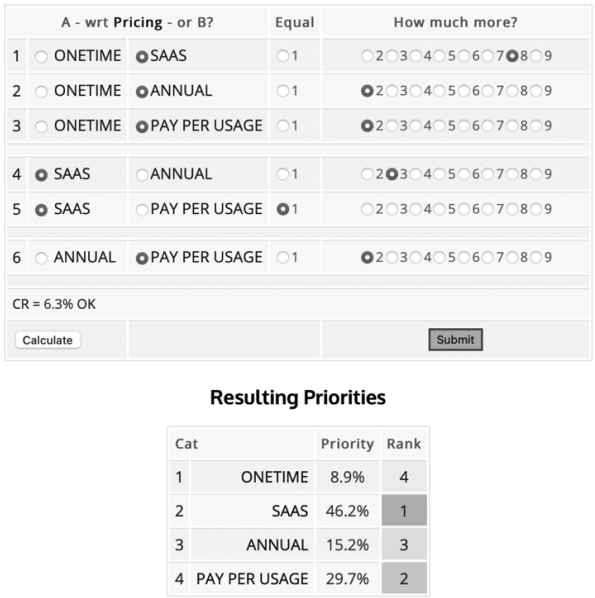


Figure 18. Pricing Method Decision

language had a heavier weighting than a database, platform and pricing methodology, as shown below. Suppose we observed secondary alternatives, particularly for a software language choice. In that case, Java came as second without a surprise as it is one of the powerful and dynamic languages that can be used, particularly for the back end.

Thanks to the above study, it was decided to run KSHAL on Microsoft's SQL Server Suite. C# collaborates with the other Microsoft family products in utmost compatibility, in harmony. Therefore, C# empowers the code flow of KSHAL. It is a SaaS-based ERP, and it was designed and deployed on the cloud VPS, using Microsoft's Azure environment.

7. Project Scheduling and Budgeting with CPM/PERT

KSHAL Project had a budget of 60,000 USD, and it was planned to be completed within 36 weeks or less. While forecasting project duration, working days were defined as Monday to Friday and working hours were set between 08:30 to 17:00, including a 1-hour lunch break between 12:00 AM to 1:00 PM. Gross salaries were scaled monthly and included team members' social security, insurance expenses, daily meal tickets, and mobile communication fees. The project budgeted for three developers as follows:

1. **Architect:** The principal designer and the team leader responsible for the project with all aspects, end to end. His duties were designing the software structure, transferring the ideas to blueprints, recruiting skilled developers, assigning their tasks and controlling whether they complied to project schedules or not, applying system and ERP analyses, and deciding when the ERP would be completed and ready to run. The monthly gross salary was 2,500 USD.

2. **Senior Developer:** The person responsible for developing the database structure, relays relational links between the tables, and coding the back-end section of the software that is the core of the KSHAL platform. The senior developer, who had a decade-long experience developing web-based ERP projects, is an engineer experienced in MSSQL Server and C# language. The monthly gross salary was 2,200 USD.

3. **Junior Developer:** The person in charge of developing the front-end of the software by using .NET infrastructure and ASP, JSON languages and creating a simple yet powerful GUI by using HTML and CSS (Cascading Style Sheets) worked with the back end without flaws. The person had a five-year long active coding experience and who had completed several similar projects. The monthly gross salary was 1,600 USD.

The project activity nodes are shown in Figure 19, starting from the project's draft until the finished product deployment. The test sequence is from Alfa to Beta.

ACTIVITY	ACTIVITY DESCRIPTION	PRD	Estimated Duration (Weeks)
A	Designing the software screens, screen flow, setting up server	-	2
B	Blueprints to Database Design Phase	A	2
C	Database Management System Building	B	3
D	Back-End Coding - Phase 1: Mainframe	C	3
E	Back-End Coding - Phase 2: Location Management Module	D	2
F	Front-End Coding - Phase 1: Design to Code Dashboard, Css	C	2
G	Back-End Coding - Phase 3: Company Management Module	E	3
H	Back-End Coding - Phase 4: Container Management Module	G	3
I	Front-End Coding - Phase 2: Adding Ready Modules	B, H	1
J	Beta Test - 1 (DB, Bugs, Flaws, Speed, Code, Screens)	I, H	1
K	Back-End Coding - Phase 5: Quotation Management Module	J	3
L	Back-End Coding - Phase 6: Billing & Reports Modules	K	2
M	Front-End Coding - Phase 3 : User Screens, Left Bar Menu	J	1
N	Back-End Coding - Phase 7: Shipping Module	L	3
O	Back-End Coding - Phase 8: Feedback Module	N	2
P	Front-End Coding - Phase 4: Adding Final Screens	O	1
R	Beta Test - 2 (End to End Complete User Experience Test)	O,P	1
S	Deploying the Software Online	R	1
Finish	Dummy Activity to close the Diagram	F, M & S	0

Figure 19. CPM/PERT Activity Nodes -Project Steps

A network arrow or a node indicates activities. The arrow's tail displays the start of an activity while the head suggests/points to the end of an activity. A single arrow reflects the given time of operation. Operation periods are shown along with the arrows. Dummy Activity represents the task that uses no money or time to finish the project. The Event is the stage or the location where all previous jobs started, and the jobs, which are yet to be done. The project's first event is the start of the project. Circles or nodes at the intersection of arrows are usually symbolic events. Events in their sequential order are serially numbered. The Network Diagram is the diagram of the whole project. Different jobs are shown in this diagram to visualize the step-by-step flow of the process.

Earliest Start Time (ES) is the earliest possible time at which an activity may start. Earliest Finish Time (EF) represents the earliest possible time to complete the assigned job. Latest Start Time (LS) is the latest possible time at which an activity may start without delaying the date of the project. Latest Finishing Time (LF) is when the project as a whole or a node can be finished at the latest time. Total Float (TF) is the difference between the maximum time allowed for an activity and its estimated duration. It is the duration of time when the activity can be started late, without disturbing the project schedule. Free Float (FF) is the duration of time by which the completion time of an activity can be delayed without affecting the start of succeeding jobs. Interfering Float (INTF) is the amount of time a scheduled activity can be delayed or extended from its ES date without delaying the project finish date.

Independent Float (INDF) is the maximum amount of time an activity can be delayed without postponing the ES of the succeeding activities and without being affected by the allowable delay of the preceding activities. Preceding Activity represents the activities that are performed before future jobs. Succeeding Activity means the activities that are performed after the predecessors. Critical Activities are events that have no floats. The essential events are required to be completed on schedule. Critical Path is the path in the network joining the critical events. Based on KSHAL Project, the cumulative duration of the project was planned as nine months. A logical network diagram revealed that D and F's activities are parallel, and F has no succeeding activity.

Similarly, activities M and K are parallel jobs, and M has no next task. Thanks to this, the duration of the project was reduced to 33 weeks in these conditions. In addition to the aspect of the whole project in-depth, we applied a scenario as if our project would be completed after the 40th week. Therefore, to meet the project requirements, we had to provide a lag of 1 week (5 working days) before these activities; D, G, H, L, N, O and R. Based on the revised table of activities, the network diagram is as follows:

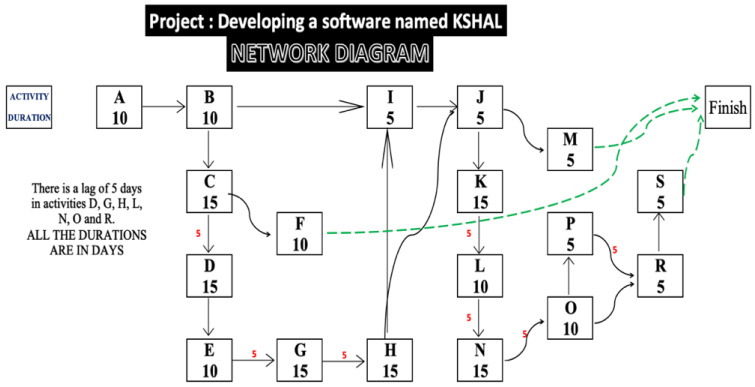


Figure 20. CPM Network Diagram of KSHAL

According to our CPM calculations, by defining the critical path, the first leg of the study showed that it was possible to start the project at the beginning of January and complete it by the beginning of October. However, best practices in the software development business predict that there is always a gap between the plan and realised timelines. Moreover, financial shortages, technical difficulties, human resources related changes, and even the weather conditions influence such projects. Thus, we should use a probabilistic method such as PERT to statistically determine whether the project will have a chance to be embodied within planned deadlines. PERT is a convenient tool for relatively smaller projects such as ours, but it is hard to apply to more significant projects with thousands of node inflows. PERT defines four types of time required to accomplish an activity:

- optimistic time: the minimum possible time required to accomplish an activity (o) or a path (O), assuming everything proceeds better than is usually expected.
- pessimistic time: the maximum possible time required to accomplish an activity (p) or a path (P), assuming everything goes wrong (but excluding major catastrophes).

- most likely time: the best estimate of the time required to accomplish an activity (m) or a path (M), assuming everything proceeds as usual.
- expected time: the best estimate of the time required to accomplish an activity (te) or a path (TE), accounting for the fact that things do not always proceed as standard (the implication being that the expected time is the average time the task would require if the tasks were repeated on several occasions over an extended period).

$$te = \frac{o + 4m + p}{6}$$

$$TE = \sum_{i=1}^{n} te_i$$

- standard deviation of time: the variability of the time for accomplishing an activity

$$\sigma_{te} = \frac{p - o}{6}$$

$$\sigma_{TE} = \sqrt{\sum_{i=1}^{n} {\sigma_{te_i}}^2}$$

Standard Deviation (SD) measures the discrepancy between the mean and the average. The weighted average determined by the PERT formula was interpreted in the current context. A low SD value shows that data points are similar to the average. Variance is the average of the squared differences from the mean. We applied the following formulas as follows:

1. Expected Time (T_e) = $\frac{O + 4M + P}{6}$
2. Standard Deviation (SD) = $(\frac{P-O}{6})^2$
3. Variance = $(\frac{P-O}{6})^2$ where O = Optimistic Time, M = Most Likely Time, and P = Pessimistic Time
4. Z = $\frac{X - T_e}{S.D}$ where X = The Desired day at which we want to check probability, T_e = Expected Duration of Critical Path, and SD = Standard Deviation of Critical Path

For this part, we used the same data we had for the CPM leg of the study and refigured the whole project timeline based on optimistic, most likely and pessimistic deadline expectations. Naturally, the optimistic approach indicated the shortest possible time expectation that our software developers needed to accomplish the completion, while the pessimistic estimation approach forecasted a more extended calendar for project completion. Concerning the above definitions, our activity estimation table was re-constructed for PERT analysis. There were eight paths out to finish, and number eight was detected as the critical path shown in Figure 20. By considering the critical path, we calculated total project duration, variance and standard deviation as follows:

$\sum T_e$ = 190 Days

$\sum$Variance = 44. 444444

S.D = $\sqrt{\sum Variance} = \sqrt{44.444444}$

S.D = 6.66666667 ≅ 6.7

General Normal Distribution Graph under conditions T_e = 190 Days and S.D = 6.7 Days.

The findings of our calculations were referenced on Z-Table. The probability calculation of completion days was as follows:

Probability of Completing the Project in Less Than 180 Days

$Z = \frac{X - T_e}{S.D}$

$Z = \frac{180-190}{6.7} = -1.49$

From Table against Z = -1.49 Probability is 0.0681 or 6.81%

Probability of Completing the Project After 180 Days

Total Probability = 1

Probability on 180 Days = 0.0681

Probability after 180 Days = 1 – 0.0681 = 0.9319 or 93.19%

Probability of Completing the Project in 200 Days

$Z = \frac{X - T_e}{S.D}$

$Z = \frac{200-190}{6.7} = 1.49$

From Table against Z = 1.49 Probability is 0.9319 or 93.19%

Probability of Completing the Project After 200 Days

Total Probability = 1

Probability on 200 Days = 0.9319

Probability after 200 Days = 1 – 0.9319 = 0.0681 or 6.81%

Probability of Completing the Project Between 180 and 200 Days

Total Probability = 1

Probability on 180 Days = 0.0681

Probability after 200 Days = 0.0681

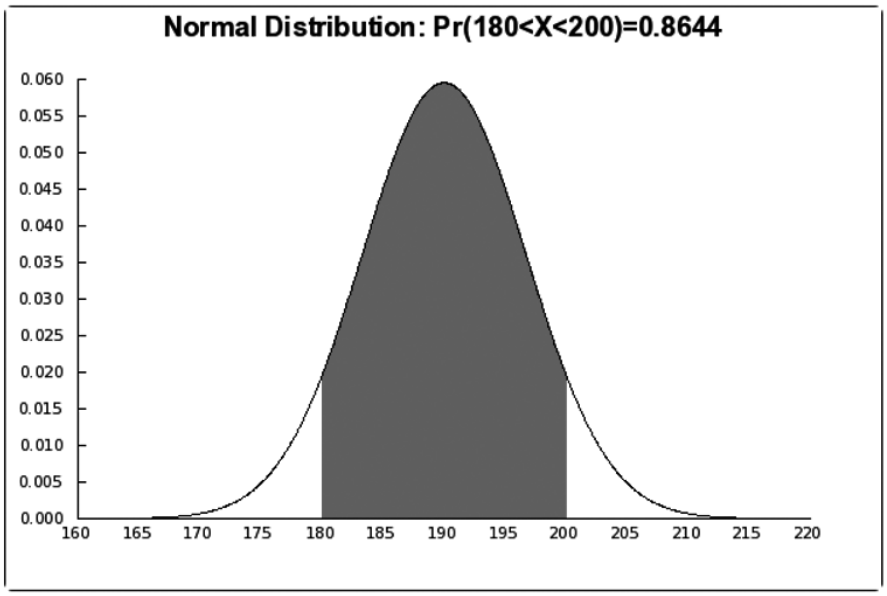
Probability between 180 & 200 Days = 1 – 0.0681 – 0.0681

Probability between 180 & 200 Days = 0.8638 or 86.38%

Table 4. CPM/PERT Results Table

Sr. No	Probability Condition	Z-Table	Beta Distribution Graph
1	Probability of Completing Project in 180 Days	6.81%	6.78%
2	Probability of Completing Project after 180 Days	93.19%	93.22%
3	Probability of Completing Project in 200 Days	93.19%	93.22%
4	Probability of Completing Project after 200 Days	6.81%	6.78%
5	Probability of Completing Project Bet 180&200 Days	86.38%	86.44%

As a conclusion of this section, KSHAL Project was completed as planned within the budget and timeline at the end of September 2020. However, the project took an evident 38 weeks, and the cost of the software was realised as 59,100 USD.



8. Measuring Effectiveness and Efficiency with Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a mathematical programming-based method used to evaluate the relative performance of organisations [9]. DEA is a benchmarking method between several variables compared based on several types of inputs and outputs. DEA is a mathematical tool that helps us measure the efficiency of limited resources and guides us to improve their efficiency. DEA is actively used in organisations with multiple branches. It helps to identify efficient and inefficient units (a.k.a DMUs: Decision-Making Units) in a framework where results are considered in their particular context.

KSHAL is in use in three companies, which are controlling five branches in two countries. All these companies have work in the same freight network called UNICA, and they all are medium-sized freight forwarding entities. These three companies co-operate with each other for their shipping and logistics activities. Company A is located in Istanbul, Company B and C are located in Ukraine. Company B and C have their offices in Odessa and Kiev. Company A employs 18 white shirt workers (DMU1), company B employs 22 people in Odessa (DMU2) and 20 people in Kiev (DMU3), company C employs 24

people in Odessa (DMU4) and nine people in Kiev (DMU5). The core business of these three companies is container shipping, selling second-hand containers, and air cargo deliveries. They all have their sales teams that call and visit customers constantly. Each of these hubs were numbered as DMU1 to DMU5. The analysis aims to determine how effectively these DMUs use KSHAL while issuing BLs, offering prices and submitting sales and marketing reports. We began with one input and one output sample and carried it to multiple inputs and multiple outputs experiments. The research focused on their half-a-year-long activity.

Table 5. One Input - One Output DEA Table

ISSUED BLs ON KSHAL	IN / OUT	DMU1	DMU2	DMU3	DMU4	DMU5
NR. OF BLS	OUTPUT	516	410	207	342	189
NR. OF EMPLOYEES	INPUT	18	22	20	24	9

According to Table 5, we can observe how productive each branch was when issuing the marine bill of ladings using KSHAL. It is supportive information to visualise how keenly these branches carry their activities onto the KSHAL platform. Table 6 divides the quantity of issued bill of ladings by each DMU's employee quantity:

Table 6. The Most Efficient DMU

ISSUED BLs ON KSHAL	IN / OUT	DMU1	DMU2	DMU3	DMU4	DMU5
NR. OF BLs	OUTPUT	516	410	207	342	189
NR. OF EMPLOYEES	INPUT	18	22	20	24	9
BL PER EMPLOYEE	EFFICIENCY	28.7	18.6	10.4	14.3	21.0

$$Efficiency = \frac{\text{No of Employees}}{\text{No of BLs}}$$

As we can in Table 6 DMU1 is the most efficient DMU based on the comparison between the BL's (Output) produced by employees (Input) of the different DMUs. It is necessary to calculate the RE (Relative Efficiency) of the other inefficient DMUs at this stage. RE is the ratio of inefficient DMUs compared to the efficient DMU.

Table 7. Relative Efficiency

RELATIVE EFFICIENCY		DMU1	DMU2	DMU3	DMU4	DMU5
NO OF BLS	OUTPUT	516	410	207	342	189
NO OF EMPLOYEES	INPUT	18	22	20	24	9
BL per EMPLOYEE	EFFICIENCY	28.7	18.6	10.4	14.3	21.0
REL. EFFICIENCY	RE	1.00	0.65	0.36	0.50	0.73

$$RE = \frac{\text{DMU}_\text{i}}{DMUe}$$

DMU_i identifies inefficient DMUs while DMUe is the efficient DMU (i.e., Company A in our example). Relevant efficiencies are sequenced between 1 and 0, as indicated on the first page. Figure 22 shows the Efficient Frontier (EF) that shows the best solution while including all DMUs. We can see which branch of our experiments is the most efficient one by using KSHAL software at this first stage. The rank is

1st DMU1: 28.7 BLs produced by or per employee (RE 1)

2nd DMU5: 21.0 BLs produced by or per employee (RE 0.73)

3rd DMU2: 18.6 BLs produced by or per employee (RE 0.65)

4th DMU4: 14.3 BLs produced by or per employee (RE 0.50)

5th DMU3: 10.4 BLs produced by or per employee (RE 0.36)

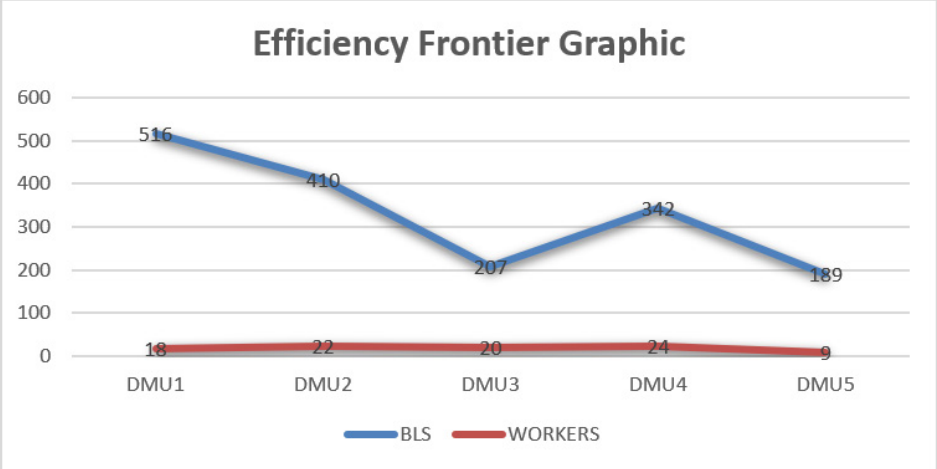


Figure 22. Efficiency Frontier

It is proved that DMU1 is the most efficient branch when comparing the results of the other DMUs. We can classify the rest of the DMUs as inefficient. The gap (or the distance) between their positions to EF shows their improvement to become an efficient DMU. So, practically these branches must push their stats all the way left to the efficiency frontier. The number of parameters (inputs and outputs) can be umpteen based on various requirements depending on what researchers would like to measure.

While modelling our DEA questionnaire it was necessary to study other parameters such as running costs, turnover of the participant DMUs and turnover by an employee of each participating DMU. In this step, our DEA study took multiple inputs and one output into consideration to visualise the efficiency level of KSHAL at DMUs.

Table 8. Multiple Inputs and Single Output

		DMU1	DMU2	DMU3	DMU4	DMU5
TURNOVER MIL $	O	1	1	1	1	1
NO OF WORKERS	I	12	22	20	24	9
RUNNING COSTS	I	27	33	30	40	12
EMP/TURNOVER	A	12	22	20	24	9
COST/TURNOVER	B	27	33	30	40	12

We measured how our DMUs reach up to a 1 million USD turnover based on two inputs: the number of employees and running costs. It was shown that DMU5 makes a one million USD turnover with nine employees while DMU4 does the same with 24 personnel. While Cost/Turnover and Employee/Turnover comparisons seek lower values, Figure 23 shows a convex graphic as shown below. Cost minimisation aiming models should

push variables (DMUs) down to zero, and this is why our graphic pictures the efficiency frontier downwards. We can indicate the opposite in maximisation models as the push-up of data expands the efficiency frontier far from zero (origin of the graphic). Here, in Figure 23 we can see some DMUs are located far from our efficiency border (the efficiency frontier). Finding out the amount of improvement, called Technical Inefficiency (TI), became more straightforward by applying the RE formula. This is supportive data for our paper when it comes down to acknowledging the efficiency that KSHAL adjusted to the daily tasks of these DMUs in shipping operations. Any software capable of offering fast response times with simple screen flow and sufficient security preventions will be one of the driving forces of maritime companies to score higher turnovers and profit margins.

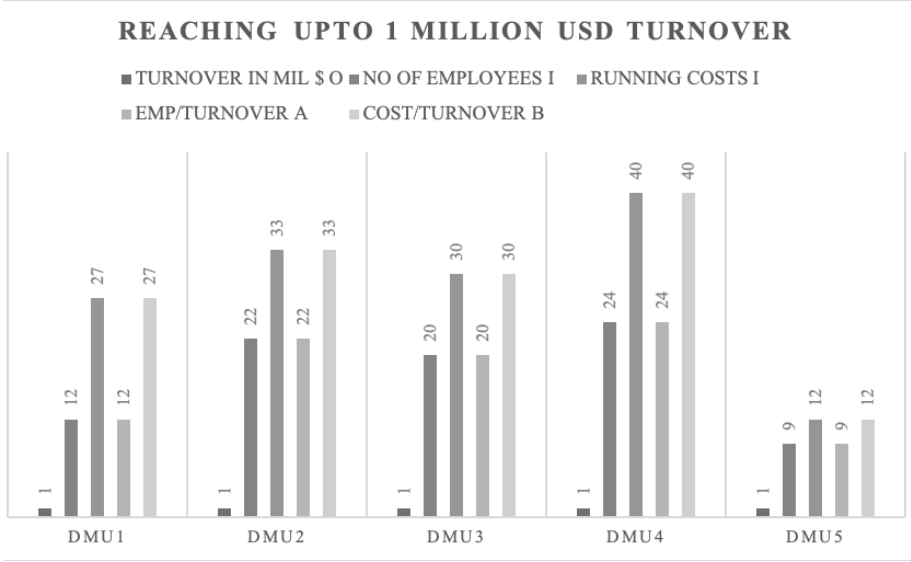


Figure 23. Efficiency Frontier

To set all DMUs efficient, we must propose the participants, which are also KSHAL users, solutions that may bring their activity results closer to the efficiency curve clustered around DMU5. DMU5 represents our EF line on the above graphic. DMU2 and DMU4 are inefficient participants who need to revise their strategies, while DMU5, 1, and 3 are efficient ones. Here, on Table 9 we may tag the distance from the origin to EF on the line to DMU1 as ψDMUi and compare that value over ψDMU, which gives us the Relative Efficiency. The visual distance between DMU1 and EF shows the amount of improvement, by another name, the technical inefficiency ratio. If we calculate a new scale for inefficient branches, we will have virtual decision-making units as our referencing points. They are suggestive 'stations' for inefficient branches. Simply, it indicates that all participants must catch the EF level of the most efficient DMU. We examined one input and multiple output variants of the DEA data in the final step, a valuable example for maximisation (profit, shipment quantity, new customers acquired, sales statistics, etc.) purposes.

Table 9. One Input and Multiple Outputs

		DMU1	DMU2	DMU3	DMU4	DMU5
VISITS PERFORMED	O	240	336	216	168	125
QUOTATIONS MADE	O	178	284	221	126	110
KSHAL USERS	I	18	22	20	24	9
VISIT/USER	A	13	15	11	7	14
QUOTATIONS/USER	B	10	13	11	5	12

Different branches have different scores for customer visits, which is where they meet with potential customers for their services. It is possible to observe that each DMU has its core activity; while one is active operationally, the other is keen on sales and marketing campaigns. In Table 9, two output variables are compiled: How many customers were visited by KSHAL users and how many freight quotations had been made through the KSHAL system. These two output indicators are enveloped by the quantity of KSHAL users working at each DMU. A simple benchmark was applied by comparing customer visits per CAL and quotations sent per CAL. The KSHAL system allows all users to provide freight quotations to customers, disregarding whether they are sales personnel or not. Therefore, we do not seek the highest score of each. Instead, we seek the highest comparison result of variables to define our EF as a maximisation task. In our example, DMU2 scored the most efficient result compared to the figures of the other DMUs in this study. DMU4 was the least efficient participant of this analysis that must improve their activity results upwards to match and even surpass the EF.

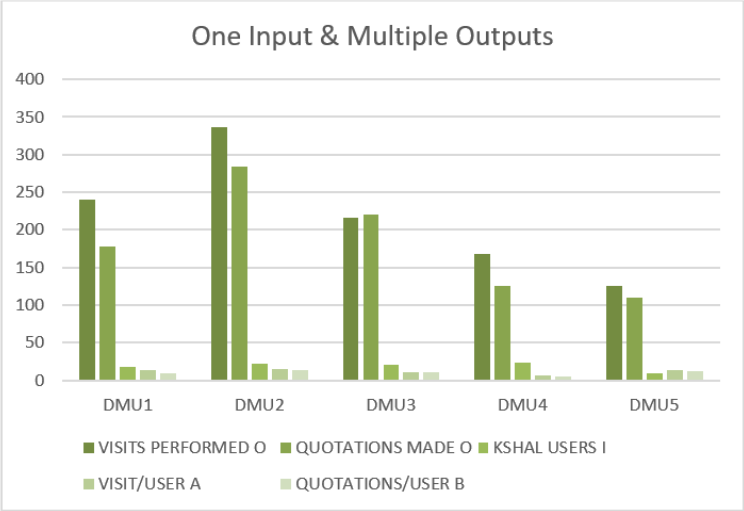


Figure 24. One Input and Multiple Outputs

KSHAL users visit customers based on their CRM Module activity using the software. They submit their phone calls, email communication and visit & meeting scheduling into the program. Table 9 shows how actively each worker of the branches uses the quotation module. Here we can observe that the least active customer-visiting branch per CAL was DMU4. As shown in Figure 24, the aim of participants must boost up sales and quotations by numbers. The boost, is in the form of an explosion that scatters from origin to outside, so the visualisation of the graphic will be a concave curve. This section concludes that we could identify the most efficient spots and weakest links of the network to support

data envelopment analysis. DEA assisted our research to visualise the possible directions that companies must head to increase or decrease their activity results for reaching their efficiency frontiers.

9. Conclusion

According to Porter's Value Chain Theory, we must focus on company activities by breaking them down into separate divisions to observe one monolithic image as a Value Chain. Each division has its fingerprint on overall expenses, directly influencing our efficiency, turnover, and, naturally, our profit margins. Each department from inbound logistics, operations, outbound logistics, marketing & sales, and other services drives the company's productivity. Therefore, each department must contribute to the goal of achieving sustainable efficiency and profitability. Most organisations engage in hundreds, even thousands, of activities to convert inputs to outputs. These activities can be classified generally as either primary or support activities that all businesses must undertake in some form [10].

Therefore, the role of a robust ERP infrastructure that communicates with each of those departments and helps them achieve their goals are vital parts of this strategy. Nowadays, value chains cannot be considered without IT systems such as KSHAL. KSHAL also structurally divides the tasks into several divisions as if it creates its Value Chain. All of its modules both, individually and collaboratively, are fully dedicated to the profitability of the user companies. In this respect, it is evident that KSHAL approaches maritime companies and their activities by how Porter's Value Chain Theory approaches companies strategically. KSHAL segments the activities into container trade, shipping operations, inbound cost controlling, outbound quotations, marketing & sales and other services. A value chain is a powerful tool for disaggregating a company into its strategically relevant activities to focus on the sources of competitive advantage, that is, the specific activities that result in higher prices or lower costs [11]. One of the hypotheses of this paper was indicating that, a web-based maritime software provides a noticeable decrease on operational software-related expenditures of small and midsized freight forwarders and supply chain companies. Thus, this research mainly walks hand in hand with Porter's Value Chain Theory along the path of decreasing the costs while increasing companies' efficiency and profitability.

The evolution of big data technologies has introduced us to the concept of data visualisation. The data owners must have these figures, which they think will be easier to work through as big heaps of data clusters, visually expressed. Data visualisation has its roots in statistics and is therefore generally considered a branch of descriptive statistics. However, because both design skills and statistical and computing skills are required to visualise effectively, it is argued by some authors that it is both art and science [12]. According to theories cited in this article, Kiyoyasu Tanaka's "Time in Transit Theory" needs data visualisation to solve complex transportation problems. According to Tanaka's theory, shippers pay higher freight for short routes compared to longer routes, proportionally. Tanaka adds that "Individual freight transactions are characterized by timely, frequent, and small-batch shipping." and with this explanation, we realise the challenge of making the right

decisions for which shipping option, service provider or tariff will be used becomes a perplexing subject for the shippers [13]. One of the obstacles in front of this issue is how to display meaningful results visually to the screens of decision-makers. Tanaka's theory aims to analyse freight and distance (route) alternatives while finding affordable solutions without compromising delivery times, safety and reliability of selected service options. This perspective is also held by KSHAL's UX while compiling costs, shipping line alternatives, surcharge derivatives and visualising them all in the most convenient way for its users. KSHAL's price quotation module brings freight variations on screens by revealing the names of the shipping lines and their transit times. KSHAL users can see all the freight and route alternatives in the same module consecutively. Moreover, they may be equipped to take the right decision for that specific shipment. At this step, with the support of Tanaka's "Time in Transit Theory", we may observe that one of the hypotheses of this paper, that states "A web-based maritime software triggers a remarkable progress for good on data handling of small and midsized freight forwarders and shipping companies." is definitely in use on KSHAL while cost storing and freight quoting.

We should cite the Theory of Constraints (TOC) that will ask us several questions; "Where will you focus your attention on your company for increasing productivity?" The overwhelming popularity of Dr Eliyahu Goldratt's bestselling business novel "The Goal" (set in a manufacturing company) has led some to believe that the Theory of Constraints applies primarily to the manufacturing environment. Although initially developed in response to specific challenges in this sector, other TOC applications have been developed for a wide variety of industries using the TOC Thinking Processes. These are successfully implemented in industries like Heavy Capital Equipment, Retail, Banking, FMCG, Logistics, Job Shops, Mining, Healthcare, etc. [14]. The correlation of this theory with our study appears in finding the right tools to apply effective management models for eliminating constraints from maritime companies. These constraints suppress companies from achieving higher productivity levels. As per our paper, economic constraints hold freight companies back from recruiting more professionals when considering CAL fees applied by the cited software companies. In addition, technical difficulties such as the impossibility of using the Cyrillic alphabet, not providing access to users via the web, delaying feedback times, and expensive pricing strategies become constraints. KSHAL's UX has been designed by focusing on these constraints and aiming to solve these issues using alternative methods to improve productivity and profitability. The paper proposes that a web-based maritime software delivers an essential refining effect on the operational documentation process of small and midsized freight forwarders and supply chain companies. KSHAL achieves this goal by simplifying data submitting steps severely. It also solves many other constraints in rival programs, such as the complexity of the quotation sending process, recording shipping costs, tracking demurrage expenses, having third-party partners involved with the business flow, and monitoring company credibility online.

According to the research, among the maritime ERP alternatives already being used in Turkey, we observed their innovative tendency to evolve from conventional software products towards web or cloud-based SaaS platforms. We have determined four major

software suppliers in Turkey during our research: SOFT, SELECT, XINERJI, and DOA. Three of these companies offer their products as SaaS solutions except for SOFT. According to SOFT's 2021-23 business strategy, which was revealed during one-on-one interviews with Ergin Kargalıoğlu, CEO of the company, SOFT also is moving its production environment to the cloud. This fact expresses that the contemporary structure of shipping ERP alternatives will be inhabited on the web or the cloud environments, just like KSHAL has persistently offered these options for its customers since day one.

This study showed that the number of quotations and shipping orders increased when the company was using a web-based, SaaS-oriented, comparatively lean ERP product. In following this, the users have submitted more visit reports into the SaaS system. Also, their average screen time has been increased. These findings showed us the supremacy of lean design over complex design. Furthermore, these results showed us SaaS systems' preponderance with the lean design over conventional and orthodox, bulky and stodgy ERP programs. The repercussion of the results takes us to one of our hypotheses, indicating that web-based maritime software creates a meaningful usage or a good value in terms of adding efficiency to their shipping operations. During this study, one of the concrete facts we observed was the tendency of both fronts of the industry as developers and users heading towards lean designs, simple interfaces, and affordable pricing systems by abandoning locally installed ERP solutions which are unaffordable for small and medium-sized freight forwarders or maritime companies. In the case of a simple comparison, KSHAL has certain advantages over two major ERP product suppliers even when we consider their basic product packages.

Table 10. Price Comparison Between KSHAL and Two Other Alternative Software Platforms

Service	Company A	Company B	KSHAL
Sales Price	$$$$$	$$$$	$$
DBMS License	$$$	$$	-
Maintenance Fee	$$$	$$$	-
CAL License	$$$	$$	$

Besides KSHAL's innovative business models, especially for container trading jobs, it has been proven that the program has a commercial value as it has been contracted to three freight forwarding companies. This fact figuratively supports the indicated approval; a web-based maritime software engenders a noteworthy improvement in sales and marketing activities of small and midsized freight forwarders and supply chain companies.

In conclusion, there is a fully functional, self-proven, commercialised, innovative, industry-specific, new models proposing, dynamic, affordable ERP alternative program named KSHAL that serves small and medium-sized maritime logistics, freight forwarding, and shipping companies in complete competence. Furthermore, the program's building and deployment process is an excellent example of a feasibility exercise for other researchers, developers, entrepreneurs or shipping companies who would like to design their ERP programmes.

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RESEARCH ARTICLE

An Overview of Air Traffic and Effective Air Traffic Control Strategies for Istanbul Airport

Hava Trafiğine Genel Bir Bakış ve İstanbul Havalimanı İçin Efektif Bir Hava Trafik Kontrol Stratejisi

İsmail Demirhan[1], Abit Balin[2], Abdullah Okumuş[3]

ABSTRACT

This study addresses the significant changes in air transportation for Turkey with the opening of Istanbul Airport and investigates the advantages and disadvantages brought about by the new airport. Previously; providing a service for Istanbul, Atatürk Airport had a limited capacity in terms of air transportation resulting in a mostly ineffective use of time and resources. Thus; this study points out how İstanbul Airport solves the problems experienced previously problems with the expectations of being a solid contender for Turkey in today's modern aviation.

In this paper, a brief explanation of how aviation reached its current place is given and numerical data are provided to further clarify the enormous growth of civil aviation both for Turkey and globally. Subsequently, the role of Istanbul Airport for Turkish civil aviation has been explained in depth. In the light of this information, strengths and weaknesses are identified first, and then opportunities and weaknesses are presented (SWOT analysis) specifically for Istanbul Airport. In the final part of this paper, the importance of new applications through aviation systems has been evaluated briefly to better understand how it positively effects companies, air traffic control units and how it shapes the future of air transportation systems. We believe that the analysis given in four sub-sections will give us a clear understanding of the pros and cons of Istanbul Airport. Considering those assumptions and taking relevant actions it will be easier to make optimum use of the whole system in the airport and to compete with other rivals in the aviation industry.

Keywords: Intelligent Transport Systems, Aviation, Air Traffic Control, SWOT, Istanbul Airport

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[1] **Corresponding author:** İsmail Demirhan (Yüksek Lisans Öğrencisi), İstanbul Üniversitesi, Ulaştırma ve Lojistik Fakültesi, İstanbul, Türkiye
E-mail: ismail.demirhan@ogr.iu.edu.tr ORCID: 0000-0001-7258-0719

[2] Abit Balin (Dr. Öğr. Üyesi), İstanbul Üniversitesi, Ulaştırma ve Lojistik Fakültesi, İstanbul, Türkiye. ORCID: 0000-0002-4590-2935

[3] Abdullah Okumuş (Prof. Dr.), İstanbul Üniversite, İşletme Fakültesi – Pazarlama Anabilim Dalı, İstanbul, Türkiye. ORCID: 0000-0002-7556-384X

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1. Introduction

Flying in the air has always captured human interest throughout the history. Even though it seemed like a utopia for the earliest civilizations, humankind has always kept hope alive to make this dream come true. The history of aviation extends back hundreds of years and the earliest forms such as kites were promising for future developments in the long run. From a tower jumping experience by Hezarfen Ahmet Celebi to futuristic designs of air vehicles drawn by Leonardo Da Vinci, every work and invention in aviation history provided a groundwork to be able to transport people through the air. Finally, the Wright Brothers were able to design the very first primitive aircraft by using previous works. Aviation has had a different vision and reached its current place with the effect of this invention (1).

People prioritize different factors such as speed, safety, comfort and cost for their transportation system choices and choose one of the four; road transport, maritime transport, rail transport or air transport. The ones who prioritize speed and comfort generally choose air transport. Hence the main reason why we choose air transportation of all the other methods is saving time as well as providing a joyful and comfortable travel. People are able to travel distances in a short period of time where they, otherwise, cannot do maybe in days or months (specifically for maritime transport). This summarizes why it becomes more and more popular among people day by day (2). Briefly, the aviation industry demonstrates an enormous development pattern affected by all of our choices and expectations. As a result; many procedures arise to provide a safe and controllable air traffic flow. Airports that are home to aircraft, airways, flying rules regarding piloting and air traffic control systems are all part of this well-sophisticated transportation system. By considering the needs of the time and sad events experienced in the past, aviation keeps its professional identity up to date through developmental activities. (3).

Despite being affected by certain events negatively; the aviation industry has historically shown a pattern of constant growth. Undoubtedly, this progress in the aviation industry requires building new facilities and upgrading technical infrastructure to meet the requirements of emerging industry. First opened in 1912 as a military airport, Atatürk Airport was converted into a civilian airport to serve passenger and cargo traffic in the early 1950s. It served more than 60 million passengers in 2015, making it one of the biggest airports in the world in terms of passenger traffic. Government authorities decided to replace Ataturk Airport with a new one with the hopes of building a groundwork for Turkey's future aviation strategies. Ataturk Airport was replaced in regards to commercial passenger functions by the newly constructed Istanbul Airport in April 2019, in order to meet Istanbul's growing domestic and international air traffic demand (4).

There is a two-way solution to providing safe and efficient air transportation; making the maximum use of current systems and/or construction. Legal authorities provided both in the case of Istanbul Airport with the intension of more competitiveness on a global scale. The objective of this paper is to search for changes and then to establish better strategies for Istanbul Airport with regard to air transportation. For these purposes we have examined capacity related problems and a variety of technical and technological

issues that are of concern. Then, we introduced problem solving methods of how to efficiently provide air transportation with new facilities and with the introduction of new sub-systems. We believe that this study will establish a new perspective to gain a lead in the constantly growing sector.

This study was prepared under the supervision of two academicians. The liability of below given statements and other technical information was confirmed by legal aviation units; the air traffic control unit at Istanbul Airport and the Airport Authority; IGA. First, we confirmed the data accuracy (airport specifications and related functions) that we collected from varies databases by IGA operations center and DHMI. Then, the impact of Istanbul Airport in terms of air traffic management was evaluated by air traffic controllers – a supervisor with 20-years of job experience and two veteran air traffic controllers with 5 and 11 years of job experience respectively. Finally, the assumptions we made were discussed by academicians that had studies in the transportation and logistics field- a professor with over 20 years of experience and a lecturer with over 10 years of experience.

This paper consists of six subsections; following a quick introductory division about the history of aviation, a variety of different studies have been listed in the second division. In the third section, a table analysis regarding air transportation in the World and in Turkey has been presented. The forth section provides in depth information about Istanbul Airport and a SWOT analysis for the airport. The fifth section is based on air traffic control strategies deducted by SWOT analysis given in the previous section. Finally, the sixth section concludes this study demonstrating, from a more general perspective, how this study is important for the future of the Turkish aviation industry.

2. Literature Review

There has been a lot of academic studies as well as technical work in air transportation to meet today's needs of the sector and to better plan the future of it. Some of the important studies chosen for the purpose of this paper are listed in table-1

Table 1. Literature review on aviation

	PAPER WORK	AUTHORS	METHODOLOGY	CONCEPT
1	Uçakların Terminal Kapılarına Atanması Probleminin Farklı Yöntemlerle Çözümü ve Uygulaması (2011)	Şefika ARSLAN	Optimization	Effective utilization of terminal gates
2	Bulamık Mantık Kontrol Tekniği Kullanarak Pist Planlama İçin Uçak Tipine Göre İniş Önceliklendirme (2019)	Tolga ÇALLIOĞLU	Fuzzy Approach	Answers for better aircraft landing sequences
3	Aircraft Parking Optimization Using Genetic Algorithm (2017)	Burak GÜLER	Optimization	Effective usage of the parking positions
4	On-line Decision Support for Take-off Runway Scheduling at London Heathrow Airport (2008)	Jason Adam David ATKIN	Optimization and Simulation	Runway scheduling
5	On The Control of Airport Departure Operations (2010)	Pierrick BURGAIN	Collaborative framework	The control of aircraft operations

6	Conflict Distribution Prediction and Optimization of Aircraft in Ground Movements (2020)	Yassine DABACHINE, Mohamed BINIZ, Belaid BOUIKHALENE, Abdessamad BALOUKI (2020)	Optimization	Ground movement control (taxi movement)
7	Models of Air Traffic Merging Techniques: Evaluating Performance of Point Merge (2009)	Dan IVANESCU, Chris SHAW, Constantine TAMVACLIS, Tarja KETTUNEN	Merge point system	Performance analysis of the system
8	Taxiing Route Scheduling between Taxiway and Runway in Hub Airport (2015)	Yu JIANG Xinxing XU Honghai ZHANG Yuxiao LUO	Optimization	Ground movement control of an aircraft
9	An Optimization Framework For Route Design and Allocation of Aircraft to Multiple Departure Routes (2019)	V. HO-HUU, S. HARTJES, H. G. VISSER, R. CURREN	Optimization	Analyzing and optimizing departure routes
10	Multirunway Optimization Schedule of Airport Based on Improved Genetic Algorithm by Dynamical Time Window (2015)	Hang ZHOU, Xinxin JIANG	Optimization	Optimizing multi runway airport movements
11	ICAO Uçak Kategorilerine Göre Tek Pist Sistemi İçin Kapasite Hesaplamalarında Kullanılacak Analitik Bir Model (2013)	Serkan BAYAR	Technical analysis	Analyzing runway capacity
12	Strategical Analysis and the Impact of Istanbul Airport on Turkish Airlines (2020)	Muhammet DEVECİ, Muharrem Enis ÇİFTÇİ, İbrahim Zeki AKYURT	SWOT analysis	The impact of İstanbul Airport on Turkish Airlines
13	System Analysis of Airport Capacity and Slot Coordination at Ataturk Airport (2016)	Savaş S. ATEŞ, Mevlüt ÜZÜLMEZ	System analysis	The assessment of slot coordination system used at Ataturk Airport
14	Kentsel Lojistik Açısından İstanbul Havalimanı ve Ataturk Havalimanı'nın Değerlendirilmesi (2019)	Doğan KILIÇ, Muhammet TURGUT	System comparison	A comparison of two airports in terms of urban logistics and capacity
15	The Economic & Social Benefits of Air Transport (2004)	Air Transport Action Group (ATAG)	System analysis	An analysis of air transport systems
16	Solving Aircraft Routing Problem with Integer Programming (2009)	Nahit KİRAZOĞLU	Optimization	Optimality of flight path among cities
17	Airport Runway Optimization (2012)	Mohammad MESGARPOUR	Optimization	Scheduling of aircraft landing and take-off problems on a single runway
18	Empirical Investigations of Properties of Robust Aircraft Routing Models (2015)	Guanqun LI	Routing	Aircraft routing problem
19	Enhancing Decision Support Systems for Airport Ground Movement (2013)	Stefan RAVIZZA	Optimization	Models and algorithms for aircraft ground movement
20	Integration of Automated Decision Aids with a Prototype Air Traffic Control Interface in Support of Time-Based Surface Operations (2012)	Kenyon T. RIDDLE	Simulation	Sequencing departure aircraft at the gate
21	Modelling of Ground Operations Using End-Around (Perimeter) Taxiways fot the Modernized Chicago O'Hare International Airport (2013)	Ashwin Vasant JADHAV	Simulation	The impact of airport layout modifications

The above-mentioned studies focus on making air traffic management more effective, using all the available sources more efficiently and searching for ways to solve any other problems experienced in aviation sub-systems.

3. Air Traffic Analysis

When we think of aviation, the first vehicles that come to mind are airplanes and helicopters as well as balloons as one of the earliest forms of aviation and drones as more recent developments (5). Nevertheless, aircraft such as airplanes, business jets and helicopters are the basis of this study considering the regular air traffic at an airport.

In a little over a century, the aviation industry has gone from learning to fly, to learning to fly faster and further. Moreover, air transportation has become widely used and continues to extend its reach through rising incomes and affordable choices. The volume of air transportation is not surprising to us anymore since the industry has been expanding.

We keep track of air transportation by annual reviews. Annual reviews for air transportation are released by certain organizations on the successes, issues and numerical changes. Those reports reveal how big the aviation industry is. In figure 1, we give a demonstration of air transportation statistics regarding passenger traffic, air cargo and aircraft movements by region.

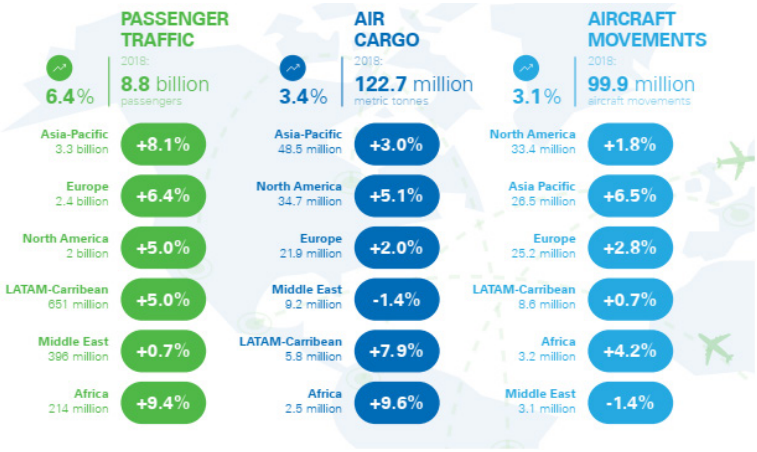

Figure 1. Annual report of passenger traffic, air cargo and aircraft movement in 2018 by Airports Council International-ACI (6).

Airports host millions of passengers to provide service in air transportation. Considering major airports specifically, those numbers require hundreds of flights each day. In table-2, we show the top airports per landing and take-off in 2010 and in 2017. Taking 16th position in 2017, Istanbul Ataturk Airport proved to be one of the fastest growing airports in the world. This growing rate also took an important role in building a new and modern airport - Istanbul Airport.

Table 2. Top airports in 2010 and in 2017 per landing and takeoff (7)

2010			2017		
RANK	**CITY (AIRPORT)**	**TOTAL MOVEMENTS**	**RANK**	**CITY (AIRPORT)**	**TOTAL MOVEMENTS**
1	ATLANTA - ATL	950 119	**1**	ATLANTA - ATL	879 560
2	CHICAGO - ORD	882 617	**2**	CHICAGO - ORD	867 049
3	LOS ANGELES - LAX	666 938	**3**	LOS ANGELES - LAX	700 362
4	DALLAS - DFW	652 261	**4**	DALLAS - DFW	654 344
5	DENVER - DEN	630 063	**5**	BEIJING - PEK	597 259
6	HOUSTON - IAH	531 347	**6**	DENVER - DEN	574 966
7	CHARLOTTE - CLT	529 101	**7**	CHARLOTTE - CLT	553 817
8	BEIJING - PEK	517 584	**8**	LAS VEGAS - LAS	542 994
9	LAS VEGAS - LAS	505 591	**9**	AMSTERDAM – AMS	514 625
10	PARIS - CDG	499 997	**10**	SHANGHAI - PVG	496 774
11	FRANKFURT - FRA	464 432	**11**	PARIS - CDG	482 676
12	PHILADELPHIA - PHL	460 799	**12**	LONDON - LHR	475 915
13	LONDON LHR	454 883	**13**	FRANKFURT - FRA	475 537
14	DETROIT - DTW	452 616	**14**	TORONTO - YYZ	465 555
15	PHOENIX - PHX	449 351	**15**	GUANGZHOU - CAN	465 295
16	MINNEAPOLIS - MSP	436 625	**16**	ISTANBUL - IST	460 785
17	MADRID - MAD	433 683	**17**	SAN FRANCISCO - SFO	460 243
18	TORONTO - YYZ	418 298	**18**	TOKYO - HND	453 126
19	NEWARK - EWR	403 880	**19**	HOUSTON - IAH	450 383
20	AMSTERDAM - AMS	402 372	**20**	MEXICO CITY - MEX	449 664

Table 3. The change in passenger and aircraft traffic for Turkey through 2010 – 2019 (10).

Year	Passenger Traffic			Aircraft Traffic		
	Domestic	**International**	**Transit**	**Domestic**	**International**	**Transit**
2010	50 575 426	52 224 966	736 121	497 862	421 549	293 714
	Total: 103 536 513			**Total: 1 213 125**		
2011	58 258 324	59 362 145	671 531	579 488	462 881	292 816
	Total: 118 292 000			**Total:1 335 185**		
2012	64 721 316	65 630 304	677 896	600 818	492 229	283 439
	Total: 131 029 516			**Total: 1 376 486**		
2013	76 148 526	73 281 895	565 447	682 685	541 110	281 178
	Total: 149 995 868			**Total: 1 504 973**		
2014	85 416 166	80 304 068	461 105	754 259	591 695	333 017
	Total: 166 181 339			**Total: 1 678 971**		
2015	97 041 210	84 033 321	362 473	832 958	623 715	358 285
	Total: 181 437 004			**Total: 1 814 958**		
2016	102 499 358	71 244 179	409 609	886 228	566 767	376 913
	Total: 174 153 146			**Total: 1 829 908**		
2017	109 511 390	83 533 953	531 501	909 332	591 125	413 560
	Total: 193 576 844			**Total: 1 914 017**		
2018	112 911 108	97 587 056	449 475	892 405	651 764	473 051
	Total: 210 947 639			**Total: 2 017 220**		
2019	**99 946 572**	**108 427 124**	**537 642**	**839 894**	**716 523**	478 013
	Total: 208 911 338			**Total: 2 034 430**		

Air transportation keeps a development pattern even though it is affected by occasional crisis like the most current one; the Covid-19 pandemic (8). While aviation keeps developing all around the world, the same growth is seen for Turkey. The General Directorate of State Airports (DHMI) is the authority that is responsible for the management and regulation of airports, aerodromes and airspace under Turkish responsibility (9). The reports by DHMI released on a monthly and yearly basis is also a clear indication of a growth in air transportation for Turkey. Table-3 summarizes the change in passenger and aircraft traffic for Turkey through the years 2010-2019.

In Figure 2 and 3, we represent the graphic form of table 2 in order to visualize the changes throughout the years.

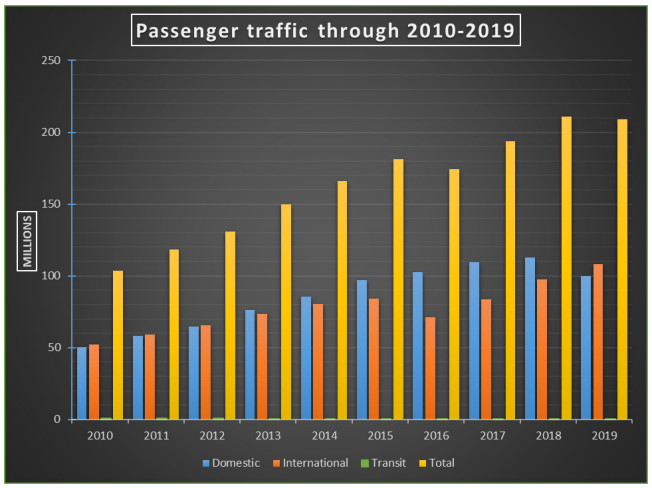

Figure 2. The change in passenger traffic for Turkey through 2010-2019

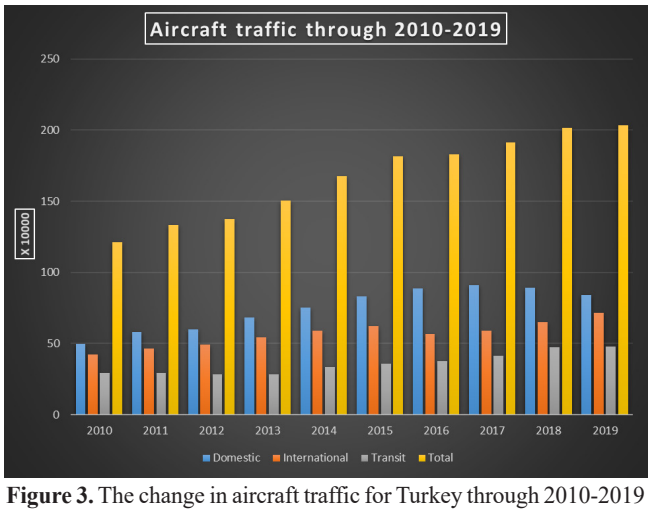

Figure 3. The change in aircraft traffic for Turkey through 2010-2019

In table 4, we specifically compare the numbers in the years 2018 and 2019. The number of domestic and international flights in total are presented for Turkey; both for state airport (DHMI) and for other civilian airports. Looking at table-3, a dramatic decrease (25,14%) can be seen in air traffic for the state airports while there is a considerable amount of increase in total. This is because Atatürk Airport, also the busiest airport in Turkey, that was run by the DHMI until early 2019 was closed to passenger traffic and

Istanbul Airport that has been run by a private organization (IGA), took its place. The number of en route traffic showed a growth rate by 1.04. The total air traffic numbers increased slightly, by 0.85%, that means a continuation of development figure in 2019 considering the year before.

Table 4. Air traffic data for Tukey in 2018 and 2019 (10)

	2018			2019		
	Domestic	**International**	**Total**	**Domestic**	**International**	**Total**
DHMI	716,407	559,287	1,275,694	591,205	363,739	954,944
General	892,405	651,764	1,544,169	839,894	716,523	1,556,417
En route			473,051			478,013
Turkey			2,017,220			2,034,430

Air transportation, for which some of the numerical data is given, holds many different advantages and disadvantages to it as a result of a constantly growing industry. While the upward trend in the number of passengers and air traffic continues, the achievements by air transportation shows promising results. With this in mind, investments are crucial to accommodate aviation growth. Recent investments over aviation in Turkey brought about significant changes that will put the country in an important position in the world. Those investments, as well as technological developments, offer noteworthy opportunities in the long term. Specifically, Istanbul Airport; one of the mega projects of Turkey in aviation, is a representation of a great vision of the country. At this point, the opening of the airport stage by stage has led to a new growth acceleration in Turkish aviation. In table-6 below, a SWOT analysis about air transportation has been presented for Istanbul Airport.

4. SWOT analysis on Istanbul Airport

4.1 Strengths of Istanbul Airport

Additional runway capacity

Ataturk Airport was famous for long departure queues specifically during rush hours. Aircraft would spend a lot of time waiting for their departure sequence in line. Istanbul Airport relieves this bottleneck with the help of an increased capacity through additional runways.

At present, Istanbul Airport has 3 parallel runways in use. There will be six of those when all the phases are completed, making the airport one of the few in the world in this category. Runway 34 (2 dependent runways-34 R/L), runway 35 (2 dependent runways-35 R/L) and runway 36 have been used for arrivals and departures as of June 2020 (11). Independent runways can be used for parallel arrival/departure operations simultaneously. This procedure helps improve the air traffic capacity with the reduction of aircraft waiting time.

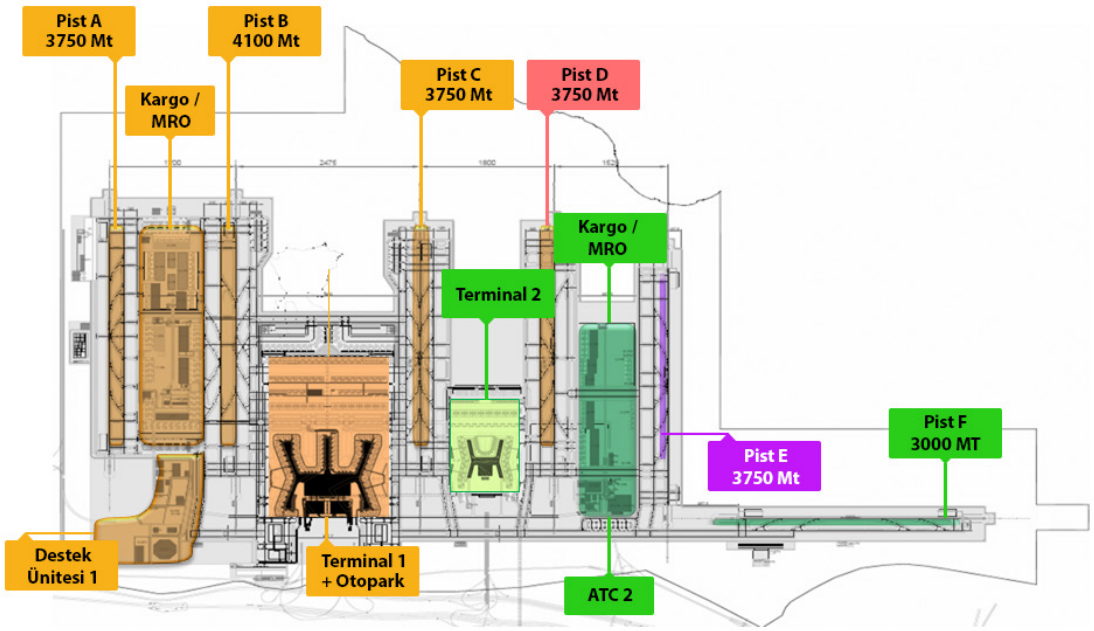

Figure 4. All phases planned for Istanbul Airport (12)

Merge Point system

A point merge system, a systemized method for sequencing arrival flows developed by the Eurocontrol Experimental Centre, is implemented at İstanbul Airport as an arrival procedure. This system was designed to work in high traffic loads without radar vectoring. It consists of a point (so-called merge point) and pre-defined legs (the sequencing legs) equidistant from this point. The legs are only used to delay aircraft when necessary. Some of the expected benefits of point merge are as follows; more orderly flows of air traffic, the standardization of operations, better airspace management, improved flight efficiency etc. (13).

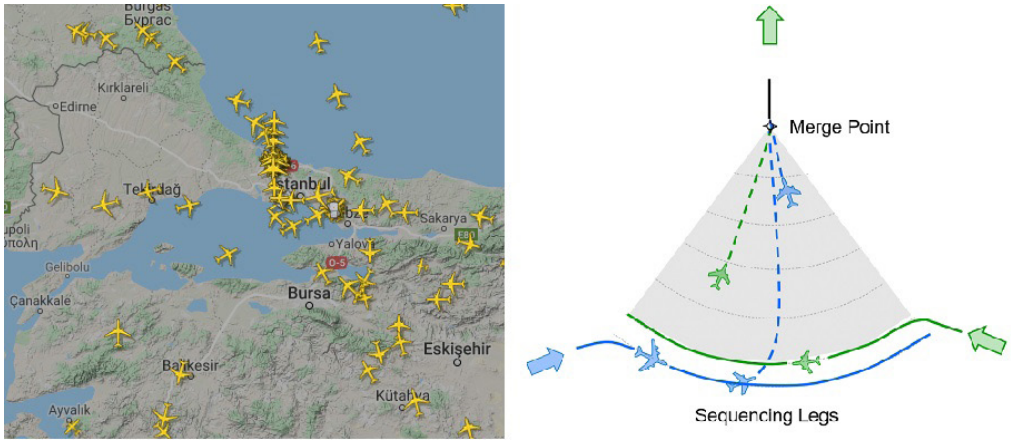

Figure 5. A congested airspace over the Marmara Region can be seen on the left, and a merge point system as a possible solution

Increased aircraft capacity

The apron area has 77 jet bridges (this number can go up to 114 for category - C aircraft), 157 open parking positions (this number can go up to 226 for category - C aircraft). Briefly, the terminal area has an extended parking capacity compared to Atatürk Airport; 234 parking positions in total and this number can also go up to 340 for category - C aircraft (14).

Table 5. Some of the important specifications of Istanbul Airport (15)

Specification	Capacity
Runways	5 runways currently
Passenger boarding bridges	143
Passenger capacity	A full capacity of 200 million
Terminals	4 terminal buildings (1,3 square meter main terminal building)
Apron	A full capacity of 500 aircraft
Parking area	Up to 70.000 indoor and outdoor parking lot
Destinations	Over 350 flight destinations
Taxiway Link	16 taxiways in total, some eligible for code-F aircraft (A380, B748)

The design to accommodate super-heavy aircraft

Runways and taxiways were designed so that companies are able to make operations with any kind of aircraft. In particular, A380 and B748 (super-heavy category aircraft) can fly from/to Istanbul Airport with the advantage of carrying more passengers or freight (14). Additionally, increased heavy aircraft parking lots presents a rare opportunity to plan for long distance flights more frequently.

A Huge Cargo Apron

Today, freight transport has an important position globally so that the sector has to be supported by project-based investments and new incentives should be granted. Hence, Istanbul Airport was built in a way that, it is planned to meet the expectations of freight transport for Turkey even in the future. For this purpose, an enormous cargo apron has been built in the project which covers an area of 1.4 million square meters. This newly built unique cargo and logistics center allows over 30 wide body aircraft to be docked at the same time (14).

Location Advantage

Istanbul, a city of two continents, is located at a point so that it has the role of a bridge between Europe and Asia. The geographical location of the city strengthens its position in commercial and economic activities. Additionally, Istanbul that is also home to Istanbul Airport has unique historical and cultural advantages to attract more tourists, which means more flights. As a consequence, Istanbul Airport has a key role in long distance transportation as well as tourism activities. The airport has the potential to be used as a hub airport for many airlines. Specifically, traffic flying between far East and Europe can use the Airport as a transfer center where they can refuel and rest.

4.2 Weaknesses of Istanbul Airport

Weak transport network

As stated above, the location of the airport is well-chosen and freight and passenger transport has great potential considering other airports in the world. However, the transport network between the airport and the city itself is not enough for optimum capacity utilization. Currently, the transportation between the city and the airport is done mostly by buses and other private units. A well-developed transport link is necessary to carry passengers and goods fast and easily. For this purpose, railway systems should be constructed to make transportation from all parts of the city efficient.

Strong wind characteristics

Located near the Black Sea, the airport is exposed to strong winds because of the characteristics of the area. Winds generally blow in the direction of North and South making the arrival/departure operations easy since the runways are located in the same direction. Nevertheless, the strong wind characteristics of the area, specifically strong cross winds, can sometimes jeopardize air traffic operations and increase the number of go-arounds.

Longer Taxi Times for Some Cases

Affected by several factors such as; runway configuration and congestion, taxiing between gates and runways are an indefinite part of air traffic management. Particularly in a major airport, the taxiing of an aircraft could take a considerable amount of time in actual flight hours.

Covering a huge land that includes 5 runways, aircraft movement area sometimes has an adverse effect on aircraft taxi times at Istanbul Airport. Distant runways are not easy to reach, particularly for southbound runway configurations.

Optimization applications are needed

The point that the modern aviation has reached and the importance of Istanbul Airport for Turkey has been explained above explicitly. The number of passengers and the amount of freight per year given on tables is an illustration of how big the sector is. While aviation keeps growing constantly in the world, there are things to be done to meet the requirements of this growth rate. Constructing new airports or adding up necessary physical instruments are sometimes hard to implement in aviation. Instead, revising prevailing procedures, making optimum use of the sources could be more efficient; time saving or less expensive. In this manner, optimization applications are quite common in modern aviation. Likewise, Istanbul Airport needs a variety of different optimization applications, specifically for aircraft taxi movements. For example: to save time and fuel, aircraft ground movements need to be optimized so that aircraft taxi times are shortened, long departure queues are eliminated. From another point of view; less fuel means less environmental damage, knowing that fuel consumption is directly correlated to environment.

4.3 Opportunities for Istanbul Airport

Major hub at the intersection of three Continents-Asia, Europe and Africa

Istanbul Airport is located at the intersection of three continents; Asia, Europa and Africa. Once completed fully, it will offer flights to as many as 350 destinations because of its location advantage. When all the phases are completed, the Airport will have an advantage in being used as a major hub for many carriers.

Figure 6. Increased flight destinations from a major hub

Increased flight frequencies for carriers

Capacity extension is generally likely to increase market concentration. With an increase in demand, airlines will benefit from new routes and additional flights as long as the capacity allows them. Theoretically, Istanbul Airport holds an important position by numerical data compared to other competing airports and it offers many advantages for flight operations. Atatürk Airport, once the country's busiest airport, had a limited capacity so that airlines had problems with operational growth. The opening of the new airport has also opened up new advantages for airlines with the help of its huge size (16). The flag carrier of the country, Turkish Airlines, and other airlines are now able to increase flight frequencies at a considerable amount.

Available new slots for new airlines

The demand for air transportation has been growing all around the world. Many major airports are already congested, with demand far exceeding available air traffic capacity. This was one of the problems experienced before at Ataturk Airport. Because of an insufficient capacity, some airlines were not able to plan and execute flight operations to/from Ataturk Airport. However, Istanbul Airport offers available new slots to many carriers with the help of its infrastructure and increased air traffic capacity.

As of April 2021, 73 different carriers have launched flight operations from/to Istanbul Airport including plans to in the near future. In recent years, carriers that did not fly to Ataturk Airport previously, have added Istanbul Airport to their destinations list such as; All Nippon Airways, IndiGo, and Juneyao Airlines (15).

Increased passenger capacity

Istanbul Airport is expected to host 200 million passengers per year when all the phases are completed. Currently, Hartsfield-Jackson Atlanta International Airport takes the lead with over 110 million passengers per year in 2019 according to International Council Airport (17). Considering this number Istanbul Airport will have almost twice the capacity of Atlanta International Airport, which also means a great contribution to the economy.

Increased employment and economic growth

The size of an airport is directly correlated to the economy. Providing employment opportunities and increasing revenues, a hub airport can foster sustainable economic growth. In this manner, new job opportunities have arisen; employment levels have increased with the capacity of the new airport. With direct and indirect employment at Istanbul Airport, thousands of people are provided with job opportunities that by far exceeds that of Ataturk Airport. Istanbul Airport is home to nearly 100 thousand employees and this number will go up to 225 thousand when it reaches full capacity with all phases operational. Clearly, those numbers are a demonstration of the airport's economic contribution to the country (18).

In addition, air transport is indispensable for tourism, and tourism has a strong linkage to the economic wealth of a country. With increased flight frequencies and additional destinations Istanbul Airport is of great importance in promoting global tourism and thus; the economy.

Logistics capacity

New cargo and logistics facilities included in the project is one of the core assets of Istanbul Airport. The size of the facilities, along with its location advantage, will play a key role for Istanbul Airport to become one of the important cargo hubs globally. Warehouses, logistic offices and all other small or large scale businesses will make a busy circulation if the capacity is used properly and effectively. The investments by national and international companies in air cargo will continuously increase revenues.

Figure-7 demonstrates the increase in freight transport (Cargo + Baggage + Postal Service) through 2010-2018 for Ataturk Airport. Clearly, the upper trend continued until the opening of Istanbul Airport (since then, those numbers have been shared by the two active airports). Now with ample place and more sophisticated facilities available at Istanbul Airport, those numbers tend to go up even more.

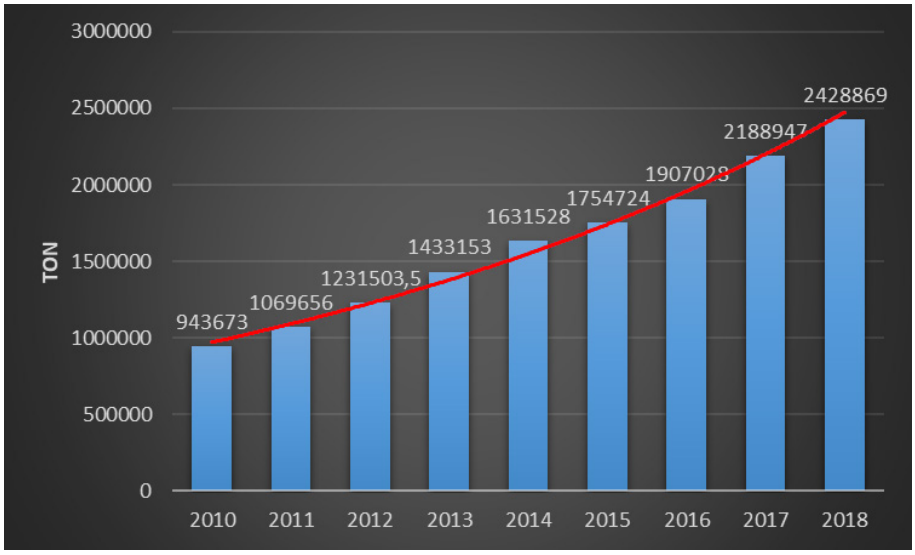

Figure 7. Freight Transport at Ataturk Airport through 2010-2018 (10).

Efficiency and Delay Reduction

We mentioned previously the kind of capacity problems at Ataturk Airport and how they are planned to be solved by the new airport. In simple terms, efficiency and reductions in delays; both for carriers and passengers are the main goals. Implementing new technologies and introducing agile optimization methods taxi time can be reduced and long departure queues can be eliminated which are quite common in hub airports.

4.4 Threats for Istanbul Airport

Competitive Middle-East countries

Even though Istanbul Airport has the above-mentioned advantages, there are other rival airport projects in the Middle East. Recently; some of the gulf countries, such as the United Arab Emirates, have declared projects that pose a strong threat to Istanbul Airport in the sector. For instance; transit traffic might find one those airports more efficient as a hub airport. For instance; airports in Dubai or Abu Dhabi, also might be an important time saving airport for transit traffic which fly from Asia to Europe or the reverse.

Small scale airlines may not adapt to a new business environment

As stated before, Istanbul Airport offers a lot for airlines in terms of capacity. However, small scale airlines are in danger of losing market share or even going bankrupt while larger scale airlines improve their flight frequencies. Hence; larger airlines might have a more advantageous position to grow while the small ones could risk their market share in this gigantic airport.

The Flag Carrier may lose its market share for some destinations

We have explained why Istanbul Airport offers a new increased flight capacity in the above -given statements. However, as for the flag carrier of Turkey, Turkish Airlines, this might be a problem for some of its destinations. With new carriers announcing flight

operations to places where Turkish Airlines also fly, the flag carrier might lose its market share for those destinations.

Migrating bird flyways

Istanbul Airport was built in a location over which migrating bird flyways exist. Migratory birds use those flyways explicitly in certain times of a year. Unfortunately, airports are well known to be a threat for bird migration and their natural ecosystem. Moreover, birds flying through aircraft arrival and departure routes might hit an aircraft and/or be sucked in the engines endangering the aircraft's safety.

Well-sophisticated management plans are required

Laying out millions of square meters, covering long distances and employing thousands of people, Istanbul Airport requires well-sophisticated management plans that we can hardly encounter even in some countries. The integrity of this enormous business environment is well dependent on how well the management plans are made. Air traffic units, airport authorities, ground services and hundreds of other private units are all parts of an important chain. Therefore, sustainability as well as innovative approaches should be an important aspect of this complex system. This so called eco-system needs to be designed even to handle serious crises, either the reason is internal or external, such as the most current one; Covid-19 pandemic. Given this example, the dramatic decrease in demand could totally threaten the whole system causing hundreds of thousands of people to lose their jobs.

Table 6. SWOT analysis of Istanbul Airport

STRENGTHS	WEAKNESSES
✓ Additional runway capacity ✓ Point merge system ✓ Increased aircraft capacity ✓ The design to accommodate super-heavy aircraft ✓ A Huge Cargo Apron ✓ Location Advantage	✓ Weak transport network ✓ Strong wind characteristics ✓ Longer taxi times for some cases ✓ Optimization applications are needed
OPPORTUNUTIES	**THREATS**
✓ Major hub at the intersection of three Continents-Asia, Europe and Africa ✓ Increased flight frequencies carriers ✓ Available new slots for new airlines ✓ Increased passenger capacity ✓ Increased employment and economic growth ✓ Logistics capacity ✓ Efficiency and delay reduction	✓ Competitive Middle-East countries ✓ Small scale airlines may not adapt to new business environment ✓ The Flag Carrier may lose its market share for some destinations ✓ Migrating bird flyways ✓ Well-sophisticated management plans required

5. Air Traffic Control Strategy for Istanbul Airport

Air traffic control strategy is based on all of the sources available, passenger and cargo statistics, current market share and the expectations from the industry in the future. Considering the SWOT analysis above, it can be inferred that Istanbul Airport has a remarkable position in aviation not just for Turkey but also globally. These analyses give us a clear understanding of what should future air traffic control strategy be like.

When we look at the information regarding Istanbul Airport, the most unique feature is the air traffic capacity and employment. Thus; making optimum use of the capacity should be of the utmost importance, because this will result in a value added to the economy of the country.

Integration of the airport and the city's transport network is quite important to carry passengers and cargo fast and comfortably. For this purpose, Istanbul Airport needs a much more developed transport network with the city itself and even with other neighboring cities. Ultimately, this will allow for uninterrupted transportation for business purposes and high commerce capacity. At this point, railway systems are efficient enough to serve as a main link. Constructing new railway systems, both for cargo and passenger transportation, after feasibility studies is needed along with ongoing railway projects.

The railway systems some of which are still ongoing projects should be designed, modernized and linked to the city so that it will easily and effectively serve to the final capacity of 200 million passengers per year. Additionally, airports that have a big cargo potential require goods to be carried in huge amounts and in a short period of time. It is a undeniable fact that railway systems are as important for cargo transportation as they are for passenger transportation. This is because these systems are economical, quicker and suitable for carrying heavy and huge amounts of goods even for long distances. For these reasons, railway transportation should also be applied to cargo transportation.

The advantageous position that Istanbul Airport has in terms of transit traffic has been explained above in depth. To retain this position, the number of facilities and the quality of services in and/or around the airport should be improved to better accommodate transit passengers. Attracted by quality services, the airport will, no doubt, be a preferable hub airport by many airlines along with its geographical advantage.

It will be easily seen that Istanbul Airport solves the capacity issue which was previously a problem for the limited area of Atatürk Airport. A limited capacity results in limited flight operations for carriers and time-delay for air traffic operations. As a result, air transportation won't be as cheap as we expect from airports such as Atatürk Airport. Hence, it is much more beneficial to provide cheaper air transportation from Istanbul Airport because of an improved capacity so that even new companies are now able to make flight operations. Providing a competitive business industry results in generalizing air transportation to the public as well as increasing companies' total income in many cases.

The expansion of Istanbul Airport is of another important subject. Prevailing runways were built according to the characteristics of the location and extend north to south. Adding a new runway parallel to the sea will make flight operations easier in the case of strong cross winds, and thus will reduce the number of go-arounds. Providing parallel runways extending east to west would be even more beneficial, one designated for arrival and another for departure operations.

6. Conclusion

On this paper, a quick review of the history of aviation has been presented and the current status of the industry has been explained by numerical data. In light of the information given, it can be said that aviation shows a constant pattern of growth for Turkey as it does globally. Particularly, massive investments that were made recently put Turkish civil aviation in an excellent position. Turkey has had an enormous development potential in air transportation, specifically with the opening of Istanbul Airport. In the meantime, this potential requires additional investments to support the growth rate as we stated before. From this perspective, we provided solution methods that will support and increase the rate of development and that will make air transportation much more productive.

The analysis we provide in this paper mostly includes statements driven by Istanbul Airport's structural design. Technical approaches that will increase air traffic efficiency are not included on this study. For future work, we will introduce a variety of different technical subjects on air transportation such as; optimization applications and queuing theory, to analysis of air traffic efficiency.

Having done the above-given analysis, it can be concluded that Turkey has an advantageous position in civil aviation compared to other rival airports either with its socio-economic position or geographically. Making additional supportive investments for projects like Istanbul Airport will put Turkish aviation to the next level. Thus, taking a step forward in today's modernized civilizations, where they are not just looking to go up in the sky but also to pull ahead in the space race, will put the flag of aviation on top and will lead to more advanced developments.

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RESEARCH ARTICLE

Visualization of the Global Supply Chain Research Domain Through Bibliometric Analysis

Bibliyometrik Analiz Yoluyla Küresel Tedarik Zinciri Araştırma Alanının Görselleştirilmesi

Serdar Semih Coşkun[1], **Halim Kazan**[2]

ABSTRACT

Over the past three decades, it has become clear that supply chain networks have surpassed borders and expanded significantly in the international arena. The effects of this transformation have been the subject of many academic studies . The aim of this study is to understand how the domain knowledge of global supply chain literature has grown and evolved over time. Through co-citation analysis using CiteSpace software, a literature cognitive map has been extracted and hotspot topics, emerging trends and burst cited articles have been discovered in this map. The secondary data (including 653 research papers and 18,197 references) used in the analysis was retrieved from the Web of Science database. The results indicate that the sub-topics "greenhouse gas emission", "corporate social responsibility" and "fair-trade labeling scheme" are new emerging trends in research of global supply chains. Also, the research focus has been sliding from cost reduction – profit maximization issues towards environmental and social issues under the sustainable supply chain management theory. Our study aims to provide a better understanding of current problems in the global supply chain area and lead to future research.

Keywords: Global Supply Chains, Scientometrics, CiteSpace

Jel Classifications: M16, C55, F64

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[1] **Corresponding author:** Serdar Semih Coşkun (Dr.), İstanbul University, Faculty of Economics, Department of Business, İstanbul, Turkey. E-mail: serdar.coskun@istanbul.edu.tr ORCID: 0000-0002-3830-6430

[2] Halim Kazan (Professor Dr.), İstanbul University, Faculty of Economics, Department of Business, İstanbul, Turkey. ORCID: 0000-0002-9234-6214

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1. Introduction

The global supply chain concept refers to the global links between an organization, its suppliers, and customers from all over the world. Due to the rapid evaluation of business sectors, a great deal of goods and services are produced by collaborations, but not by single organizations. Today, even small components of a particular product are subcontracted to specialized suppliers. Also, this deterioration exceeds the borders of nations very quickly (Dietzenbacher, Los, Stehrer, Timmer, and De Vries, 2013; Gereffi, Humphrey, and Sturgeon, 2005). In this sense, global supply chain management has become accepted as the most popular operation strategy contributing to the competitiveness of organizations (Gunasekaran, Lai, and Cheng, 2008). It is also stated that the globalization process enhances income revenue by penetrating new markets and providing access to suppliers in order to cater raw materials and semi-products with lower costs (Halldórsson et al., 2010). Such strategic initiatives require the integration of retailers, distributors, manufacturers, and suppliers in an effective and efficient manner (Yeung, 2008).

Beside many opportunities, it is inevitable that sharpening complexity of global supply chain networks also evoke a lot of threat within the business environment. As they exceed national boundaries, the designing of either existing or new product lines are more likely to meet challenges of globalization (Meixell and Gargeya, 2005). These challenges disrupt the process of value creation. In this respect, it is very crucial to understand the effects of the deterioration of production on economic, social and environmental outputs across countries and industries. On the other hand, supply chain oriented problems have already become so substantial that many practitioners and scholars have paid attention since the middle of the 1990's (Gunasekaran et al., 2008). The focus of these studies have been on various aspects. They have utilized several business models to put forward a comprehensive insight into the literature. Therefore, it would be helpful to use scientometrics tools to conceive the domain knowledge of global supply chain management literature.

The main objective of this paper is to reveal the cognitive map of global supply chain related studies in which hotspot sub-topics and emerging trends are clarified. This provides a research agenda for the future, illustrating the gaps and limitations of past research. We believe that the evaluation of the existing research over a certain period of time indicates how the problems and solutions actually evolve, so the findings may shed some light on the track of subsequent studies. In this perspective, a scientometrics analysis was conducted within research published under the topic of the global supply chain between 1995 and 2016. More specifically the document co-citation analysis has been applied through CiteSpace software, as it is explained with whole details later on.

2. Methodology

2.1. Scientometric Analysis

Scientific ideas mostly emerge from the basis of former research. They produce solutions for scientific problems. Thus, reviewing the extant literature is the backbone of a scientific research . The validity of outcomes derived from the research process also depends on to what extent former research supports them (Colepicolo, 2015). Such cause and effect

relations between succeeding publications requires a kind of communication proceeding through citations (Zuccala, 2006). It is inevitable that this communication aggregates in a scientific network during the period. Beyond the network linkages, there might be "invisible colleges" hidden within a complicated network. The concept of hidden colleges suggests that scholars who propose similar ideas have strong relationships among scientific society, even if they do not officially study together in the same institution (Crane, 1969; Yalçin and Yayla, 2016).

From this point of view, scientometrics is described as a method for measuring the scientific communication of a particular discipline using mathematical and statistical techniques (Pritchard, 1969). Scientometric tools can reveal the invisible colleges in a discipline (Ding, 2011). These tools detect the mathematical patterns on metadata, to visualize the big picture regarding the research topic (Klavans and Boyack, 2011).

2.2. Co-citation Analysis

Co-citation is one of bibliographic coupling, which examines the relationships between publications citing the same references. Co-citation analysis enables us to understand the intellectual infrastructure of the knowledge domain regarding periodic transformations (Rorissa and Yuan, 2012; Small, 1973).

In this study, document co-citation analysis was applied. This analysis identifies the top cited publications through scanning the bibliographic dataset (Chen, Song, Yuan, and Zhang, 2008). The evaluation of a particular research field, as well as emerging sub-research fields, can be explored with this method (Chen, Ibekwe-SanJuan, and Hou, 2010). Furthermore, publications that have crucial importance in the network can be identified based on citation frequency.

In this study, CiteSpace was employed to conduct data visualization. CiteSpace is a Java-based freeware developed for visualizing the semantic and social networks in a specific literature (Chen and Leydesdorff, 2014). It has been widely used by researchers from all over the world since it was developed in 2004 (Zhang, Wang, Hao, and Yu, 2016). The underlying attention that scholars pay this tool is because it has powerful illustration features which make it easy to understand the relationships between research items in a specific research topic. Furthermore, CiteSpace was developed for scientific literature reviews, but not for different aims, i.e. finding out the nature of any social network as other social network analysis tools can do. Therefore, CiteSpace shows the best performance in the literature review, among many other social network analysis software (Al, Sezen, and Soydal, 2012). Specifically, CiteSpace conducts a semantic analysis of the dataset, so that milestones and critical paths of knowledge can be discovered. It is also available to choose the analysis of cooperation status between author, institution and country, keywords co-occurrence, author co-citation and document co-citation networks in the same data unit (Zhang et al., 2016).

2.3. Data Collection

In this study, 653 research papers and 18,197 references published between 1995 and 2016 were analysed. A dataset of bibliographic records was retrieved from the Web of

Science Core Collection database. Using a topic search, the information of the author(s), title, source, abstract and cited references were retrieved.

3. Results

In order for hotspot research papers and emerging trends to be extracted, the document co-citation analysis was conducted. Figure 1 shows the document co-citation network containing clusters. Each node represents an individual reference. The bigger circle of a certain node means the higher frequency which has been cited so far. The lines between nodes come up when the co-citation occurs. In other words, if a paper simultaneously cites two different references together, then the line between two cited references emerges. As the frequency of co-citation increases, the lines get thicker.

CiteSpace seeks the patterns embedded in the citation relations within the cognitive map of global supply chain literature. Hence, the dataset was divided into 98 co-citation clusters. The cluster names are taken from title words. Index terms label these clusters. Table 1 summarizes the largest 10 clusters of the co-citation network. (TFIDF = term frequency-inverse document frequency; LLR = log-likelihood ratio; MI = Mutual information). According to these parameters used by underlying layout algorithms, it is possible to extract several clusters labeled the CiteSpace.

As it is seen in Table 1, the ClusterID refers to the cluster codes. The size shows the number of papers in each cluster. Mean year of citation is the age of the cluster. It refers to the renewal of clusters. Silhouette score is the clustering performance of the layout algorithms. The higher silhouette score indicates that elements within a cluster better resemble each other (Kaufman and Rousseeuw, 2009). This score can measure the homogeneity of a cluster. It is noted that the acceptable silhouette score should be a minimum 0.7 points (SIMOVICI, 2007).

Table 2 indicates the top 20 core cited references extracted from global supply chain research. One can comprehend the knowledge domain of the research field by scanning these papers. The citation counts are the number of times other papers have cited this reference in the dataset . Centrality scores show the strategic importance of each paper. Papers with high centrality have a crucial position in the network. The burst scores show the degree of activity volume of a paper along a specific period. In other words, papers with high burst scores are paid a great deal of attention in a short time.

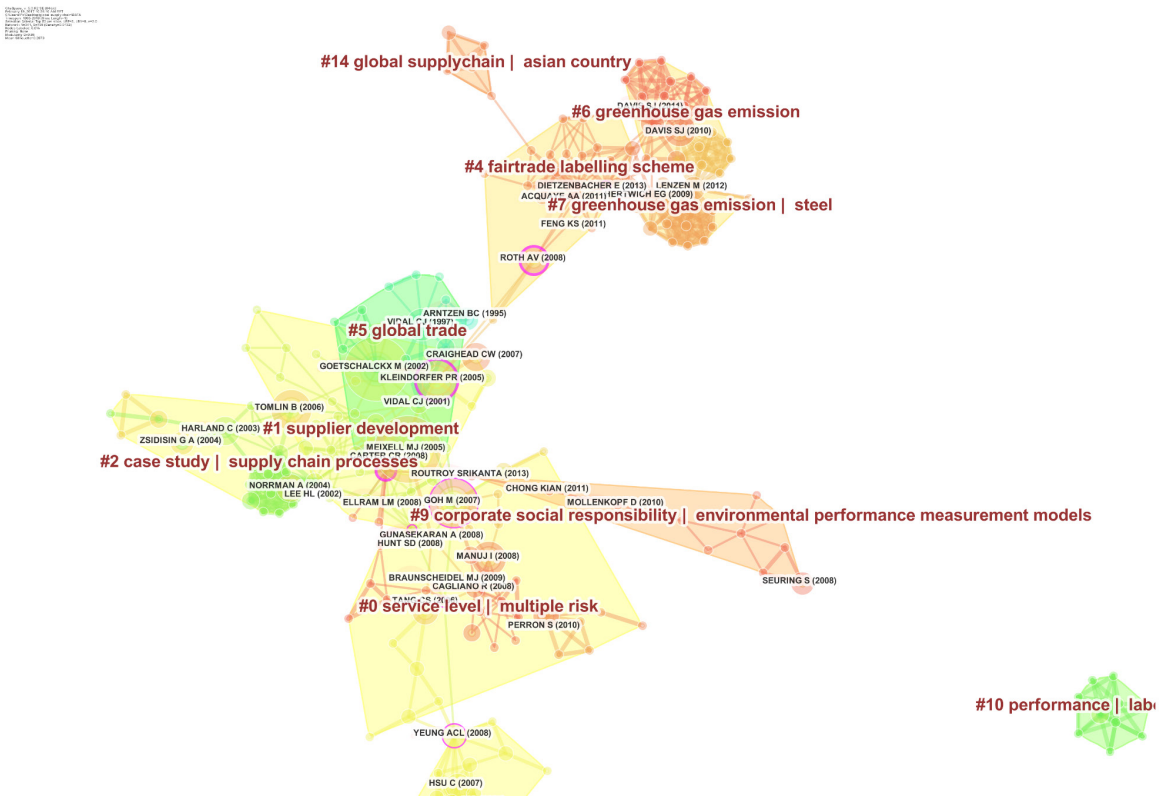

Figure 1. Visualization of co-citation clusters and cited references

Table 1. Summary of largest 10 emerging clusters from 1995 to 2016

ClusterID	*Size*	*Silhouette*	*Label*			*Mean year of citee*
			TFIDF	*LLR*	*MI*	
0	35	0.871	service level | multiple risk	global supply chain	cross entropy	2008
1	30	0.857	supplier development	integrative supply chain model	supply chain security	2005
2	21	0.977	case study | supply chain processes	global supply chain risk management	computational analysis	2003
3	21	0.989	developing global supply chain quality management	quality management	multi-tier global supply chain	2007
4	21	0.786	fairtrade labelling scheme	input output analysis	multi-tier global supply chain	2010
5	21	0.867	global trade	supply chain design	industrial district	2000
6	20	0.913	greenhouse gas emission	co2 emission	change policy	2011
7	15	0.945	greenhouse gas emission | steel	international trade	global supply chain	2010
8	12	1	services | processes	integrating information	global supply chain	2009
9	11	0.967	corporate social responsibility | environmental performance measurement models	voluntary governance mechanism	global supply chain	2010

Table 2. Outstanding references with frequency, centrality and burst score

Citation counts	*Centrality*	*Burst*	*References*	*Cluster*
14	0.04	5.87	Goetschalckx M, 2002, EUR J OPER RES, V143, P1	5
14	0.06	3.71	Meixell MJ, 2005, TRANSPORT RES E-LOG, V41, P531	5
11	0.10	0.10	Goh M, 2007, EUR J OPER RES, V182, P164	0
9	0.05	-	Tomlin B, 2006, MANAGE SCI, V52, P639	2
9	0.31	0.31	Kleindorfer PR, 2005, PROD OPER MANAG, V14, P53	1
8	0.01	-	Manuj I, 2008, J BUS LOGIST, V29, P133	0
7	0.03	4.64	Vidal CJ, 1997, EUR J OPER RES, V98, P1	5
7	0.01	-	Davis SJ, 2010, P NATL ACAD SCI USA, V107, P5687	6
6	0	-	Norrman A, 2004, International Journal of Physical Distribution & Logistics Management, V34, P434	2
6	0	-	Craighead CW, 2007, DECISION SCI, V38, P131	1
6	0.29	-	Roth AV, 2008, J SUPPLY CHAIN MANAG, V44, P22	4
6	0.03	3.42	Harland C, 2003, J PURCH SUPPLY MANAG, V9, P51	2
5	0.14	-	Yeung ACL, 2008, J OPER MANAG, V26, P490	3
4	0.32	-	Carter CR, 2008, INT J PHYS DISTR LOG, V38, P360	1
4	0.09	-	Lee HL, 2002, CALIF MANAGE REV, V44, P105	2
4	0.08	-	Gunasekaran A, 2008, OMEGA-INT J MANAGE S, V36, P549	0
4	0	3.42	Arntzen BC, 1995, INTERFACES, V25, P69	5
2	0.16	-	Dietzenbacher E, 2013, ECON SYST RES, V25, P71	4
2	0.15	-	Hunt SD, 2008, J SUPPLY CHAIN MANAG, V44, P10	1
2	0.14	-	Braunscheidel MJ, 2009, J OPER MANAG, V27, P119	0

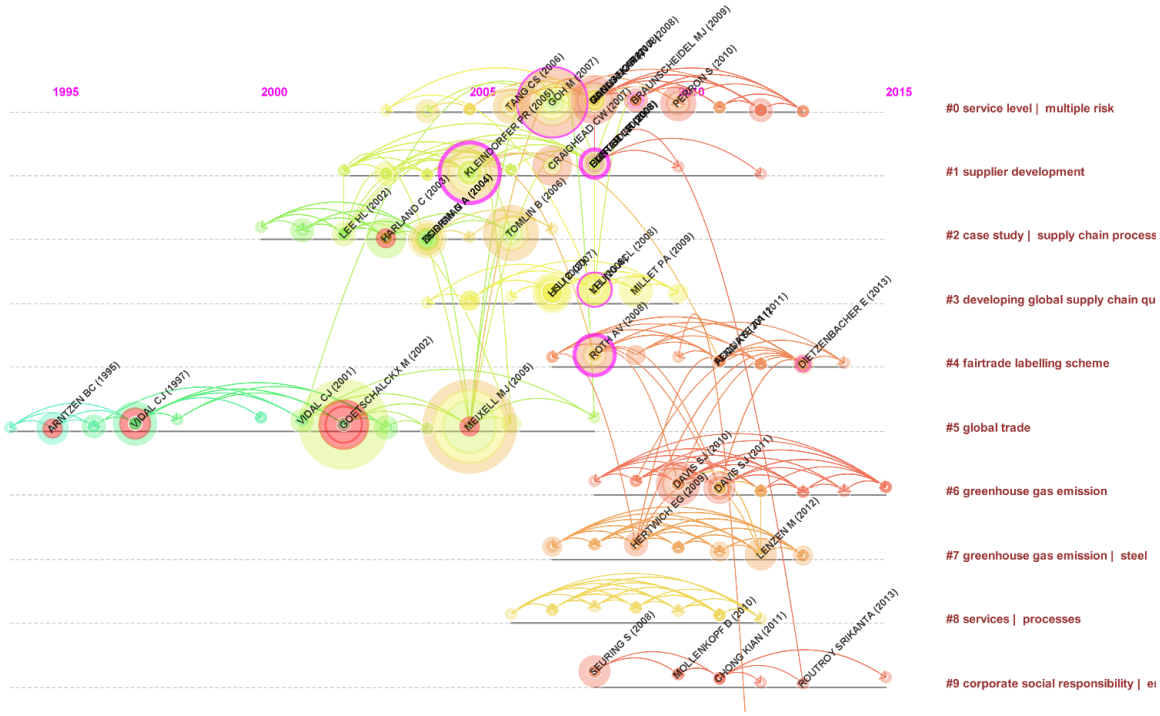

Figure 2. Timeline visualization of co-citation references

In CiteSpace, it is possible to obtain a standard graph view as well as a time zone view, both of which facilitate some specific visual attributes with which researchers can interact. Figure 2 is the time zone view of the largest 10 clusters.

Figure 3 shows the visual results of a burst analysis. There are only five references that have burst scores in the dataset. Besides that, thanks to relatively high frequency and centrality scores, these papers also compound the basic theoretical infrastructure of the research field (see Table 2). However, all the burst references come from before 2010. This result indicates that recent studies do not catch the attention of other researchers.

Figure 3. Top 5 references with the strongest citation burst

4. Discussion

Figure 1 shows the essential framework of a cognitive map consisting of global trade, service level/multiple risks, supplier development, and supply chain process clusters. Also, these clusters widely overlap in a nested manner. Thus, the majority of papers regarding these sub-topics depend on a very close intellectual basis. Furthermore, corporate social responsibility, the fair-trade labeling scheme, and greenhouse gas emission are the underlying subsidiary research clusters bonded to the main body in the cognitive map. Figure 2 also shows the timeline visualization of cited references. In this graph, it is easy to assess whether the sub-research fields are unsaturated or mature as well as classical or new trends.

In the global trade cluster, Meixell and Gargeya (2005) demonstrate that research needs to tackle multi-tier supply chains involving internal manufacturing and external supplier locations in a larger variety of industry settings (i.e. aircraft, heavy machinery, and services). Global supply chain designs should tackle outsourcing, integration and strategic alignment. Goetschalckx, Vidal, and Dogan (2002) articulate the cost-saving potential in the integration of transfer prices and production-distribution allocations into the global supply chain networks. Vidal and Goetschalckx (1997) describe several mathematical strategic production-distribution models for global supply chain design, highlighting their contribution and constraints. The remarkable drawback of these models is a lack of flexibility to adapt the continuous redesigning of the global supply chain.

In the service level/multiple risk cluster Goh, Lim, and Meng (2007) proposed a stochastic model for multi-stage global supply chain problems with profit maximization and risk minimization, namely supply, demand, exchange, and disruption. Perron, Hansen, Le Digabel, and Mladenović (2010) also attempt to maximize the global profit by determining the flow of goods, transfer prices and transportation cost allocation between each of its subsidiaries.

In the supplier development cluster, Kleindorfer and Saad (2005) handle risks arising from disruptions to normal activities and provide a conceptual framework for risk assessment and risk mitigation. These kinds of risk factors include natural disasters, such as strikes and economic disruptions, as well as acts of purposeful agents, including terrorists. Craighead, Blackhurst, Rungtusanatham, and Handfield (2007) explain how and why some supply chain disruptions regarding operational and financial risks would be more severe than others . Tomlin (2006) argues the optimal disruption risk mitigation strategies that a risk-neutral firm can adopt in different scenarios. A supplier's percentage uptime and the nature of the disruptions are found to be the key determinants of optimal strategy. In case the supplier is unreliable, and the capacity is infinite, a mixed mitigation strategy can be the optimal one. Similarly, if a reliable supplier can ramp up its processing capacity of a contingent, rerouting is another possible tactic that remarkably reduces the firm's costs. Carter and Rogers (2008) introduce the concept of sustainable supply chain management based on resource dependence theory and exhibit the relationships among environmental, social, and economic performance within this concept. This paper has one of the most strategic positions in the network (see Table 2). As seen in the cognitive map, this paper stands on the hottest line of connection between the clusters of corporate social responsibility, service level/multiple risks, and global trade clusters.

In the case study/supply chain processes cluster, Harland, Brenchley, and Walker (2003) describe and classify the type of risks that threaten the supply network, within a holistic and managerial point of view.

In the greenhouse gas emission cluster, Davis and Caldeira (2010) present a global consumption-based CO_2 emission inventory, derived from import and export of goods and services, in contrast with production- based CO_2 emission. It is found that 23% of global CO_2 emissions resulted from international trade in 2004. Consumption-based accounting reveals that a substantial amount of carbon leakage occurs in international trade. The direction of emissions mostly originates in China and other emerging markets and is passed on to consumers in the USA, Western Europe, and Japan. Sharing responsibility among producers and consumers could facilitate an international agreement on global climate policy, in order to compensate for regional emissions inequality. . Davis, Peters, and Caldeira (2011) challenge the myths that CO_2 emissions from the burning of fossil fuels derive from the country where the emission is produced (i.e. where the fuels are burned). According to statistics, 37% of global emissions are from fossil fuels that are internationally traded, and 23% of emissions come from traded goods. In consequence, it is important to discuss how to reduce carbon leakage along the global supply chain. . Hertwich and Peters (2009) illustrate the quantities of greenhouse gas emissions, regarding the consumption rates of goods and services in 73 nations and 14 world regions. The categories of consumption are construction, shelter, food, clothing, mobility, manufactured products, services, and trade. As results show , 72% of emissions are associated with household consumption, 10% with government consumption, and 18% with investment. 20% of greenhouse gas emission is because of food, 19% because of operations and maintenance, and 17% because of mobility. Food and services are prominent for developing countries, whereas mobility and manufactured goods accelerate

in rich countries. Politicians do not understand the significance of public services and manufactured goods.

In the fair-trade labeling scheme cluster, Lenzen et al. (2012) demonstrates how international trade chains along complex routes and consumers with demands for commodities drive biodiversity habitat degradation . Results showed that 30% of threats are because of international trade. In this perspective, it could be better to handle biodiversity loss as a global systematic phenomenon than by just looking at degrading or polluting producers in isolation. To describe the food supply chain and disruption, Roth, Tsay, Pullman, and Gray (2008) developed a conceptual framework containing traceability, transparency, testability, time, trust, and training points, which are critical factors to assure preservation of public health-care through a safe food supply. This study touches upon the food-related quality risk as well as contemporary research topics, i.e. ethical concerns. Therefore, this study bridges middle period clusters to recent period clusters as a strategic turning point in the cognitive map. Dietzenbacher et al. (2013) introduce The World Input-Output Database (WIOD) project. This database involves the subject associated with fragmentation and socio-economic aspects (i.e. water usage, energy usage and emissions to air). Moreover, it contains indicators related to the input of operations, such as capital and labor, as well as pollution derived from industrial activities like greenhouse gas emissions.

In the corporate social responsibility cluster, Seuring and Müller (2008) indicate that research is dominated by green/sustainable supply chain issues. However, social aspects and three dimensions of sustainability are overlooked by scholars. Halldórsson et al. (2010) examine the relationships among green, lean, and global supply chain strategies through a comprehensive literature review. In consequence, four major required themes are suggested: theoretically grounded research, multi-functional approaches, a systemic approach that adds strategic insight and integrated measurement applications.

5. Conclusion

The main objective of this study is to reveal how the domain knowledge of global supply chain growth has evolved over time. For this purpose, the document co-citation analysis was applied via CiteSpace. We believe that the results reveal a sufficient amount of clues to more easily grasp the gist of the literature.

As a result of this study, intellectually leading papers, as well as sub research fields, are determined via document co-citation analysis. As the timeline indicates, the knowledge domain of global supply chain research is divided into three periods. In the earlier period, research gathered in global trade is the oldest cluster. Research in this cluster mostly focuses on how to maximize after-tax profits and minimize costs for multinational corporations. Mathematical models are the prominent tools for achieving these goals. In the middle period, the main objective of studies slides towards risk assessment and mitigation in global supply networks. In the recent period three original research fields appear: greenhouse gas emissions, corporate social responsibility, and the fair-trade labeling scheme. Environmental issues and sustainability within global supply chains have become very popular in the recent period. Therefore, these sub-topics are the emerging trends in global supply chain literature.

However , results indicate a lack of burst- cited references in emerging clusters. In other words, the papers in emerging trends are incapable of calling attention to themselves quickly . When the content of these references is examined, it can be seen that they only describe the contemporary problems of global supply chains. They are incapable of producing effective ideas to solve these problems. In order for these requirements to be met, theoretically grounded frameworks need to be developed. Thus future research may address this gap in the literature.

The apparent limitation of this study is that only the WoS database was used for collecting data. Although WoS assures the quality of papers, scanning other databases would enrich the quantity of the dataset. In that case, results may depict a more comprehensive grasp of the literature, which may be a further result of this research.

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AMAÇ VE KAPSAM

Ulaştırma ve Lojistik Dergisi (JTL), İstanbul Üniversitesi Ulaştırma ve Lojistik Fakültesi'nin çok disiplinli ve altı aylık resmi bir dergisidir. Derginin amacı, taşımacılık ve lojistik endüstrisinin küresel ekonomi için geri döndürülemez hale gelen sorunları hakkında yeni fikirleri yayınlamaktır. JTL, akademisyenlere ve saha uygulayıcılarına ulaştırma ve lojistik için yeni konuları tartışmak ve analiz etmek için dinamik bir platform sunmaktadır. JTL Dünya çapında iş yöneticileri ve araştırmacılar arasında lojistik ve tedarik zinciri yönetimi ile ilgili bilgi alışverişinin yanı sıra, lojistik ve tedarik zinciri yönetim sorunları ve teknikleri hakkında yeni bir düşünce platformunda bağımsız, özgün ve özenli bir analiz olanağı sunar. Dergimize akademisyenler ve saha uygulayıcıları tarafından yapılan ulaştırma, lojistik ve tedarik zinciri yönetimi ve uygulamalarını geliştiren makaleler, araştırma çalışmaları, örnek olay analizleri ve inceleme makaleleri davet edilmektedir. Ulaştırma, lojistik veya tedarik zinciri yönetiminin herhangi bir alanındaki makaleler dergimize kabul edilmektedir. Dergimiz editörleri gelen çalışmalar ile ilgili eserlerin teorik ve yöntemsel süreçlerin uygulamalar ile ne derecede örtüştüğünü test etmektedirler. Yayınlanmak üzere gönderilen makalelerin tedarik zincirinde ulaştırma ve lojistik süreci perspektifinden uygulamalarının yapılması ve yorumlanması kabul için öncelikli tercih nedeni olmaktadır. Bu nedenle, dergimize işletmecilik, girişimcilik, yönetim, muhasebe, kurumsal yönetim müşteri ilişkileri yönetimi (CRM), pazarlama, insan kaynakları yönetimi, ekonomi, finans, işletme, imalat sanayi, lojistik, tedarik zinciri yönetimi, ulaşım endüstrileri, yeşil lojistik, ters lojistik, insani lojistik, sürdürülebilirlik, şehir lojistiği sektörleri ile ilgili çalışmalar kabul edilmektedir. Tüm makaleler, hakemler tarafından yayınlanmak üzere olarak incelenmektedir.

POLİTİKALAR

Yayın Politikası

Dergiye yayınlanmak üzere gönderilen makalelerin içeriği derginin amaç ve kapsamı ile uyumlu olmalıdır. Dergi, orijinal araştırma niteliğindeki yazıları yayınlamaya öncelik vermektedir.

Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir.

Ön değerlendirmeyi geçen yazılar iThenticate intihal tarama programından geçirilir. İntihal incelemesinden sonra, uygun makaleler Editör tarafından orijinaliteleri, metodolojileri, makalede ele alınan konunun önemi ve derginin kapsamına uygunluğu açısından değerlendirilir.

Bilimsel toplantılarda sunulan özet bildiriler, makalede belirtilmesi koşulu ile kaynak olarak kabul edilir. Editör, gönderilen makale biçimsel esaslara uygun ise, gelen yazıyı yurtiçinden ve /veya yurtdışından en az iki hakemin değerlendirmesine sunar, hakemler gerek gördüğü takdirde yazıda istenen değişiklikler yazarlar tarafından yapıldıktan sonra yayınlanmasına onay verir.

Makale yayınlanmak üzere dergiye gönderildikten sonra yazarlardan hiçbirinin ismi, tüm yazarların yazılı izni olmadan yazar listesinden silinemez ve yeni bir isim yazar olarak eklenemez ve yazar sırası değiştirilemez.

Yayına kabul edilmeyen makale, resim ve fotoğraflar yazarlara geri gönderilmez.

Açık Erişim İlkesi

Journal of Transportation and Logistics (JTL) dergisinin tüm içeriği okura ya da okurun dahil olduğu kuruma ücretsiz olarak sunulur. Okurlar, ticari amaç haricinde, yayıncı ya da yazardan izin almadan dergi makalelerinin tam metnini okuyabilir, indirebilir, kopyalayabilir, arayabilir ve link sağlayabilir.

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İşlemleme Ücreti

Derginin tüm giderleri İstanbul Üniversitesi tarafından karşılanmaktadır. Dergide makale yayını ve makale süreçlerinin yürütülmesi ücrete tabi değildir. Dergiye gönderilen ya da yayın için kabul edilen makaleler için işlemleme ücreti ya da gönderim ücreti alınmaz.

Telif Hakkında

Yazarlar, Journal of Transportation and Logistics'nde yayınlanan çalışmalarının telif hakkına sahiptirler ve çalışmaları Creative Commons Atıf-GayrıTicari 4.0 Uluslararası (CC BY-NC 4.0) olarak lisanslıdır. Creative

ETİK

Yayın Etiği Beyanı

Journal of Transportation and Logistics, yayın etiğinde en yüksek standartlara bağlıdır ve Committee on Publication Ethics (COPE), Directory of Open Access Journals (DOAJ), Open Access Scholarly Publishers Association (OASPA) ve World Association of Medical Editors (WAME) tarafından yayınlanan etik yayıncılık ilkelerini benimser; Principles of Transparency and Best Practice in Scholarly Publishing başlığı altında ifade edilen ilkeler için: https://publicationethics.org/resources/guidelines-new/principles-transparency-and-best-practice-scholarly-publishing

Gönderilen tüm makaleler orijinal, yayınlanmamış ve başka bir dergide değerlendirme sürecinde olmamalıdır. Her bir makale editörlerden biri ve en az iki hakem tarafından çift kör değerlendirmeden geçirilir. İntihal, duplikasyon, sahte yazarlık/inkar edilen yazarlık, araştırma/veri fabrikasyonu, makale dilimleme, dilimleyerek yayın, telif hakları ihlali ve çıkar çatışmasının gizlenmesi, etik dışı davranışlar olarak kabul edilir.

Kabul edilen etik standartlara uygun olmayan tüm makaleler yayından çıkarılır. Buna yayından sonra tespit edilen olası kuraldışı, uygunsuzluklar içeren makaleler de dahildir.

Araştırma Etiği

Journal of Transportation and Logistics araştırma etiğinde en yüksek standartları gözetir ve aşağıda tanımlanan uluslararası araştırma etiği ilkelerini benimser. Makalelerin etik kurallara uygunluğu yazarların sorumluluğundadır

- Araştırmanın tasarlanması, tasarımın gözden geçirilmesi ve araştırmanın yürütülmesinde, bütünlük, kalite ve şeffaflık ilkeleri sağlanmalıdır.
- Araştırma ekibi ve katılımcılar, araştırmanın amacı, yöntemleri ve öngörülen olası kullanımları; araştırmaya katılımın gerektirdikleri ve varsa riskleri hakkında tam olarak bilgilendirilmelidir.
- Araştırma katılımcılarının sağladığı bilgilerin gizliliği ve yanıt verenlerin gizliliği sağlanmalıdır. Araştırma katılımcıların özerkliğini ve saygınlığını koruyacak şekilde tasarlanmalıdır.
- Araştırma katılımcıları gönüllü olarak araştırmada yer almalı, herhangi bir zorlama altında olmamalıdırlar.
- Katılımcıların zarar görmesinden kaçınılmalıdır. Araştırma, katılımcıları riske sokmayacak şekilde planlanmalıdır.
- Araştırma bağımsızlığıyla ilgili açık ve net olunmalı; çıkar çatışması varsa belirtilmelidir.
- Deneysel çalışmalarda, araştırmaya katılmaya karar veren katılımcıların yazılı bilgilendirilmiş onayı alınmalıdır. Çocukların ve vesayet altındakilerin veya tasdiklenmiş akıl hastalığı bulunanların yasal vasisinin onayı alınmalıdır.
- Çalışma herhangi bir kurum ya da kuruluşta gerçekleştirilecekse bu kurum ya da kuruluştan çalışma yapılacağına dair onay alınmalıdır.
- İnsan öğesi bulunan çalışmalarda, "yöntem" bölümünde katılımcılardan "bilgilendirilmiş onam" alındığının ve çalışmanın yapıldığı kurumdan etik kurul onayı alındığı belirtilmesi gerekir.

Yazarların Sorumluluğu

Makalelerin bilimsel ve etik kurallara uygunluğu yazarların sorumluluğundadır. Yazar makalenin orijinal olduğu, daha önce başka bir yerde yayınlanmadığı ve başka bir yerde, başka bir dilde yayınlanmak üzere değerlendirmede olmadığı konusunda teminat sağlamalıdır. Uygulamadaki telif kanunları ve anlaşmaları gözetilmelidir. Telife bağlı materyaller (örneğin tablolar, şekiller veya büyük alıntılar) gerekli izin ve teşekkürle kullanılmalıdır. Başka yazarların, katkıda bulunanların çalışmaları ya da yararlanılan kaynaklar uygun biçimde kullanılmalı ve referanslarda belirtilmelidir.

Gönderilen makalede tüm yazarların akademik ve bilimsel olarak doğrudan katkısı olmalıdır, bu bağlamda "yazar" yayınlanan bir araştırmanın kavramsallaştırılmasına ve dizaynına, verilerin elde edilmesine, analizine ya da yorumlanmasına belirgin katkı yapan, yazının yazılması ya da bunun içerik açısından

eleştirel biçimde gözden geçirilmesinde görev yapan birisi olarak görülür. Yazar olabilmenin diğer koşulları ise, makaledeki çalışmayı planlamak veya icra etmek ve / veya revize etmektir. Fon sağlanması, veri toplanması ya da araştırma grubunun genel süpervizyonu tek başına yazarlık hakkı kazandırmaz. Yazar olarak gösterilen tüm bireyler sayılan tüm ölçütleri karşılamalıdır ve yukarıdaki ölçütleri karşılayan her birey yazar olarak gösterilebilir. Yazarların isim sıralaması ortak verilen bir karar olmalıdır. Tüm yazarlar yazar sıralamasını Telif Hakkı Formunda imzalı olarak belirtmek zorundadırlar.

Yazarlık için yeterli ölçütleri karşılamayan ancak çalışmaya katkısı olan tüm bireyler "teşekkür / bilgiler" kısmında sıralanmalıdır. Bunlara örnek olarak ise sadece teknik destek sağlayan, yazıma yardımcı olan ya da sadece genel bir destek sağlayan, finansal ve materyal desteği sunan kişiler verilebilir.

Bütün yazarlar, araştırmanın sonuçlarını ya da bilimsel değerlendirmeyi etkileyebilme potansiyeli olan finansal ilişkiler, çıkar çatışması ve çıkar rekabetini beyan etmelidirler. Bir yazar kendi yayınlanmış yazısında belirgin bir hata ya da yanlışlık tespit ederse, bu yanlışlıklara ilişkin düzeltme ya da geri çekme için editör ile hemen temasa geçme ve işbirliği yapma sorumluluğunu taşır.

Editör, Hakem Sorumlulukları ve Değerlendirme Süreci

Baş editör, makaleleri, yazarların etnik kökeninden, cinsiyetinden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirir. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlar. Gönderilen makalelere ilişkin tüm bilginin, makale yayınlanana kadar gizli kalacağını garanti eder. Baş editör içerik ve yayının toplam kalitesinden sorumludur. Gereğinde hata sayfası yayınlamalı ya da düzeltme yapmalıdır.

Baş editör; yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkiye sahiptir ve dergide yayınlanacak makalelerle ilgili nihai kararı vermekle yükümlüdür.

Hakemlerin araştırmayla ilgili, yazarlarla ve/veya araştırmanın finansal destekçileriyle çıkar çatışmaları olmamalıdır. Değerlendirmelerinin sonucunda tarafsız bir yargıya varmalıdırlar. Gönderilmiş yazılara ilişkin tüm bilginin gizli tutulmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar.

Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir. Bazı durumlarda editörün kararıyla, ilgili hakemlerin makaleye ait yorumları aynı makaleyi yorumlayan diğer hakemlere gönderilerek hakemlerin bu süreçte aydınlatılması sağlanabilir.

Hakem Süreci

Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir. Gönderilen ve ön kontrolü geçen makaleler iThenticate yazılımı kullanılarak intihal için taranır. İntihal kontrolünden sonra, uygun olan makaleler baş editör tarafından orijinallik, metodoloji, işlenen konunun önemi ve dergi kapsamı ile uyumluluğu açısından değerlendirilir. Baş editör, makaleleri, yazarların etnik kökeninden, cinsiyetinden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirir. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlar.

Seçilen makaleler en az iki ulusal/uluslararası hakeme değerlendirmeye gönderilir; yayın kararı, hakemlerin talepleri doğrultusunda yazarların gerçekleştirdiği düzenlemelerin ve hakem sürecinin sonrasında baş editör tarafından verilir.

Hakemlerin değerlendirmeleri objektif olmalıdır. Hakem süreci sırasında hakemlerin aşağıdaki hususları dikkate alarak değerlendirmelerini yapmaları beklenir.

- Makale yeni ve önemli bir bilgi içeriyor mu?
- Öz, makalenin içeriğini net ve düzgün bir şekilde tanımlıyor mu?
- Yöntem bütünlüklü ve anlaşılır şekilde tanımlanmış mı?

- Yapılan yorum ve varılan sonuçlar bulgularla kanıtlanıyor mu?
- Alandaki diğer çalışmalara yeterli referans verilmiş mi?
- Dil kalitesi yeterli mi?

Hakemler, gönderilen makalelere ilişkin tüm bilginin, makale yayınlanana kadar gizli kalmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar. Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir.

YAZILARIN HAZIRLANMASI

Dil

Dergide Türkçe ve İngilizce makaleler yayınlanır. Gönderilen makalelerde makale dilinde öz, İngilizce öz ve İngilizce geniş özet olmalıdır. Ancak makale İngilizce ise, İngilizce geniş özet istenmez.

Yazıların Hazırlanması ve Yazım Kuralları

Aksi belirtilmedikçe gönderilen yazılarla ilgili tüm yazışmalar ilk yazarla yapılacaktır. Makale gönderimi online olarak https://jtl.istanbul.edu.tr/en/_ sayfasından erişilen https://mc04.manuscriptcentral.com/jtl üzerinden yapılmalıdır. Gönderilen yazılar, makale türünü belirten ve makaleyle ilgili detayları içeren (bkz: Son Kontrol Listesi) Kapak Sayfası; yazının elektronik formunu içeren Microsoft Word 2003 ve üzerindeki versiyonları ile yazılmış elektronik dosya ve tüm yazarların imzaladığı Telif Hakkı Anlaşması Formu eklenerek gönderilmelidir.

1. Yazılar Makale Şablonu kullanılarak hazırlanmalıdır. Makale ana metninde, çift taraflı kör hakemlik süreci gereği, yazarın / yazarların kimlik bilgileri yer almamalıdır.
2. Yayınlanmak üzere gönderilen makale ile birlikte yazar bilgilerini içeren Kapak Sayfası gönderilmelidir. Kapak Sayfasında, makalenin başlığı, yazar veya yazarların bağlı bulundukları kurum ve unvanları, kendilerine ulaşılabilecek adresler, cep, iş ve faks numaraları, ORCID ve e-posta adresleri yer almalıdır (bkz. Son Kontrol Listesi).
3. Giriş bölümünden önce 180-200 kelimelik çalışmanın kapsamını, amacını, ulaşılan sonuçları ve kullanılan yöntemi kaydeden makale dilinde öz ve İngilizce öz ile 600-800 kelimelik İngilizce genişletilmiş özet yer almalıdır. Makale İngilizce ise İngilizce geniş özet istenmez. Özlerin altında çalışmanın içeriğini temsil eden, 3'er adet anahtar kelime yer almalıdır.
4. Çalışmaların başlıca şu unsurları içermesi gerekmektedir: Makale dilinde başlık, öz ve anahtar kelimeler; İngilizce başlık, öz ve anahtar kelimeler; geniş özet, ana metin bölümleri, kaynaklar, tablolar ve şekiller.
5. **Makale Türleri:**

   Araştırma Makaleleri: Orijinal araştırma makaleleri derginin kapsamına uygun konularda önemli, özgün bilimsel sonuçlar sunan araştırmaları raporlayan yazılardır. Orijinal araştırma makaleleri, Öz, Anahtar Kelimeler, İngilizce Geniş Özet, Giriş, Yöntem, Bulgular, Tartışma, Sonuçlar, Kaynaklar bölümlerinden ve Tablo, Grafik ve Şekillerden oluşur.

   Öz: Makale dilinde başlık ve İngilizce başlık öz'lerin üzerinde yer almalıdır. Araştırma yazılarında Türkçe ve İngilizce özler 180-200 kelime arasında olmalı ve çalışmanın amacı, yöntemi, ana bulguları ve sonuçlarını ifade etmelidir. Ayrıca Türkçe, Almanca, Fransızca ya da İtalyanca makaleler için özlerden sonra 600-800 kelimelik İngilizce geniş özet de yer almalıdır.

   Giriş: Giriş bölümünde konunun önemi, tarihçe ve bugüne kadar yapılmış çalışmalar, hipotez ve çalışmanın amacından söz edilmelidir. Hem ana hem de ikincil amaçlar açıkça belirtilmelidir. Sadece gerçekten ilişkili kaynaklar gösterilmeli ve çalışmaya ait veri ya da sonuçlardan söz edilmemelidir. Giriş bölümünün sonunda çalışmanın amacı, araştırma soruları veya hipotezler yazılmalıdır.

   Yöntem: Yöntem bölümünde, veri kaynakları, çalışmaya katılanlar, ölçekler, görüşme/değerlendirmeler ve temel ölçümler, yapılan işlemler ve istatistiksel yöntemler yer almalıdır. Yöntem bölümü, sadece çalışmanın planı ya da protokolü yazılırken bilinen bilgileri içermelidir; çalışma sırasında elde edilen tüm bilgiler bulgular kısmında verilmelidir.

   Bulgular: Ana bulgular istatistiksel verilerle desteklenmiş olarak eksiksiz verilmeli ve bu bulgular

uygun tablo, grafik ve şekillerle görsel olarak da belirtilmelidir. Bulgular yazıda, tablolarda ve şekillerde mantıklı bir sırayla önce en önemli sonuçlar olacak şekilde verilmelidir. Tablo ve şekillerdeki tüm veriyi yazıda vermemeli, sadece önemli noktaları vurgulanmalıdır.

Tartışma: Tartışma bölümünde o çalışmadan elde edilen veriler, kurulan hipotez doğrultusunda hipotezi destekleyen ve desteklemeyen bulgular ve sonuçlar irdelenmeli ve bu bulgu ve sonuçlar literatürde bulunan benzeri çalışmalarla kıyaslanmalı, farklılıklar varsa açıklanmalıdır. Çalışmanın yeni ve önemli yanları ve bunlardan çıkan sonuçları vurgulanmalıdır. Giriş ya da sonuçlar kısmında verilen bilgi ve veriler tekrarlanmamalıdır.

Sonuçlar: Çalışmadan elde edilen sonuçlar belirtilmelidir. Sonuçlar, çalışmanın amaçları ile bağlantılı olmalıdır, ancak veriler tarafından yeterince desteklenmeyen niteliksiz ifadeler ve sonuçlardan kaçınılmalıdır. Yeni hipotezler gerektiğinde belirtilmeli, ancak açıkça tanımlanmalıdır.

Şekil, Resim, Tablo ve Grafikler:. Metin içinde kullanılan fotoğraf, plân, harita vb. materyallerin ".jpg / .tiff" uzantılı kayıtları gönderilecek dokümanlara eklenmelidir. Bu tür belgelerin baskı tekniğine uygun çözünürlükte (en az 300 piksel) ve sayfa alanını aşmayacak büyüklükte olmasına dikkat edilmelidir. Fotoğraf ve levhaların 10 sayfayı aşmamasına dikkat edilmeli ve metin içinde parantezle atıfta bulunulan resim, harita veya diğer ekler makalenin sonuna eklenmelidir.

Derleme: Yazının konusunda birikimi olan ve bu birikimleri uluslararası literatüre yayın ve atıf sayısı olarak yansımış uzmanlar tarafından hazırlanmış yazılar değerlendirmeye alınır. Yazarları dergi tarafından da davet edilebilir. Derleme yazısı, başlık, öz, anahtar kelimeler, İngilizce geniş özet (Türkçe, Almanca, Fransızca ve İtalyanca makaleler için), ana metin bölümleri ve kaynaklardan oluşmalıdır.

6. Referanslar derginin benimsediği American Psychological Association (APA) 6 stiline uygun olarak hazırlanmalıdır.
7. Kurallar dâhilinde dergimize yayınlanmak üzere gönderilen çalışmaların her türlü sorumluluğu yazar/ yazarlarına aittir.

KAYNAKLAR

Referans Stili ve Formatı

Journal of Transportation and Logistics, metin içi alıntılama ve kaynak gösterme için APA (American Psychological Association) kaynak sitilinin 6. edisyonunu benimser. APA 6.Edisyon hakkında bilgi için:

- American Psychological Association. (2010). Publication manual of the American Psychological

Association (6th ed.). Washington, DC: APA.

- http://www.apastyle.org/

Kaynakların doğruluğundan yazar(lar) sorumludur. Tüm kaynaklar metinde belirtilmelidir. Kaynaklar aşağıdaki örneklerdeki gibi gösterilmelidir.

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(Sayıner ve Demirci, 2007, s. 72)
Üç, dört ve beş yazarlı kaynak;
Metin içinde ilk kullanımda: (Ailen, Ciambrune ve Welch, 2000, s. 12–13) Metin içinde tekrarlayan kullanımlarda: (Ailen ve ark., 2000)
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REFERENCES

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Basic Reference Types

Book

a) Turkish Book
Karasar, N. (1995). *Araştırmalarda rapor hazırlama* (8th ed.) [Preparing research reports]. Ankara, Turkey: 3A Eğitim Danışmanlık Ltd.
b) Book Translated into Turkish
Mucchielli, A. (1991). *Zihniyetler* [Mindsets] (A. Kotil, Trans.). İstanbul, Turkey: İletişim Yayınları.
c) Edited Book
Ören, T., Üney, T., & Çölkesen, R. (Eds.). (2006). *Türkiye bilişim ansiklopedisi* [Turkish Encyclopedia of Informatics]. İstanbul, Turkey: Papatya Yayıncılık.
d) Turkish Book with Multiple Authors
Tonta, Y., Bitirim, Y., & Sever, H. (2002). T*ürkçe arama motorlarında performans değerlendirme* [Performance evaluation in Turkish search engines]. Ankara, Turkey: Total Bilişim.
e) Book in English
Kamien R., & Kamien A. (2014). *Music: An appreciation.* New York, NY: McGraw-Hill Education.
f) Chapter in an Edited Book
Bassett, C. (2006). Cultural studies and new media. In G. Hall & C. Birchall (Eds.), *New cultural studies: Adventures in theory* (pp. 220–237). Edinburgh, UK: Edinburgh University Press.
g) Chapter in an Edited Book in Turkish
Erkmen, T. (2012). Örgüt kültürü: Fonksiyonları, öğeleri, işletme yönetimi ve liderlikteki önemi [Organization culture: Its functions, elements and importance in leadership and business management]. In M. Zencirkıran (Ed.), *Örgüt sosyolojisi* [Organization sociology] (pp. 233–263). Bursa, Turkey: Dora Basım Yayın.
h) Book with the same organization as author and publisher
American Psychological Association. (2009). *Publication manual of the American psychological association* (6th ed.). Washington, DC: Author.

Article

a) Turkish Article
Mutlu, B., & Savaşer, S. (2007). Çocuğu ameliyat sonrası yoğun bakımda olan ebeveynlerde stres nedenleri ve azaltma girişimleri [Source and intervention reduction of stress for parents whose children are in intensive care unit after surgery]. *Istanbul University Florence Nightingale Journal of Nursing, 15*(60), 179–182.

b) English Article

de Cillia, R., Reisigl, M., & Wodak, R. (1999). The discursive construction of national identity. *Discourse and Society, 10*(2), 149–173. http://dx.doi.org/10.1177/0957926599010002002

c) Journal Article with DOI and More Than Seven Authors

Lal, H., Cunningham, A. L., Godeaux, O., Chlibek, R., Diez-Domingo, J., Hwang, S.-J. ... Heineman, T. C. (2015). Efficacy of an adjuvanted herpes zoster subunit vaccine in older adults. *New England Journal of Medicine, 372,* 2087–2096. http://dx.doi.org/10.1056/NEJMoa1501184

d) Journal Article from Web, without DOI

Sidani, S. (2003). Enhancing the evaluation of nursing care effectiveness. *Canadian Journal of Nursing Research, 35*(3), 26–38. Retrieved from http://cjnr.mcgill.ca

e) Journal Article wih DOI

Turner, S. J. (2010). Website statistics 2.0: Using Google Analytics to measure library website effectiveness. *Technical Services Quarterly, 27,* 261–278. http://dx.doi.org/10.1080/07317131003765910

f) Advance Online Publication

Smith, J. A. (2010). Citing advance online publication: A review. *Journal of Psychology.* Advance online publication. http://dx.doi.org/10.1037/a45d7867

g) Article in a Magazine

Henry, W. A., III. (1990, April 9). Making the grade in today's schools. *Time, 135,* 28–31.

Doctoral Dissertation, Master's Thesis, Presentation, Proceeding

a) Dissertation/Thesis from a Commercial Database

Van Brunt, D. (1997). *Networked consumer health information systems* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 9943436)

b) Dissertation/Thesis from an Institutional Database

Yaylalı-Yıldız, B. (2014). *University campuses as places of potential publicness: Exploring the politicals, social and cultural practices in Ege University* (Doctoral dissertation). Retrieved from Retrieved from: http://library.iyte.edu.tr/tr/hizli-erisim/iyte-tez-portali

c) Dissertation/Thesis from Web

Tonta, Y. A. (1992). *An analysis of search failures in online library catalogs* (Doctoral dissertation, University of California, Berkeley). Retrieved from http://yunus.hacettepe.edu.tr/~tonta/yayinlar /phd/ickapak.html

d) Dissertation/Thesis abstracted in Dissertations Abstracts International

Appelbaum, L. G. (2005). Three studies of human information processing: Texture amplification, motion representation, and figure-ground segregation. *Dissertation Abstracts International: Section B. Sciences and Engineering, 65*(10), 5428.

e) Symposium Contribution

Krinsky-McHale, S. J., Zigman, W. B., & Silverman, W. (2012, August). Are neuropsychiatric symptoms markers of prodromal Alzheimer's disease in adults with Down syndrome? In W. B. Zigman (Chair), *Predictors of mild cognitive impairment, dementia, and mortality in adults with Down syndrome.* Symposium conducted at the meeting of the American Psychological Association, Orlando, FL.

f) Conference Paper Abstract Retrieved Online

Liu, S. (2005, May). *Defending against business crises with the help of intelligent agent based early warning solutions.* Paper presented at the Seventh International Conference on Enterprise Information Systems, Miami, FL. Abstract retrieved from http://www.iceis.org/iceis2005/abstracts_2005.htm

g) Conference Paper - In Regularly Published Proceedings and Retrieved Online

Herculano-Houzel, S., Collins, C. E., Wong, P., Kaas, J. H., & Lent, R. (2008). The basic nonuniformity of the cerebral cortex. *Proceedings of the National Academy of Sciences, 105,* 12593–12598. http://dx.doi.org/10.1073/pnas.0805417105

h) Proceeding in Book Form

Parsons, O. A., Pryzwansky, W. B., Weinstein, D. J., & Wiens, A. N. (1995). Taxonomy for psychology. In J. N. Reich, H. Sands, & A. N. Wiens (Eds.), *Education and training beyond the doctoral degree: Proceedings of the American Psychological Association National Conference on Postdoctoral Education and Training in Psychology* (pp. 45–50). Washington, DC: American Psychological Association.

i) Paper Presentation

Nguyen, C. A. (2012, August). *Humor and deception in advertising: When laughter may not be the best medicine.* Paper presented at the meeting of the American Psychological Association, Orlando, FL.

Other Sources

a) Newspaper Article

Browne, R. (2010, March 21). This brainless patient is no dummy. *Sydney Morning Herald, 45.*

b) Newspaper Article with no Author

New drug appears to sharply cut risk of death from heart failure. (1993, July 15). *The Washington Post,* p. A12.

c) Web Page/Blog Post

Bordwell, D. (2013, June 18). David Koepp: Making the world movie-sized [Web log post]. Retrieved from http://www.davidbordwell.net/blog/page/27/

d) Online Encyclopedia/Dictionary

Ignition. (1989). In *Oxford English online dictionary* (2nd ed.). Retrieved from http://dictionary.oed.com

Marcoux, A. (2008). Business ethics. In E. N. Zalta (Ed.). *The Stanford encyclopedia of philosophy.* Retrieved fromhttp://plato.stanford.edu/entries/ethics-business/

e) Podcast

Dunning, B. (Producer). (2011, January 12). *in Fact: Conspiracy theories* [Video podcast]. Retrieved from http://itunes.apple.com/

f) Single Episode in a Television Series

Egan, D. (Writer), & Alexander, J. (Director). (2005). Failure to communicate. [Television series episode]. In D. Shore (Executive producer), *House;* New York, NY: Fox Broadcasting.

g) Music

Fuchs, G. (2004). Light the menorah. On *Eight nights of Hanukkah* [CD]. Brick, NJ: Kid Kosher.

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