ÜRETİM YÖNETİMİ ALANINDA GELİŞMELER

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PROF. DR. MEHMET ULUKAN
DOÇ. DR. FADİME DİLBER

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Editörler

Prof. Dr. Mehmet Ulukan

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Telefon: +90 312 390 1 118
web: www.platanuskitap.com
e-mail: platanuskitap@gmail.com

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İÇİNDEKİLER

BÖLÜM 1

Ulusal İnovasyon Etkinliği: Oecd Örneği

Fatma Zehra Balcı[1] & Mehmet Fatih Acar[2]

[1] İzmir Katip Çelebi Üniversitesi, ORCID: 0009-0001-9910-1412
[2] Doç. Dr., İzmir Katip Çelebi Üniversitesi, ORCID: 0000-0002-7388-8720

1.GİRİŞ

İnovasyon, ekonomik büyümeyi ve toplumsal refahı artırmayı hedefleyen ülkelerin odaklanması gereken temel konulardan biridir. Bu, ihracat rakamlarını ve istihdam oranlarını olumlu yönde etkileyerek ekonominin gelişimine katkı sağlar. Ayrıca, kaynakların etkin ve verimli bir şekilde kullanılmasını destekleyerek sürdürülebilir ekonomik büyümeyi teşvik eder. Bu sebeplerle, ülkelerin inovasyon performansı çeşitli ölçüm araçlarıyla sürekli olarak değerlendirilir ve yakından takip edilir. Küresel İnovasyon İndeksi (Kİİ), çok yönlü değerlendirme yapabilme yeteneği ve düzenli güncellemeleri sayesinde ülkelerin inovasyon performanslarını izlemek için yaygın bir tercih haline gelmiştir.

Küresel İnovasyon İndeksi-Kİİ (Global Innovation Index-GII), dünya genelindeki ülkelerin inovasyon performansını değerlendiren ve sıralayan bir indekstir. Bu indeks, ülkelerin inovasyon kapasitelerini ölçmek için çeşitli kriterlere dayanır. İnovasyon indeksi genellikle Ar-Ge yatırımları, eğitim, altyapı, pazar erişimi gibi faktörleri değerlendirir ve bu verileri kullanarak ülkeleri inovasyon konusundaki sıralamaya tabi tutar. Kİİ, bir ülkenin ekonomik gelişimini ve rekabet gücünü değerlendirme amacı taşır.

Dünya Fikri Mülkiyet Örgütü (WIPO) tarafından her sene ekonomik durumu göz önünde bulundurarak oluşturulan Küresel İnovasyon İndeksi, düzenli aralıklarla yayınlanan bir değerlendirme aracıdır.İnovasyon girdi alt endeksi, kurumlar, beşerî sermaye ve araştırma, altyapı, pazarın gelişmişliği ve iş gelişmişliği olmak üzere beş unsurdan oluşurken, inovasyon çıktı alt endeksi bilgi ve teknoloji çıktıları ile yaratıcı çıktılar olmak üzere iki temel bileşenden meydana gelmektedir.Dünyanın birçok güçlü ekonomisini de içinde bulunduran Ekonomik Kalkınma ve İşbirliği Örgütü (OECD) topluluğunun inovasyon performanslarının etkileri küresel ekonomiler açısından büyük önem taşımaktadır. Bu çalışmada da OECD ülkelerin inovasyon etkinliklerinin üstünde durulmuştur.

Bu bağlamda, Küresel İnovasyon İndeksi (Kİİ), devletlerin inovasyon performansını daha iyi ölçmek ve anlamak için yeni yaklaşımlar geliştirmeye odaklanmaktadır. Bu durum özellikle gelişmekte olan ülkeler için kendilerini geliştirme adına farklı ve değerli bakış açıları sunabilir. Dolayısıyla, bu çalışmada 2020-2022 yıllarına ait Kİİ verileri, dünyanın önemli ekonomilerine sahip Ekonomik Kalkınma ve İşbirliği Örgütü (OECD) üye ülkeleri örneği üzerinden etkinlik analizine tabii tutulacaktır. Bu işlem için yöntem olarak Veri Zarflama Analizi (VZA) tercih edilmiştir.

Çalışmanın temel amacı, seçilmiş ülkeler için inovasyon girdileri bileşenleri (kurumlar, insan sermayesi ve araştırma, altyapı, pazar olgunluğu ve iş geliştirme) ve inovasyon çıktıları (bilgi ve teknoloji çıktıları ve yaratıcı çıktılar) açısından ana ekonomik faktör ve rekabet sürecinin belirleyicisi olarak kabul edilen inovasyon etkinliğini ölçmek ve karşılaştırmaktır. Kısacası, araştırmanın temel motivasyonu, inovasyon etkinliği anlamında başarılı ülkelerin politikalarına odaklanılmasıdır.

Araştırma, dünya ekonomisinde yüksek bir paya sahip olan OECD üyesi ülkeleri içermesi nedeniyle literatürdeki birçok araştırmadan ayrışmaktadır. Çalışmada; i) inovasyon etkinliği açısından hangi OECD ülkeleri daha iyi performans göstermektedir?, ii) inovasyon etkinliği çok düşük olan OECD ülkeleri hangileridir? , iii) OECD ülkeleri için yıllara göre inovasyon etkinliğinin gelişimi nasıldır?, iv) diğer OECD ülkeleri ile karşılaştırıldığında, Türkiye'nin inovasyon etkinliği konusunda durumu nedir? ve v) Türkiye özelinde ilerleyen yıllarda daha iyi etkinlik performansı ve sürdürülebilir başarı için politika yapıcılara ne gibi tavsiyelerde bulunmak gerekir sorularına cevap aranacaktır.

Makalenin devamı şu şekilde düzenlenmiştir; 2. bölümde inovasyon ve Kİİ hakkında literatür taraması yapılmış, 3. bölümde ise Veri Zarflama Analizi ve Malmquist konusunda teknik bilgiler verilmiştir. 4. bölümde OECD için etkinlik sonuçları gösterilmiş, 5. bölümde ise bulgular tartışılmıştır. Son kısım olan 6. Bölüm ise sonuçtur.

2. LİTERATÜR TARAMASI

Bugün küreselleşen rekabet ile birlikte; araştırma / geliştirme ve yenilik gibi kavramların önemi artmıştır. Özellikle son yıllarda, yenilik kavramı rekabet avantajı arayan işletmeler ve ülkeler için önemli bir silah olarak ortaya çıkmıştır (Korucuk, vd., 2020). Yenilik, kaynak oluşturucu bir eylem ve zenginlik için bir araç olarak tanımlanmıştır (Drucker,1985). Başka bir ifadeyle, bu kavram mevcut yapıların yeniden düzenlenmesidir (Giunchiglia,2013). Yenilik ulusal, bölgesel ve kurumsal düzeylerde çok önemlidir. Bu sebeple, şirketler ve devletler için önemli bir ekonomik büyüme ve gelişme motoru olarak kabul edilir. Yenilik, ekonomik büyümeyi teşvik eder, ücretleri yükseltir, yaşam süresini artırır, teknolojiyi daha erişilebilir hale getirir, yeni örgütsel yapıları devreye sokarak yaşam standartlarını iyileştirir ve yeni ev teknolojileriyle aileye ve eğlenceye daha fazla zaman kazandırır (Greenstone vd.,2011; Paredes-Frigolett vd.,2021). Kısacası, yenilik, ekonomik ve sosyal faydalar sağlayan bir değerdir. Dolayısıyla, kurumlarda ve ve hükümetlerde yenilik yani inovasyon için yapılan yatırımlar her geçen gün artmaktadır (Şimşit vd.,2014).

Schumpeter (1934), inovasyonu girişimcilerin kar elde etmesini sağlayan ve teknolojik ilerlemeler sonucu ortaya çıkan her türlü yenilik olarak tanımlamıştır. Oslo Kılavuzu (2005: 50) ise inovasyonu, işletme içi uygulamalar, kurum organizasyonu veya dış ilişkilerde yeni veya önemli derecede iyileştirilmiş süreçler, ürünler veya hizmetler, yeni bir pazarlama stratejisi veya yeni bir örgütsel yöntemin gerçekleştirilmesi olarak ifade etmektedir. Politika yapıcıları, akademisyenler ve yetkililer, inovasyonun ölçülmesinin önemini vurgulayarak genel eğilimleri belirlemek, politika senaryoları oluşturmak ve performans hedeflerini belirlemek için inovasyonun önemine dikkat çekmişlerdir. Literatürde konu ile ilgili çok çeşitli araştırmalar mevcuttur.

Güler ve Veysikarani (2018), OECD ülkelerinin inovasyon performanslarındaki benzerlik ve farklılıkları belirlemek amacıyla faktör analizi ve kümeleme analizlerinden faydalanarak bir karşılaştırma yapmıştır. Faktör analizi bulgularına göre dört faktör elde edilerek ülkeler genel faktör puanlarına göre sıralanmıştır. Kümeleme analizi sonucunda beş küme elde edilmiştir. Çalışmanın bulgularına göre en yüksek performansa sahip ülkeler kümesinde ABD ve Japonya yer alırken, ikinci küme Almanya, İngiltere, Fransa, Güney Kore, İsrail ve İsviçre'den oluşmaktadır. Türkiye ise Meksika ve Şili ile birlikte dördüncü küme olarak belirlenmiştir.

Ayçin ve Çakın (2019), Avrupa'daki ülkelerin inovasyon performanslarını Avrupa İnovasyon Karnesi verilerinden faydalanarak ve Entropy ve MABAK yöntemlerini kullanarak değerlendirmiştir. Bulgulara göre, İsviçre, İsveç ve Danimarka en yüksek inovasyon performansına sahipken, Ukrayna, Romanya ve Makedonya en düşük performansı göstermiştir. Türkiye ise 31. sırada yer almıştır. Murat (2020), Veri Zarflama Analizi ile OECD ülkelerinin 2019 yılı inovasyon performanslarını ölçmüştür. Analiz bulguları, İsviçre, Birleşik Krallık ve ABD'nin en yüksek inovasyon performansına sahip olduğunu, Kolombiya, Meksika ve Şili'nin ise en düşük performansa sahip ülkeler olduğunu göstermektedir.

Garcia-Bernabeu vd. (2020), İspanya'daki bölgesel inovasyon performansını değerlendirmek için çok kriterli referans noktasına dayalı bir yaklaşım kullanmıştır. İspanya bölgelerinin inovasyon performansını ölçmek için ışık diyagramı adlı bir görselleştirme aracı önermişlerdir.

Altıntaş (2021a), G7 ülkelerinin 2020 yılı Küresel İnovasyon İndeksi bileşenlerinin önemlilik derecelerini Entropy yöntemi ile tespit etmiş ve ülkelerin inovasyon performanslarını küresel inovasyon indeksi skorlarıyla karşılaştırmıştır. Analiz sonuçlarına göre, ABD ve Birleşik Krallık en yüksek inovasyon performansına sahiptir. Altıntaş (2021b), Karadeniz Ekonomik İşbirliği Örgütü üye ülkelerinin 2020 yılı inovasyon performanslarını CRITIC tabanlı GİA yöntemi ile değerlendirmiştir. Bulgular, Bulgaristan, Rusya, Türkiye, Ukrayna, Romanya ve Yunanistan'ın ortalamanın üzerinde bir performansa sahip olduğunu göstermiştir.

Aytürkmen ve Aynaoğlu'nun (2017) yaptığı çalışmada, 2009-2017 yılları arasında 29 ülkenin verileri kullanılarak küresel rekabet endeksinin küresel inovasyon endeksi üzerindeki etkisi incelenmiştir. Araştırmanın sonuçlarına göre, yüksek eğitim ve öğretim, inovasyon ve emek piyasası etkinliği arasında anlamlı ve pozitif yönlü ilişkiler tespit edilmiştir. Ayrıca, makroekonomik çevrenin küresel rekabet endeksindeki düşük etkinliği, inovasyon boyutunda dikkate değer bir faktör olarak belirlenmiştir. Çalışmada, küresel rekabet endeksi faktör gruplarına dayalı bir model oluşturularak inovasyon ve bu faktör grubu arasında anlamlı ilişkilerin olduğu belirlenmiştir.

Son yıllarda araştırmalar, inovasyon performansına etki eden faktörler üzerine odaklanmıştır (Caird,vd.,2013). Bununla birlikte, inovasyon literatürüne bakıldığında, Kİİ verileri kullanarak çok sayıda araştırmanın olmadığı görülmektedir. Bu durum, ele alınması gereken bir konudur. Dolayısıyla bu çalışmanın, VZA metodolojisi ve OECD üye ülkeleri üzerine uygulama örneği açısından literatüre katkı sağlaması beklenmektedir.

Birçok araştırma VZA yöntemini değişik etkinlik ölçümleri için sıklıkla kullanmıştır. VZA birçok girdi ve çıktının kullanılmasına izin verdiği için, inovasyon alanında değişik faktörleri içeren Kİİ verileri bu yöntem ile rahat bir şekilde analiz edilebilir. Literatürde Kİİ ile ilgili çeşitli çalışmalar olsa bile (ör. Aytekin vd., 2022), birçoğu belirli bir yıl için etkinlikleri araştırmıştır. Ancak bu güncel araştırma, 2020-2022 yılları arasında OECD üyesi ülkelerin inovasyon etkinliklerini hem her bir yıl için hem de belirlenen yıllar arasındaki etkinlik değişimlerini ölçmektedir. Dolayısıyla bu araştırmanın, içinde Türkiye'nin de bulunduğu OECD ülkeleri için inovasyon etkinliğinin yıllar arasındaki değişimini gözlemlemek için VZA ve Malmquist İndeks (Mİ) yöntemleriyle yönetim bilimleri literatürüne katkı sağlayacağını söyleyebiliriz. Ayrıca bu çalışma, Türkiye örneğinden hareketle gelişmekte olan bir ülkenin inovasyon etkinliğinin gelişmiş ülkelere kıyasla nasıl değerlendirebileceğini de ortaya koymaktadır.

3. YÖNTEM

İnovasyon indeksleri, inovasyonun mikro, makro, teknolojik ve diğer yönlerden çeşitli değişkenler üzerindeki etkilerini nesnel olarak belirlemeyi amaçlar. Bu kapsamda Kİİ, bir ülkenin inovasyon yapabilme kabiliyetini ölçen en önemli göstergelerden biri olarak kabul edilebilir (Krstic et al., 2019).

Kİİ, her yıl 141 ekonomiyi içeren detaylı bir ölçüm sağlar. Bu indeks, küresel nüfusun %95,1'i ve küresel GSYİH' nın %98,6'sı için kullanılır. Kİİ, dört farklı ölçümden oluşur: genel Kİİ, girdi alt indeksleri, çıktı alt indeksleri ve inovasyon etkililik oranı (Hancıoğlu, 2016). Dolayısıyla, bu indeks birçok ekonomi açısından değerli bilgiler sunar (Benavente vd., 2012). Diğer bir ifadeyle, Kİİ, inovasyonla ilgili politika ve uygulamalar aracılığıyla bir ülkenin güçlü ve zayıf yönlerini ortaya çıkarmaya yardımcı olur (INSEAD,2007).

Küresel İnovasyon verileri, Cornell Üniversitesi ve Birleşmiş Milletler'in özel bir ajansı olan Dünya Fikri Mülkiyet Örgütü (WIPO) tarafından yayınlanmaktadır. 2020-2022 verileri de bu ortak oluşumun internet sayfasından elde edilmiştir.Bu çalışmada, etkinlik ölçümünde sıklıkla kullanılan Veri Zarflama Analizi (VZA) kullanılmıştır. VZA modeli için DEA Solver16 yazılımı tercih edilmiştir. Bununla birlikte analizde, karşılaştırılabilir bilgiler sağlamak için girdi odaklı model göz önünde bulundurulmuştur. Çalışmada, Kİİ'nin, “kurumlar”, “beşeri sermaye ve araştırma”, “altyapı”, “piyasaların gelişmişliği” ve “ticari gelişmişlik” girdi faktörleri olarak, “bilimsel çıktılar” ve “yaratıcı çıktılar” faktörleri ise çıktı olarak düşünülmüştür (Cornell University, vd.,2015).

Yukarıda bahsedildiği üzere, bu araştırmada, OECD ülkelerinin etkinlik ölçümü için Veri Zarflama Analizi (VZA) ve yıllara göre etkinlik değişimini gösteren Malmquist İndeks (Mİ) kullanılacaktır. Bu yöntem matematiksel programlamaya dayanmaktadır (Charnes vd., 1978). Etkinliği ölçülen olgular VZA terminolojisinde karar verme birimleri (KVB) olarak anılır. VZA, farklı KVB’lerin göreli etkinliklerini değerlendirmek için popüler bir araçtır ve bazı avantajları nedeniyle çoğu akademik çalışmada sıklıkla kullanılır. VZA’nın en önemli avantajlardan birisi, her KVB için karşılaştırılabilir bir etkinlik puanı sunmasıdır. Diğer bir ifadeyle, VZA tüm girdi ve çıktı düzeylerinin değerlendirilmesine izin veren karşılaştırmalı etkinlik performansını ortaya koyar. Bununla birlikte, özellikle, etkin olmayan birimler için bir sınır tanımlayarak, KVB’ler arasında değerlendirmeye izin verir. VZA’da değerlendirilebilecek farklı birimlere sahip birçok farklı girdi ve çıktı bulunmaktadır. Bunlara ek olarak, bu yöntem için üretim fonksiyonunun doğası hakkında herhangi bir ön koşul bulunmamaktadır. Çalışmada, VZA için dünyada ekonomik anlamda önemli konuma sahip olan ve içinde Türkiye’nin de bulunduğu OECD üye ülkeleri göz önünde bulundurulmuştur.

4.BULGULAR

İnovasyon, her ne kadar ürün özelinde düşünülse bile, süreç ve hizmet sektörleri açısından da kritik bir öneme sahiptir. Dolayısıyla günümüzde artan rekabet, kurumların teknoloji, etkinlik / verimlilik ve inovasyon gibi unsurlara odaklanması gerektiğini göstermiştir. Firmalar ve hükümetler açısından bu kavramları tek başına düşünmek artık imkansız hale gelmiştir. Kİİ, bir ülkenin genel inovasyon performansını göstererek gelişmekte olan ekonomilerin teknolojiyi yakalamasına yardımcı olmaktadır. Kİİ'nin "kurumlar", "beşeri sermaye ve araştırma", "altyapı", "piyasaların gelişmişliği", "ticari gelişmişlik", "bilimsel çıktılar" ve "yaratıcı çıktılar" faktörleri, inovasyon performansının temel göstergeleridir. Diğer bir ifadeyle bu indeks, kurumların, araştırmacıların, şirketlerin ve bölgelerin devletler bazında inovasyon yapma yeteneğini özetleyen bir dizi sayısal göstergedir. Ayrıca, Kİİ politika yapıcılar ve araştırmacılar açısından ulusal rekabet edebilirliği değerlendirmeye yardımcı olan bir araç olarak kabul edilir (Wonglimpiyarat, 2010, Altıntaş, 2020). Bu bağlamda, Küresel İnovasyon İndeksi (Kİİ), devletlerin inovasyon performansını daha iyi ölçmek ve anlamak için yeni yaklaşımlar geliştirmeye odaklanmaktadır. Bu durum özellikle gelişmekte olan ülkeler için kendilerini geliştirme adına farklı ve değerli bakış açıları sunabilir. Dolayısıyla, bu çalışmada 2020-2022 yıllarına ait Kİİ verilerini, dünyanın önemli ekonomilerine sahip OECD üye ülkeler örneği üzerinden etkinlik analizine tabii tutulmuştur.

Tablo 1'de 2020 Kİİ verilerine dayalı olarak OECD ülkeleri için VZA sonuçlarına yer verilmiştir. Buna göre; Estonya, Finlandiya, Almanya, İzlanda, İrlanda, İsrail, İtalya, Lüksemburg, Hollanda, Slovakya, İsveç, İsviçre ve Birleşik Krallık tam etkin olarak bulunmuştur. Analiz sonuçlarında, son üç sıralamada Slovanya (0,78), Kolombiya (0,65) ve Şili (0,64) yer almıştır. Türkiye ise 0,89 etkinlik puanıyla 22. sırada yer almıştır.

Tablo 1: 2020 Yılı VZA Sonuçları

Sıralama	Ülkeler	VZA Puanı
1	Estonya	1
2	Finlandiya	1
3	Almanya	1
4	İzlanda	1
5	İrlanda	1
6	İsrail	1
7	İtalya	1
8	Lüksemburg	1
9	Hollanda	1
10	Slovakya	1
11	İsveç	1
12	İsviçre	1
13	Birleşik Krallık	1
14	Portekiz	0,99
15	ABD	0,97
16	Letonya	0,97
17	İspanya	0,96
18	Çekya	0,95
19	Fransa	0,94
20	Macaristan	0,93
21	Yunanistan	0,90
22	Türkiye	0,89
23	Danimarka	0,89
24	Japonya	0,88
25	Kore	0,86
26	Litvanya	0,86
27	Meksika	0,86
28	Polanya	0,84
29	Kosta Rica	0,84
30	Avusturya	0,83
31	Norveç	0,83
32	Yeni Zelanda	0,82
33	Kanada	0,81
34	Avustralya	0,81

35	Belçika	0,80
36	Slovenya	0,78
37	Kolombiya	0,65
38	Şili	0,64

Tablo 2'de 2021 KİI verilerine dayalı olarak OECD ülkeleri için VZA sonuçları gösterilmiştir. Bulgulara göre; Çekya, Estonya, Fransa, İsrail, İtalya, Lüksemburg, Hollanda, Portekiz, Slovakya, İsveç, İsviçre, Türkiye, Birleşik Krallık ve Amerika Birleşik Devletleri tam etkindir. VZA'ne göre, son üç sıralamada Norveç (0,81), Şili (0,74) ve Kolombiya (0,66) yer almıştır.

Tablo 2: 2021 Yılı VZA Sonuçları

Sıralama	**Ülkeler**	**VZA Puanı**
1	Çekya	1
1	Estonya	1
1	Fransa	1
1	İsrail	1
1	İtalya	1
1	Luksemburg	1
1	Hollanda	1
1	Portekiz	1
1	Slovakya	1
1	İsveç	1
1	İsviçre	1
1	Türkiye	1
1	BirleşikKrallık	1
1	ABD	1
15	Kore	0,99
16	Almanya	0,99
17	Finlandiya	0,99
18	İzlanda	0,98
19	İrlanda	0,97
20	İspanya	0,95
21	Kosta Rika	0,95
22	Macaristan	0,94
23	Litvanya	0,92
24	Meksika	0,92

25	Yeni Zelanda	0,91
26	Letonya	0,90
27	Yunanistan	0,87
28	Japonya	0,87
29	Danimarka	0,85
30	Slovenya	0,84
31	Belçika	0,83
32	Polanya	0,83
33	Avustralya	0,83
34	Avusturya	0,82
35	Kanada	0,82
36	Norweç	0,81
37	Şili	0,74
38	Kolombiya	0,66

Tablo 3'de 2022 KİI verileri ile OECD ülkeleri için VZA sonuçları gösterilmiştir. Buna göre; Çekya, Almanya, İzlanda, İsrail, İtalya, Kore, Lüksemburg, Slovakya, İsveç, İsviçre, Türkiye, Birleşik Krallık ve Amerika Birleşik Devletleri 1 puanla tam etkin olarak bulunmuştur. Analiz sonuçlarında, son üç sıralamada Litvanya (0,72), Avustralya (0,72) ve Kolombiya (0,71) yer almıştır.

Tablo 3: 2022 Yılı VZA Sonuçları

Sıralama	Ülkeler	VZA Puanı
1	Çekya	1
1	Almanya	1
1	İzlanda	1
1	İsrail	1
1	İtalya	1
1	Kore	1
1	Luksemburg	1
1	Slovakya	1
1	İsveç	1
1	İsviçre	1
1	Türkiye	1
1	Birleşik Krallık	1
1	ABD	1
14	Hollanda	0,99
15	Fransa	0,98
16	Finlandiya	0,96
17	İrlanda	0,96
18	Estonya	0,94
19	Belçika	0,92
20	Portekiz	0,92
21	Macaristan	0,91
22	Japonya	0,90
23	Meksika	0,89
24	Danimarka	0,88
25	Avusturya	0,85
26	İspanya	0,85
27	Slovenya	0,84
28	Polanya	0,83
29	Yeni Zelanda	0,81
30	Letonya	0,81
31	Yunanistan	0,80
32	Şili	0,76
33	Kanada	0,75
34	Kosta Rika	0,75

35	Norweç	0,75
36	Litvanya	0,72
37	Avustralya	0,72
38	Kolombiya	0,71

Tablo 4 Malmquist İndeks değerlerini göstermektedir. Tabloda her OECD ülkesi için 2020-2021 ve 2021-2022 arası ilgili indeks değerleri verilmiştir. Bu indekste 1'den az puana sahip ülkelerin ilgili yıllar arasında etkinliğinin azaldığı, 1'den fazla puana sahip ülkelerin yine ilgili yıllar arasında etkinliğinin arttığını söyleyebiliriz. Bu kapsamda, 2020-2021 yılları arasında birçok ülkenin etkinliği artarken veya azalırken, 2021-2022 arasında Amerika Birleşik Devletleri hariç bütün OECD üye ülkeleri etkinliklerini artırmıştır. Türkiye ise hem 2020-2021, hem de 2021-2022 yılları arasında inovasyon etkinliğini artırmıştır.

Tablo 4: Malmquist İndeks Sonuçları

Ülkeler	**2020=>2021**	**2021=>2022**
Avustralya	0,97	1,14
Avusturya	0,97	1,27
Belçika	1,00	1,24
Kanada	0,97	1,05
Şili	1,12	1,19
Kolombiya	1,05	1,16
Kosta Rika	0,93	1,15
Çekya	1,15	1,06
Danimarka	0,98	1,19
Estonya	0,98	1,01
Finlandiya	0,97	1,10
Fransa	0,98	1,03
Almanya	1,03	1,08
Yunanistan	0,92	1,22
Macaristan	1,03	1,15
İzlanda	1,07	1,19
İrlanda	0,85	1,14
Israil	1,01	1,04
İtalya	0,98	1,12
Japonya	1,03	1,12

Kore	1,11	1,14
Letonya	0,95	1,15
Litvanya	0,94	1,07
Lüksemburg	0,91	1,11
Meksika	1,06	1,09
Hollanda	1,03	1,06
Yeni Zelanda	0,96	1,25
Norveç	1,05	1,16
Polonya	0,93	1,15
Portekiz	0,93	1,11
Slovakya	0,91	1,26
Slovenya	1,00	1,41
İspanya	0,94	1,08
İsveç	1,00	1,12
İsviçre	0,97	1,09
Türkiye	1,03	1,19
Birleşik Krallık	0,95	1,13
ABD	1,05	0,98

5. TARTIŞMA

İnovasyon, genel olarak bir ülkenin uluslararası rekabet gücünü, verimliliğini, üretim kapasitesini ve istihdam performansını artıran ana faktörlerden biridir (Johannessen,2009). Dolayısıyla, inovasyon bir ülkenin gelişmişlik düzeyini değerlendirmede yardımcı bir araç olarak görülebilir. Bu kapsamda bir ülkenin inovasyon verimliliği, inovasyon politikası için kritik bir faktördür (Kijek, vd.,2010). Ulusal inovasyon performansı açısından, inovasyon girdileri ve çıktıları arasındaki ilişkinin analizi, yenilik faaliyetlerinin doğru alanda yürütülmesi adına önemli bir durumdur.

Bununla birlikte, inovasyon girdileri sadece ekonomilerin ve işletmelerin büyümesine yardımcı olmakla kalmaz, aynı zamanda insanların daha iyi bir yaşam sürmelerine neden olarak yüksek üretim seviyeleri ve artan verimlilik düzeyi sağlar (INSEAD ,2009, Atkinson vd.,2012). Yaygın inancın aksine, inovasyon sadece üründe değil, aynı zamanda süreçte, organizasyonda ve çeşitli pazarlama türlerinde de meydana gelebilir (Memiş vd., 2019). Kısacası, inovasyon ekonomik büyümeyi hızlandıran bir katalizördür. İnovasyonun önemi nedeniyle, ülkeler ve şirketler bu konuda şiddetli bir rekabete girmişlerdir (Hancıoğlu, 2016).

Literatürde, bir ülke veya şirketin, bilim, teknoloji, yenilik politikaları ve yenilik girdileri aracılığıyla inovasyon faaliyetlerini harekete geçirdiğinde, üretim ve verimlilik performansının iyileşeceği belirtilmektedir. Özellikle Kİİ, ülkelerin yenilik altyapılarını geliştirmelerine ve bu altyapıları değerli yenilik çıktılarına dönüştürmelerine yardımcı olur (Rajput et al., 2012). Kİİ, dünya çapındaki ülkelerin ve ekonomilerin, birkaç temel kategoriden gelen göstergeler kullanarak ilerlemelerini takip etmelerine olanak tanır. Kısacası, Kİİ verileri, ülkelerin ulusal yenilik kapasitesinin geliştirmesine yardımcı olur (Cui et al., 2020).

Çalışmanın bulguları arasında ilginç sonuçlar yer almaktadır. Buna göre Birleşik Krallık, İsveç, İsviçre gibi bazı ülkeler 2020-2022 yılları arası her sene etkin çıkmıştır. Bununla birlikte, Kolombiya ve Şili ise inovasyon lojistik etkinlik bakımından 2020,2021 ve 2022 yıllarında son sıralarda yer almıştır. Türkiye ise 2020 senesinde 22. sırada iken 2021 ve 2022 senelerinde tam etkin olarak bulunmuştur. Türkiye'nin bu durumu 2020 yılında iyice ortaya çıkan Covid-19 pandemisinin neden olduğu tedarik zincirindeki kesintiler ile açıklanabilir. Fakat, ülkemiz inovasyon etkinliği bakımından 2021 ve 2022 yıllarında oldukça iyi performans göstererek en etkin ülkeler arasında yer almıştır. Malmquist İndeks sonuçları da Türkiye'nin artan performansına işaret etmektedir. Buna göre Türkiye, 2020-2021 ve 2021-2022 yılları arasında artan etkinliğe sahiptir. Türkiye'nin inovasyon etkinliği bağlamından yükselen bu grafiği koruması için analizde kullanılan girdilere ve çıktılara dikkat etmesi gerekir. Bu kapsamda Kİİ'nin ana kriterleri ve alt kriterleri olan, kurumların performansı (politik ortam, iş ortamı), beşeri sermaye ve araştırma (eğitim, yüksek öğretim, AR-GE), altyapı (bilgi ve iletişim teknolojileri, genel altyapı, ekonomik sürdürülebilirlik), pazar gelişmişliği (kredi, yatırım, ticaret ve rekabet), iş gelişmişliği (kalifiye işçi, yenilik bağlantıları, bilgi emilimi), bilgi ve teknoloji çıktısı (bilgi üretme, bilgi etkisi, bilgi yayılması), inovatif çıktı (inovatif mal ve hizmetler, internet üzerinden inovasyon) gibi hususlara önem vermesi gerekir. Araştırmanın bulguları literatür ile aynı bağlamdadır (Altıntaş, 2020; Duran ve Soydan, 2022).

6.SONUÇ

İnovasyon günümüz iş, politika ve akademik çevrelerinin en çok tartıştığı konulardan biridir. Yüksek rekabet, bileşenleşme ve ürün ve hizmetlerin emtialaşması nedeniyle inovasyon kurum, sektör ve ülkeler için çıkış yolu olarak görülmektedir. (Baykal, 2007). Her ülke, küreselleşmiş dünyadaki ekonomik büyümeden en büyük payı almayı, aynı zamanda kendi rekabet gücünü de en üst seviyeye çıkarmayı hedefler. Bu süreçte, iç ve dış dinamiklerini kısa, orta ve uzun vadede olumsuz etkilemeden sürdürmeyi amaçlar.

Bu çalışmada, KİI verileri ile etkinlik analizi yapılmıştır. KİI'nin "kurumlar", "beşeri sermaye ve araştırma", "altyapı", "piyasaların gelişmişliği" ve "ticari gelişmişlik" faktörleri girdi olarak, "bilimsel çıktılar" ve "yaratıcı çıktılar" faktörleri ise çıktı olarak düşünülmüştür. Araştırmada, dünya ekonomisinde önemli bir paya sahip olmaları nedeniyle Ekonomik Kalkınma ve İşbirliği Örgütü (OECD) üye ülkeleri örneklem olarak seçilmiştir. Çalışmada, Veri Zarflama Analizi (VZA) ile 2020, 2021 ve 2022 KİI verileri kullanılarak ilgili ülkelerin inovasyon etkinlikleri her bir yıl için hesaplanmıştır. Aynı zamanda Malmquist İndeksi(Mİ) yöntemi ile de ülkelerin yıllar arasındaki etkinlik değişimleri incelenmiştir. VZA'nın tercih edilmesinin nedeni, karar birimi etkinliğini analiz etmesi, etkisiz olanlar için önerilerde bulunması, değişken ve sabit ölçekli getirilere izin vermesidir (Aldamak, vd.,2017, Rakhshan, 2017). Bu araştırmada etkin ve etkin olmayan tüm OECD ülkeleri sıralanmıştır. Ayrıca, araştırmada Türkiye'nin inovasyon etkinliği ve Mİ değerleri üzerinde durulmuştur. Bu çalışma, literatürde ilgili indeksi VZA yöntemini kullanarak inovasyon etkinliğini inceleyen ender çalışmalardan biridir. Ancak çalışmanın bazı sınırlamaları bulunmaktadır. Analiz için sadece üç yıllık veriler ile birlikte OECD'ye üye ülkeler göz önünde bulundurulmuştur. İlerleyen çalışmalarda daha fazla yıla ait veriler ile birlikte G-20'ye üye ülkelerde analize dahil edilebilir.

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BÖLÜM 2

Sürdürülebilirlik Kriterlerinin Yatırım Kararlarına Etkisi: Moora Modeli ile Banka Seçimi

Hüseyin Şenkayas[1] & Zeynep Aydın İncioğlu[2]

[1] Prof.Dr., Aydın Adnan Menderes Üniversitesi Nazilli İİBF, ORCID No: 0000-0002-9533-9853
[2] Aydın Adnan Menderes Üniversitesi İşletme Doktora Öğrencisi, ORCID No: 0000-0002-3358-0000

Giriş

Mevcut doğal kaynakların çeşitli endüstriler ve bireyler tarafından hızla kullanılması, küresel ısınmayı ciddi bir oranda arttırmaktadır. Bu oranı azaltmak için, Avrupa'daki çoğu hükümet çeşitli politikalarla birlikte endüstrilerden iklim değişikliği ve çevresel sorunlarla ilgili karbon ayak izlerini azaltmalarını talep etmektedir. Talep doğrultusunda endüstriler, karbon emisyonlarını azaltmak için paketlemelerinde geri dönüştürülebilir kâğıt, su tüketimini azaltmak için yenilebilir enerji ve doğal gaz hatta biyoplastikler kullanmaya başladı. Bu süreçle birlikte akıllı bir üretim süreci (katmanlı üretim olarak da adlandırılan) olan Endüstri 4.0 daha popüler bir hal almıştır. Geleneksel üretim süreciyle karşılaştırıldığında Endüstri 4.0, üç boyutlu bileşenlerin daha sürdürülebilir şekilde katman katman malzeme eklenerek üretim yapan ve aynı zamanda, atıkları azaltarak ve kaynakları verimli kullanarak karbon ayak izini azaltma potansiyeline sahip birçok endüstri tarafından kullanılan bir süreçtir. Ekonomik açıdan bakıldığında geleneksel üretime göre, azalan işletme maliyeti, üretim adımları ve üretim süresi daha yüksek seviyede kaynak verimliliği sağlamaktadır.

Çok kriterli karar verme (ÇKKV), kriterlerin çatıştığı karmaşık problemler için kullanılan bir yöntemdir. Bu karar verme hem nitel hem de nicel faktörler üzerinde olabilir. Karar verme teknikleri, sorunları uygun bir çerçevede düzenlemeye ve en uygun çözümü bulmak için karşılaştırmaya yardımcı olur. Bu çalışmada da gelecek nesillerin taleplerini bir ölçüde karşılayabilmek için mevcut kaynakları daha az etkileyerek üretimi veya hizmeti yerine getiren şirketleri tespit etmek amaçlanmıştır. Bir imalat sanayi sürekli olarak mevcut kaynakları verimsiz kullanırsa, gelecekte imalat talebi karşılanamaz. Endüstri 4.0 en yeni üretim teknolojisi olduğundan, kaynağı 4.0 ürünler için üretim veya imalatta kullanmak, sürdürülebilirliği sağlamak için uygun faktörlere ve süreçlere ihtiyaç duyacaktır. Sürdürülebilirliğin bu objektif sayılabilecek kriterleri (faktörleri) Kamuyu Aydınlatma Platformundan (Kap.gov.tr) alınmış olup kriterleri en iyi şekilde sağlayan şirketler sıralanmıştır.

Çalışmada amaç edinilen bir diğer husus da tüketim kültürünün giderek arttığı günümüz koşullarında doğal kaynak kullanımının çevreye etkisine değinmek ve farkındalık sağlamaktır. Kaçınılmaz olarak hemen hemen her işletmede kullanılan kaynaklar sıfırlanamasa dahi, enerji tasarrufu sağlayarak veya çalışanlar arasındaki sosyal sürdürülebilirliğe önem vererek kaynakların tükenmesini geciktirilebilir. Bu açıdan bakacak olursak, bankalar ihtiyaç sahiplerine veya şirketlere kredi verirken kişisel sürdürülebilirliğe (hane içi elektrik, su tüketimi gibi) ekonomik açıdan bakabilecekleri gibi, ihtiyaç sahipleri veya şirketler de kredi kullanacakları zaman sürdürülebilirliğe önem veren ve en iyi uygulayan şirketlere başvurabilir. Sürdürülebilirliğe tüketici bakış açısıyla yaklaşan bu makalede seçilen bankaların sürdürülebilirlik raporları incelenmiş ve veriler nicel araştırma ile sıralanmıştır.

Literatür Taraması

Şirketler bazında sürdürülebilirliğin kullanımı ile ilgili çalışmalarda nitel araştırmaların yanı sıra nicel araştırma yöntemleri de ele alınmıştır. Daha çok nitel araştırma yöntemlerinin kullanılmış olduğu çalışmaların aksine yapılan bu çalışmada, tüketicilerin günlük hayatta dahi kullanabileceği ve sosyal olguları inceleyen ve de bu olgular arasında istatistiksel çözümler üretebilen nicel araştırma yöntemlerinden ve aynı zamanda çok kriterli karar verme tekniği olan MOORA yöntemi tercih edilmiştir. Bu yöntemin tercih edilmesindeki en büyük etken de verilere objektif olarak yaklaşılması ve tüketici bakış açısıyla yaklaşmaya olanak sağlamasıdır.

Ali, vd. (2019), çalışmalarında Irak Menkul Kıymetler Borsası'nda işlem gören bankalara ve sanayi sektörlerine uygulanan GRI göstergelerine göre sürdürülebilirlik raporlamasının yatırımcıların ekonomik kararlarındaki etkisini incelemeyi amaçlamaktadır. Sonuç olarak sürdürülebilirlik raporlamasının yatırımcıların ekonomik kararları üzerinde istatistiksel olarak anlamlı bir etkisinin olmadığı kanıtlanmıştır.

Sürdürülebilir finans ve yatırım kararları, uzun dönemli küresel sürdürülebilirliği hedefleyen stratejileri ele alarak, ölçülebilir kaynaklar ve yatırımlarla sürdürülebilir projeler, çözümler ve inovasyonlar sağlar. Finansal kuruluşlardan olan bankalar, özellikle motive girişimcilere ve kredi verilebilir müşterilere uygun finansal imkanlar sunar. Faiz oranları ve sözleşme koşullarını sürdürülebilirlik kriterlerine göre farklılaştırabilir, inovatif, sürdürülebilir finansal ürün ve hizmetler geliştirebilir. (Cunha, vd, 2021)

Thomas, vd. (2020), tedarikçi seçimi üzerindeki sürdürülebilirlik etkilerini belirlemek için sosyal sürdürülebilirliği çalışan refahı ve hayırseverlik boyutlarına ayırmışlardır. Sonuç olarak alıcıların arzu edilen düzeyde çalışan refahı, hayırseverlik ve fiyatlandırmaya sahip tedarikçileri seçme, güvenme ve onlarla iş birliği yapma konusunda önemli tercihlere sahip olduğunu göstermiştir.

Agrawal ve Singh (2019), tersine lojistiği Hindistan elektronik endüstrisi bağlamında araştırmak ve tasarruf kararlarının Üçlü Sonuç Çizgisi (TBL) yani tersine lojistiğin ekonomik, çevresel ve sosyal performansı üzerindeki etkisini incelemeyi amaçlamıştır. Sonuç olarak, kısmi en küçük kareler modellemesi yapılarak, eğilim kararlarının etkinliği ile TBL performansı arasında pozitif yönde ilişki olduğu belirlenmiştir.

Trude (2018), son 20 yıldaki araştırmaları özetlemiş ve sürdürülebilir tüketici davranışının psikolojik etmenlerini araştırmıştır. Araştırma gündemlerine hâkim olan dört bilimsel araştırma alanı tanımlanmıştır: (a) bilişsel engeller, (b) benlik, (c) sosyal etki ve (d) ürün özellikleri. Çalışmanın amacı, sürdürülebilir tüketici davranışı alanında ek araştırmaları teşvik eden bir araştırma aracı sağlamaktır.

Taleizadeh, vd. (2019), çok dönemli çok kademeli sürdürülebilir kapalı döngü tedarik zincirinin planlama problemini araştırmaktadır. Vaka çalışmasına ilişkin duyarlılık analizlerinin sonuçları, indirim teklifinin kullanılmış ürünlerin toplanma oranını önemli ölçüde iyileştirdiğini ve bunun da sürdürülebilirliğin iyileştirilmesine yardımcı olduğunu göstermektedir.

Bemmann ve Hussmann (2020), sürdürülebilir tüketimi destekleyen BİT araştırmalarının durumunu incelemekte, çözülmemiş zorlukların ana hatlarını çizmekte ve son olarak yeni bir konsept olarak tavsiye sistemleri gibi klasik ikna edici yaklaşımlar yerine öz-düşünceye dayalı bir sistem önermektedirler. İklim değişikliğiyle mücadele etmek için daha sürdürülebilir endüstrilere doğru bir değişimi teşvik eden böyle bir sistemin konuşlandırılmasını tasavvur etmektedirler.

Rohmer, vd. (2019), küresel gıda sisteminde sürdürülebilirlik konularını ele alan bir ağ tasarım probleminin yeni bir uygulaması üzerine çalışmışlardır. Problem, doğrusal programlamaya dayalı olarak formüle edilip, ϵ-kısıtlama yöntemi ve uyumlu programlama uygulanarak analiz yapılmıştır. Alternatif üretim ve tüketim senaryolarının yanı sıra çelişen hedefler arasındaki dengeleri araştıran çalışmada, bir beslenme vaka çalışmasına dayalı olarak gösterilmektedir ve gerçek hayattaki LCA verileriyle desteklenmektedir.

Niu, vd. (2019), çalışmada tedarik dış kaynak kullanımı yoluyla ekonomik sürdürülebilirliği (artan talep ve karlar nedeniyle) ve çevresel sürdürülebilirliği (düşük talep ve kaynak tüketimi nedeniyle) koordine etmektedir. Sonuç olarak, çevresel sürdürülebilirlik anlamında, ekonomik sürdürülebilirliği sağlama önceliği nedeniyle ekonomik ve çevresel sürdürülebilirlik arasında bir teşvik çatışması olduğunu bulmuşlardır.

Costanza (2020), sürdürülebilir sistemler bağlamında verimlilik, adalet ve sürdürülebilirlik hedeflerine yönelik olarak doğal sermaye ve ekosistem hizmetleri'nin anlaşılmasını, değerlendirilmesini geliştirmeye yönelik bir gündemi tartışmaktadır.

Khosroshah, vd. (2018), şeffaflığın talep fonksiyonu üzerindeki etkisini ele almakta ve şeffaflık ile kurumsal sosyal sorumluluğun bir tedarik zinciri üyelerinin kararları ve yeşil ve sürdürülebilir ürün için elde ettikleri kazançlar üzerindeki etkisini araştırmaktadır. Çalışmanın katkısı ise, bir üreticinin şeffaflığının tedarik zinciri üyelerinin kârları ve müşteri memnuniyeti üzerindeki etkisini dikkate almaktır.

Basset ve Muhammed (2020), çalışmalarındaki amaç sürdürülebilir tedarik zinciri risk yönetiminin tahminidir. Çalışmanın metodolojisi, İdeal Çözüme Benzerliğe Göre Tercih Sırasına Göre Tekniğe (TOPSIS) ve Kriterler Arası Korelasyon Yoluyla Kriter Önemi (CRITIC) yöntemlerine dayanan çok kriterli karar verme yaklaşımının bir kombinasyonudur.

Markovic vd. (2020), bütünleşik sübjektif-objektif modeli, bankaları sürdürülebilirliğin sosyal yönünü geliştirmede önemli bir faktör olarak ele almak ve değerlendirmek için dar bir coğrafi alanda uygulamıştır. Bu çalışmanın amacı doğrultusunda, hâlihazırda yabancı sermayenin baskın paya sahip olduğu sekiz bankanın faaliyet gösterdiği RS bankacılık sektörü analiz edilmiştir. Bankaların iş performansları, sıralama kriterlerini de temsil eden, bankaların performansının en önemli dört yönü üzerinden ölçülmüştür: likidite, verimlilik, karlılık ve ödeme gücü. En iyi olarak sıralanan bankalar, yüksek faiz maliyetleri ödemedikleri sağlam sermaye kaynaklarına sahip bankalardır ve bulundukları piyasa göz önüne alındığında, önemli faiz gelirleri elde edebilmekte ve böylece karlılık ve verimlilik açısından olağanüstü sonuçlar göstermektedirler.

Nosratabadi (2020), Delphi-Analitik Hiyerarşi Süreci yöntemini kullanarak, ilk olarak bankaların iş modelinin sürdürülebilirliğini değerlendirmek için sürdürülebilir bir iş modeli geliştirmiştir. İkinci aşamada, Norveç, Birleşik Krallık, Polonya, Macaristan, Almanya, Fransa, İspanya ve İtalya olmak üzere sekiz Avrupa ülkesinden on altı bankanın sürdürülebilirlik performansı değerlendirilmiştir. Bu çalışmada önerilen iş modeli bileşenleri, sürdürülebilirlik hedeflerine ulaşma üzerindeki etkileri açısından sıralanmıştır. Sonuç olarak, bu çalışmada önerilen model bileşenleri, sürdürülebilirlik üzerindeki etkilerine göre sırasıyla değer önerisi, temel yetkinlikler, finansal unsurlar, iş süreçleri, hedef müşteriler, kaynaklar, teknoloji, müşteri arayüzü ve iş ortağı ağıdır.

Bankaların sürdürülebilirlik yolunda ilerlemeleri için üç genel yaklaşım vardır. (Nosratabadi, 2020)

1. İlk yaklaşımda, kurumsal sosyal sorumluluk sürdürülebilir bankacılığa giden bir yol olarak değerlendirilmektedir.

2. İkinci yaklaşımda bankalar, çevre üzerindeki zararlı etkileri doğrudan azaltan, karbon emisyonlarını hafifleten ve iklimi koruyan faaliyetler yürütmeye teşvik edilmektedir.
3. Bankaların sürdürülebilirlik hedeflerine ulaşması için literatürdeki üçüncü yaklaşım ve eğilim ise sürdürülebilir kalkınmaya katkı sağlayacak ürünler sunmaktır.

Yüksel vd. (2017), çalışmalarında Türk bankacılık sektöründe finansal performansı ölçmek ve veri madenciliği ile çok kriterli karar verme yöntemlerini birleştirmeyi amaçlamıştır. Öncelikle, kriterlerin ikili karşılaştırmasını ölçmek için bir metin madenciliği süreci uygulanmış ve sonuçlar entegre modellerde kullanılmıştır. DEMATEL-GRA ve DEMATEL-MOORA iki entegre model olarak tanımlanmıştır. Sonuçlar, entegre modellerin tutarlı sonuçlar verdiğini ve metin madenciliği sürecinin çok kriterli karar verme yöntemlerine uygun şekilde uyarlanabileceğini göstermektedir. Ayrıca, yabancı bankaların kamu ve özel bankalara kıyasla daha iyi performansa sahip olduğu sonucuna varılmıştır.

MOORA Yöntemi Kuramsal Çerçeve

MOORA yöntemi Brauers ve Zavadskas (2006) tarafından çok kriterli karar verme metotları arasına girmiştir. Yöntemde çözümleme, farklı seçeneklerin gruplandırılması ile gerçekleştirilir. (Brauers ve Zavadskas, 2006, s.445-469). Yöntemin başlangıcında oluşturulan matriste (x_{ij}) seçenekler satırları ve kriterler sütunları oluşturur (Kracka, vd., 2010, s.352; Önay, 2014, s.246).

$$X_{ij}= \begin{pmatrix} X_{11} & X_{12} & X_{1n} \\ X_{21} & X_{22} & X_{2n} \\ X_{m1} & X_{m2} & X_{mn} \end{pmatrix}$$

x_{ij} = i. niteliğin/amacın j. seçeneğe tepkisi

i = 1, 2, 3, …, n (kriterlerin sayısı)

j = 1, 2, 3, …, m (alternatiflerin sayısı)

MOORA metodu üç farklı bölümden oluşur: ilki oran yaklaşımı, bir diğeri referans noktası yaklaşımı ve son olarak amaçların önem değeri verildiği yaklaşımdır. Ancak uygulama bölümünde referans noktası yaklaşımı ve oran yaklaşımı kullanıldığından dolayı bu iki bölüme değinilmiştir.

a. Oran Yaklaşımı

Oran yaklaşımında, satırlarda alternatiflerin (seçenekler) ve sütunlarda kriterlerin bulunduğu matris şeklinde, verilerin yazılması ile başlar ve şu şekilde devam eder (Özcan ve Ömürbek, 2016:67) ;

Mevcut alternatiflerin sayısı $i = 1, 2, .., m$ ve kriter sayısı $j = 1, 2, \ldots, n$ olarak belirtilir. Normalizasyon yapmak için alternatiflerin her birinin karelerinin toplamının karekökü alınır ve bunlar kriterlere bölünür. Bu işlem,

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^{2}}} \qquad 1$$

formülü ile hesaplanır. x_{ij}^{*}; *i.* alternatifinin *j.* kriterinin normalleşmiş değeridir.

Öncelikle normalizasyon işlemi yapılarak sonra tablo oluşturulur. Bu tabloda yer alan ölçütler, maksimum ya da minimum değerlerine göre belirlenip toplanmaktadır. Maksimum kriterlerin değerinden minimum kriterlerin toplam değeri çıkarılır.

Bir diğer deyişle, maksimizasyon gerçekleştirilecek ölçütle $j = 1, 2, g$ olarak ve minimizasyon gerçekleştirilecek ölçütler de $j = g+1, g+2, \ldots, n$ olarak şu şekilde gösterilir:

$$y_{i}^{*} = \sum_{j=1}^{g} x_{ij}^{*} - \sum_{j=g+1}^{n} x_{ij}^{*} \qquad 2$$

Kriter ağırlıkları bazen farklılaştığında, w_j *j* kriterinin ağırlığı (önem derecesi) olacak şekilde hesaplama aşağıdaki denklem yardımı ile yapılır:

$$y_{i}^{*} = \sum_{j=1}^{g} w_j x_{ij}^{*} - \sum_{j=g+1}^{n} w_j x_{ij}^{*} \qquad 3$$

Bütün kriterlere göre *i* alternatifinin normalleştirilmiş değerlendirilmesi y_i^{*} değeridir. y_i^{*}'lerin sıralanmasıyla oran yaklaşımı sona erer. (Özcan ve Ömürbek, 2016:67)

b. Referans Noktası Yaklaşımı

Referans noktasında, oran metoduna ek işlem olarak her kriter için; amaç maksimizasyonsa maksimum noktalar, amaç minimizasyonsa minimum noktalardan oluşan, her biri için referans noktaları (r_j ler) tespit edilir. Belirlenen bu noktaların, her x_{ij}^{*} ile uzaklıkları bulunur. Hesaplamalar aşağıdaki gibi yazılarak matris halinde yazılır:

$$r_j - x_{ij}^{*} \quad (4)$$

Burada; alternatiflerin mevcut sayıları için $i = 1, 2, \ldots, m$; kriterlerin sayısı için $j = 1, 2, \ldots, n$; i. alternatifin j. kriterindeki normalleştirilmiş değeri için x_{ij}^{*}; j. kriterinin referans noktası için r_j, kullanılmaktadır (Yıldırım ve Önder, 2015:248).

Bu şekilde ortaya çıkan matris için, "*Tchebycheff Min-Max*" metrik işlemi uygulanmaktadır:

$$min_i \left\{ maks_j \left(\left| r_j - x_{ij}^{*} \right| \right) \right\} \quad (5)$$

Daha sonra her bir alternatifte bulunan maksimum değerler seçilerek sıralanmaktadır. Bu şekilde sıralama referans noktasına göre gerçekleştirilir. (Özcan ve Ömürbek, 2016:68)

Uygulama

MOORA metodunun kullanıldığı uygulamada 7 sürdürülebilirlik kriteri ve seçime konu olan 4 banka arasında sürdürülebilirliğe en uygun bankayı seçmek amaçlanmıştır. Kriter olarak; Su tüketimi, Enerji Tüketimi, Firmada Çalışan Genç Personel yaş ortalaması, Sera gazı (emisyon) derecesi ve Kâğıt tüketimi minimizasyonda kullanılan kriterleri oluşturmakta, Sürdürülebilirlik yatırımı ve CDP İklim Değişikliği Notu maksimizasyon olarak seçilmiştir. CDP iklim değişikliği notlarının sayısal verilere uygun hale gelebilmesi için puanlama da A+=8, A-=7, B+=6, B-=5, C+=4, C-=3, D+=2, D-=1 olarak belirlenmiştir. Belirlenen kriterler ışığında Excel'de hesaplanan veriler matriste karşılık gelen yere Tablo 1 de ki gibi yerleştirilmiştir.

Tablo 1: Bankalara Ait Karar Matrisi

	Su Tüketimi m3	Enerji Tüketimi Gj	Çalışan Genç İnsan Yaş Ortalama	Sürdürülebilirlik Yatırımı (Milyon TL)	CDP İklim Değişikliği Değerlendirme Notu	Sera Gazı CO2e	Kâğıt Tüketimi (Ton)
İş Bankası	32.252	657.908	38	350	7	23.400	27
Garanti	30.548	1.044.989	40	500	8	22.000	10
Akbank	144.450	511.568	42	200	5	52.656	56
Albaraka	46.863	13.807	36,8	553	5	107.116,40	124

Tablo 1'de bankaların kap.gov.tr den alınan sürdürülebilirlik raporlarındaki veriler tabloya yerleştirilmiş ve karar matrisi elde edildikten sonra, ilk olarak oran metodu, daha sonra ise referans metodu kullanılarak değerlendirme yapılmıştır.

a. Oran metodu ile değerlendirme

Tablo 1 de oluşturulan karar matrisi eşitlik 1 ve sonra da eşitlik 2 ile işleme tabi tutulmuş her bir bankanın y_i^* değerlerine ulaşılarak sıralama yapılmıştır. Tablo 2' de normalize karar matrisi gösterilmiştir.

Tablo 2: Normalize Karar Matrisi ve Oran Metodu Sıralaması

NORMALİZE MATRİS	**MİN**	**MİN**	**MİN**	**MAKS**	**MAKS**	**MİN**	**MİN**		
	Su Tüketimi	**Enerji Tüketimi**	**Çalışan Genç İnsan Yaş Ortalaması**	**Sürdürülebilirlik Yatırımı (Milyon TL)**	**CDP İklim Değişikliği Değerlendirme Notu**	**Sera Gazı Derecesi**	**Kâğıt Tüketimi (Ton)**	* Yİ	**Oran metodu sıralama**
İş Bankası	0,20383564	0,49219228	0,484076826	0,412964187	0,5482823	0,1893131	0,1941441	-0,60232	**2**
Garanti	0,193066201	0,78177423	0,509554554	0,589948838	0,6266083	0,1779867	0,0719052	-0,51773	**1**
Akbank	0,912937434	0,38271281	0,535032281	0,235979535	0,3916302	0,426003	0,4026693	-2,03175	**4**
Albaraka	0,296178518	0,01032925	0,468790189	0,652483415	0,3916302	0,8666041	0,8916249	-1,48941	**3**

Oluşturulan karar matrisinden sonra Tablo 2'de Maksimum olması ve Minimum olması istenen kriterler belirlenmiş ve ardından normalizasyon işlemi yapılıp oran metoduna göre bankaların sıralaması yapılmıştır.

b. Referans noktası yaklaşımı ile değerlendirme

Referans noktası yaklaşımı ile değerlendirme yaparken oluşturulan karar matrisi öncelikle eşitlik 1 ile normalize değerlere ulaşılmış, daha sonra da eşitlik 4 ile referans noktaları belirlenmiştir. Sıralamanın belirlenmesi için de eşitlik 5'ten yararlanılmış ve y_i^* değerlerine ulaşılmıştır. Tablo 3' de Normalize değerler ve referans noktasına göre sıralama yapılmıştır.

Tablo 3: Normalize Değerler ve Referans Noktası Yaklaşımı Sıralaması

	Su Tüketimi	**Enerji Tüketimi**	**Çalışan Genç İnsan Yaş Ortalaması**	**Sürdürülebilirlik Yatırımı (Milyon TL)**	**CDP İklim Değişikliği Değerlendirme Notu**	**Sera Gazı Derecesi**	**Kâğıt Tüketimi (Ton)**	**MAKS-LAR**	**Referans Nok. Yak. Sıralama**
İş Bankası	0,0107	0,4818	0,0152	0,2395	0,0783	0,0113	0,1222	0,4818	**1**
Garanti	0	0,7714	0,0407	0,0625	0	0	0	0,7714	**3**
Akbank	0,7198	0,3723	0,0662	0,4165	0,2349	0,2480	0,3307	0,7198	**2**
Albaraka	0,1031	0	0	0	0,2349	0,6886	0,8197	0,8197	**4**

Tablo 3'de Oran Metodu ile sıralama yapmadan önce oluşturulan karar matrisi kullanılıp yine aynı maksimum ve minimum kriterlerle Referans Noktası yaklaşımına göre sıralama yapılmıştır.

Oluşturulan matrisler ve yapılan sıralamalara göre Oran Metodu ve Referans Noktası yaklaşımı arasında farklılıklar görülmüştür. Bu farklılıkları daha iyi görebilmek için iki yöntemin karşılaştırma tablosu Tablo 4' de gösterilmiştir.

Tablo 4: Oran Metodu ve Referans Noktası Yaklaşımı Sıralamalarının Karşılaştırılması

Bankalar	**Oran Metodu**	**Referans Noktası Yaklaşımı**
İş Bankası	2	1
Garanti	1	3
Akbank	4	2
Albaraka	3	4

Oran metodu ve Referans noktası yaklaşımının karşılaştırıldığı Tablo 4'de Garanti bankası Oran metoduna göre sürdürülebilirliği en iyi banka iken Referans noktası yaklaşımına göre 3. sıradadır. İş bankası da Referans noktası yaklaşımına göre sürdürülebilirliği en iyi kullan banka iken oran metoduna göre 2. Sırada yer almaktadır.

Sonuç ve Öneriler

Çalışmada, BİST'te yer alan beş adet bankanın sürdürülebilirlik yaklaşımına göre en iyi alternatifini belirlemek amacıyla ÇKKV yöntemlerinden biri olan MOORA yöntemi ile uygulaması yapılmıştır. 7 kriter açısından 5 bankanın kıyaslanması sonucunda MOORA yönteminin oran metoduna göre sürdürülebilirliğe en uygun banka Garanti bankası iken, uygun olmayan banka ise Akbank olarak ortaya çıkmıştır. Referans noktası yaklaşımına göre ise en uygun banka İş Bankası iken, uygun olmayan banka Albaraka'dır.

Sürdürülebilirliğin gün geçtikçe önem kazanması ile birlikte şirketlerin yanı sıra bireyler de sürdürülebilirliği en iyi kullanan firmalara yatırım yapmak, hatta alış-verişlerini dahi o firmalardan yapmak istemektedirler. Bu çalışmada olduğu gibi seçenekler arasında kararsız kalındığında uygulanabilecek karar verme modeli, işletmelerin veya bireylerin karşı karşıya kaldığı diğer karar problemlerinin çözümlerinde de kullanılabilir. ÇKKV yöntemlerinin finansal ve yatırım kararlarında kullanılması öznelliği en aza indirmekte ve daha nesnel kararların alınmasına da ayrıca katkı sağlamaktadır.

Bu alanda yapılacak olan çalışmalarda, sürdürülebilirlik sektörel bazda değerlendirilebilir, bunun yanı sıra aynı veya farklı sektördeki ulusal ya da uluslararası işletmelerin sürdürülebilirlik performansları Çok Kriterli Karar Verme yöntemleri yardımıyla belirlenebilir ve firmalar arasında kıyaslama yapılabilir. Literatür incelendiğinde de MOORA metodunu yapılan diğer araştırmalarda, yapılan bu çalışmadaki bakış açısının daha önce kullanılmadığı saptanmıştır. İşletme bölümü olarak her ne kadar çoğunlukla şirketlerin bakış açısıyla araştırmalara başlanıp ekonomik refah ve canlılık hedeflense de tüketici bakış açısıyla bakmak da bir o kadar önemlidir. Çünkü bir tüketicinin bakış açısını anlayabilmek ve o yönden bakmak diğer on tüketiciyi kazanmak anlamına da gelebilmektedir.

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BÖLÜM 3

New Disruptive Technologies in the Supply Chain Context: Implementations during the COVID-19 Period and Critical Points for Their Achievements*

Özden Özkanlısoy[1]

* This book chapter is derived from Özden Özkanlısoy's doctoral dissertation titled *"The Mediating Role of Supply Chain Visibility on The Relationship Between Using Disruptive Technology and Supply Chain Performance"*, carried out at Yeditepe University, Graduate School of Social Sciences, International Trade and Logistics Management Ph.D. program with her supervisor Prof. Dr. Füsun Bulutlar.

[1] Ph.D., Independent Researcher

1. Introduction

The concept of disruptive technology (DT) was first discussed by Harvard Business School faculty member Professor Clayton Christensen in his book "*The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (1997)*". The book attracted much attention at the time of its publication and sold more than 200000 copies in the first three years. Christensen was considered a "*guru*" by the business community in that period (Scherreik, 2000). His work has also been cited in many disciplines and fields (Danneels, 2004, p. 246). Christensen's study elaborated on the issue of old technologies rapidly disappearing or vanishing as novel technologies emerge after a while (Liu et al., 2020, p. 315). He initially mentioned the phrase DT and then comprehensively explained disruptive innovation (DI) in his study (Dru, 2015, p. 171).

Christensen's destructive and revolutionary thought is based on the concept of "*creative destruction*" (Schumpeter, 2010, p. 83). That concept was put forward by Joseph Schumpeter, an economist deeply interested in the dynamic development and future of capitalism, in his book "*Capitalism, Socialism, and Democracy*" in 1942 (Schneider, 2017, p. 64). He argued that the achievement of capitalism was associated with creating the circumstances that allowed entrepreneurs to arise. Creative destruction is described as disrupting the market equilibrium and attaining a new equilibrium with technology development (Schumpeter & Swedberg, 2021). Furthermore, it is the introduction of these new technologies into the production process by organisations that produce novel and better products, eliminating old products and the organisations that make them and disseminating new ones (Montgomery & Wascher, 1988, p. 168). It also means that old structures are replaced by new structures, and successful innovations constantly constitute novel ones while the old ones vanish, and in this direction, industrial change that radically alters the economic structure takes place (Kiessling, 2004, p. 84). In this context, when the concept of DT is examined, it is obvious that its theoretical background is based on the concept of creative destruction.

Disruptive is "*the interruption or disruption of the orderly progress of an event, process, or activity*". Besides, this concept signifies a considerable alteration in structure (Lele, 2019, pp. 31-33). DTs first outperform settled ones in attending to the mainstream market, then replace established technologies. These initially underperforming technologies are continually improved and outperform previous technologies over time (Christensen, 2000, p. 11). In later studies, different views emerged from those of Christensen, who introduced the concept of DT. Another study argued that the assumption that the performance of DTs always starts below and exceeds that of legacy technology is incorrect. According to this study, there can be irregular jumps in the performance of DT (Tellis, 2006, p. 36). In this study, the assumptions of Christensen's theory are considered.

DTs, a type of technological alteration, execute through a determined mechanism and yield determined outcomes. Moreover, they are technologies that change the basis of competition. They perform this regarding the changing performance metrics of the companies (Danneels, 2004, p. 247). DTs influence the competitive market area, the market position of the dominant technology, and who controls the market remarkably. They are technologies that eliminate the systems or technologies they replace, generate new markets and implementations that did not exist before, or change the dominant players in existing markets thanks to their superior characteristics (Madry, 2020, p.4). It should be noted that technological change is not the only factor necessary for the success or survival of companies (Tellis, 2006, p. 38). While utilising these technologies is a threat to the companies in the industry, it is an opportunity for those who have just started to implement them (Danneels, 2004, p. 247). Therefore, companies and their supply chains (SCs) must have information about DTs.

DTs have some specific features. The service and product structures they generate have positively changed compared to traditional methods in terms of their features (Charitou & Markides, 2003, p. 56). These technologies first expand to small markets and then to mass markets. Products generated with DT expand the existing product markets. Moreover, they enable opportunities for novel goods markets. They have a proactive, high-risk- high payoff. However, they provide crucial long-term contributions as well as ensuring revolutionary change in the executive of activities (Kostoff et al., 2004, pp. 143-144). Their prices are moderately greater than those of current technologies for first utilisation. The prices lessen when they expand to mass markets. Their use makes some operations more straightforward to perform, and their contributions ensure easy adoption by clients (Christensen & Euchner, 2011, p. 12). When DTs are accomplished, they decrease the profits and market share of large-settled firms in the upper segment. A few years after their success, they take over the market (Christensen et al., 2015, pp. 7-8). DTs impact infrastructure, end users, and market leaders. Their effects in these fields are accepted as three disruptive impacts. The technologies can be benchmarked through these effects regarding their disruptiveness. A technology with these three effects simultaneously is considered the technology with the highest disruptive effect (Hardman et al., 2013, p. 15439). This is a significant issue for SCs and companies so that managers can select the technology and make accurate decisions (Christensen & Euchner, 2011, p. 12).

DTs focus on new and revolutionary technologies (Tushman & Anderson, 2018, p. 346). Therefore, the technologies with a disruptive effect differ according to the current period (Schwab & Davis, 2018, p. 60). Today's DTs are the technologies that the Fourth Industrial Revolution (4IR) offers, also called 4IR technologies or emerging technologies. 4IR has many DTs to offer (Manyika et al., 2013). DTs have made and proceeded to make contributions to SCs dramatically (Ben-Daya et al., 2019, p. 4720). For companies to exist in today's global vying environment, they need to follow existing technological advancements, extant innovations and trends, research DTs and innovations and invest in them (Katsamakas & Georgantzas, 2010, p. 218). For this reason, comprehending the latest trends in utilising DTs to give form to the world is necessary (Bali et al., 2021).

When the concept of DI is investigated, it is comprehended that it was derived from the concept of DT and is defined as the business model offered by these technologies (Christensen et al., 2009, p. 2; Johnson et al., 2008, p. 64). The concept of creative destruction reveals the potential effects of DI. It is a product or service designed for a new customer group. It also refers to the process by which a product or service initially takes root in simple implementations at the lower end of the market and then relentlessly moves upmarket, eventually displacing established competitors (Christensen, 2000, p. 15). The concept of innovation was first used by Joseph Schumpeter, who introduced the concept of creative destruction (Schumpeter, 2010, p. 83). Clayton Christensen not only learned how creative destruction works but also revealed what companies and managers can do to trigger and manage it by introducing the concept of DI. Afterwards, Afterwards, he studied what innovations could destroy or disrupt market processes and combined those ideas into a single model (Schneider, 2017, p. 73). DI has three main features. They are that their products are low cost, extremely useful and can comprehensively lessen the total cost of the target market (Liu et al., 2020, p. 316). DIs are driven by technologies and put forward novel ways to create value (Han et al., 2020, p. 9). All in all, the prevailing literature illustrates that the term DI is based on DT, and the term DT relies on the concept of creative destruction.

The rest of the study is designed as follows: Section 2 elaborated each new disruptive technology separately. Section 3 illustrated DT implementations in the course of COVID-19 period. Section 4 clarified the critical points for their achievements. Section 5 outlined the most critical insights of the study.

2. Disruptive Technologies

The current era's revolutionary technologies are presented by the industrial revolutions of that period (Brettel et al., 2014, p. 38). Therefore, DTs may change in every period of life or every industrial revolution (Schwab & Davis, 2018, p. 60). The DTs offered by 4IR are revolutionary technologies for today's SCs that transform SC activities and business processes (Luthra & Mangla, 2018, p. 7). Only sixteen technologies that are prevalently used in SCM are included among the DTs offered by 4IR within the scope of this study. These are cyber-physical systems (CPSs), internet of things (IoT), artificial intelligence (AI), autonomous robots, big data analytics (BDA), blockchain, simulation, and 5G (Özkanlısoy & Bulutlar, 2022, p. 1343). They are explained respectively below:

2.1. Cyber-Physical Systems (CPSs)

CPSs are one of the core technologies of 4IR. These systems are formed by by integrating cyber and physical systems with each other (Xu et al., 2018, p. 2947). They are technologies that merge physical operations with networks of information technology. Their fundamental aim is to realise self-controlled loops in technical systems and decentralized decision processes and through a manufacturing system (Bucherer & Uckelmann, 2011, p. 265). The systems that adhere to the physical world and cyberspace with the internet are named CPSs. They are endorsed through sensors, take motions in the physical environment through internet services and consist of the interplay of global things (Geisberger & Broy, 2012, p. 314). The Internet enables physical devices to work safely, intelligently, and efficiently in CPSs (Khakifirooz et al., 2018, p. 2; Cardin, 2019, p. 11). 4IR enables new manufacturing strategies by utilising CPSs principles that entail tremendously customized assembly systems. They aim to simplify flexible customized manufacturing at mass costs (Ivanov et al., 2018, p. 135).

The basic aim of CPSs is the realisation of "*smart monitoring*" and "*smart control*". They rest on the data transfer formations, decision-making, data analysis, and the substantiation of full-time information attainment (Yue et al., 2015, p. 1262). In the CPSs, physical things and software are interlocked, and various components interact with each other to exchange information with each other. They comprise numerous interdisciplinary methodologies. The most significant difference between a CPS-enabled system and a conventional system is that it includes networked interactions. Therefore, sensors play significant roles in CPSs (Zhong et al., 2017, p. 620). To exemplify, sensors are placed in whole directions to connect physical things to virtual models in CPS manufacturing systems. The advances in communication and computing with CPSs and 4IR cause this revolution to be seen as a CPS (Tay et al., 2018, p. 1383).

There are many illustrations of the CPS in the extant literature. However, there is no universally approved description all over the world. According to the German Industry 4.0 Expert Committee, CPSs are defined as "*systems that directly connect real (physical) things and processes with computing (virtual) tools and processes through open, partially global and always interconnected information networks*". CPS contains mechatronic things equipped with sensors that collect data about business movements that impact physical operations. They are intelligent systems where altering data is fastened simultaneously in a virtual cloud system (Hirsch-Kreinsen & Weyer, 2014, p. 7). According to another definition, "*embedded systems are systems that include many processes such as logistics, production, engineering, management and coordination as well as internet services and can directly collect physical data through sensors and affect physical operations through actuators*" (Bartodziej, 2017, pp. 52-53).

As discussed at the beginning, CPSs are systems that incorporate two characteristics: "*cyber*" and "*physical*". The benchmarking of CPSs from the standpoint of these characteristics is given in Table 1 below (Hu et al., 2016, p. 450):

Table 1

The benchmarking of cyber and physical characteristics of CPSs

	Physical	Cyber
Method of enabling right order	Real-time	Sequences
Synchronization of event	Asynchronous	Synchronous
Time features	Perpetual	Discrete
Structure	Physical laws	Computing abstractions

Note. Hu, F., Lu, Y., Vasilakos, A. V., Hao, Q., Ma, R., Patil, Y., ... & Xiong, N. N. (2016). Robust cyber–physical systems: Concept, models, and implementation. *Future Generation Computer Systems, 56*, 449-475. doi: 10.1016/j.future.2015.06.006

CPSs utilise information and communication technologies to trace and control physical systems and processes. They include smart robots, embedded sensors, and additive manufacturing (3D printing) devices that can instantly adjust themselves to suit the product to be manufactured (Kalluri et al., 2021, p. 4; Korki et al., 2022, p. 510). he physical environment, information, electronics, and networks interact with each other in these systems (Mosterman & Zander, 2016, p. 18). Cyber-physical production systems merge elements from both material and information subsystems (Ivanov et al., 2016, p. 386). The achievement of CPSs in realising an intelligent production system varies regarding the degree of cooperation of knowledge platforms and mobile devices with internet-connected technology (Hohmann & Posselt, 2019; Salam, 2021, p. 1699).

2.2. Internet of Things (IoT)

Sensors embedded in or near things are placed. Afterwards, the things are interlocked by connecting to the internet through these sensors. This makes up a network for data collection, data distribution and communication. These systems are named as the Internet of Things (IoT) (Faulds & Raju, 2019, p. 28; Ashton, 2009, p. 99). The concept was coined by a British entrepreneur, Kevin Ashton. The thought was formulated in 1999 to define a system in which the material world gets into touch with computers (exchange of data) with ever-present sensors (Witkowski, 2017, p. 764). In the initial decade of the 21st century, it has become extremely popular. It has been accepted as one of the significant technologies for industries to transition to 4IR by augmenting information to products and operations in the SCs (Trappey et al., 2017, p. 210).

IoT technology is an emerging internet-based information structure that can be utilised to simplify the flow of information in SC networks globally. Things have digital functionality and can be automatically defined and traced with IoT. This facilitates the management of the SC and quality factors (Xu, 2011, pp. 184-185). IoT contributes to data creation, improving data detail and quality and ensuring high availability of data (Pflaum et al., 2018, p. 5038). According to another definition, IoT is defined as hardware, software, databases, physical things, virtual things, and sensors that connect and work together to serve humanity. This technology can enable communication of anything and any media, anytime and anywhere. It lessens the costs arising from acquiring knowledge in the SC and enables a smarter SC. Furthermore, it enables real-time visibility of inventory across the SC. In this way, it improves inventory management. Information is shared on demand, and information is shared only with one SC member in traditional SCM. However, IoT enables any kind of information to be recorded and shared with all SC members. This has the impact of boosting the efficiency of SCM. Traceability and customer satisfaction enhance, and return costs lessen in the SCs (Abdel-Basset et al., 2018, p. 616).

IoT is significant for the effectiveness of 4IR as well as the SCM (Rajput & Singh, 2018, p. 1582). It positively affects relations with competitiveness and consumers (Piccarozzi et al., 2018, p.2). It enhances SC's flexibility and enables optimum efficiency in SCs. It reduces energy consumption costs from the standpoint of sustainability in the SC (Mitra et al., 2017, p. 17). It accelerates payment systems by enhancing information sharing (Tiwari, 2021, p. 1019). It boosts the coordination of manufacturing by supporting obtaining the necessary information about the manufacturing units. It reduces errors and disruptions during manufacturing and product delivery (Sanchez, 2019, p. 2). Additionally, connecting things to the Internet can enable new product features and workflow models (Branke et al., 2016, p. 264).

IoT system has a connectionless data management that speeds up the supervision of processes. Moreover, it enables the data to be converted into information that will put the CPSs into action (Lee et al., 2015, p. 4). The IoT, an exhaustive extension of the Internet, can also perform prevalent connections between things; information gathering and real-time can bridge the gap between things in the material world (Lou, 2011, p. 1). IoT is a technology that improves order tracking. It simplifies manufacturing processes and lessens manufacturing costs. It ensures the improvement of the services enabled to the customer by allowing them to trace their orders (Liu et al., 2012, p. 231). When IoT is utilised in transportation activities, it provides better traffic management. It realises this by playing a role in various communications, such as vehicle-to-vehicle and vehicle-to-infrastructure and contributing to the execution of smart transportation systems implementations (Martínez de Aragón et al., 2018, p. 1). It ensures the reduction of fuel consumption, CO^2 emissions, reduction of malfunction and downtime, and monitoring of driver behaviour in transportation activities. It is utilised in stock management, determining when stock is running low (called digital shelves), tracking containers and products, and optimizing stock. It enables the inventory level to be reduced by monitoring the inventory. It eliminates real-time tracking of people, assets and packages and excludes manual interventions, thereby automating business processes (Manners-Bell & Lyon, 2019; pp. 52-56).

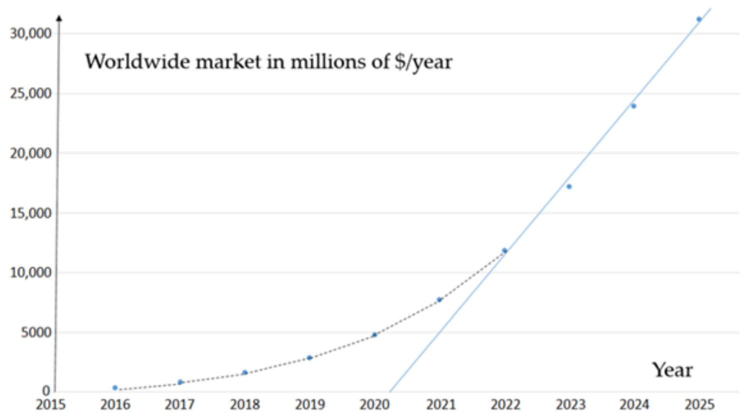
2.3. Artificial Intelligence (AI)

AI technology has been advancing rapidly and has been frequently discussed in recent years (Gil et al., 2020, p.3). AI is identified as "*a branch of science that studies how natural systems can do every cognitive activity, with or without intelligence, to artificial systems at higher levels of performance*" (Say, 2021, p. 82). From the viewpoint of business strategists, it is "*a body of menu-interactive* *pattern recognition and robotic systems that can be used alone or in combination with other tools so far, including expert systems, natural speech input/output, graphical input, natural language*" (Rhines, 1985, p. 22). AI is divided into four groups based on various definitions. In this context, it can be defined as "*systems that think like humans, systems that act like humans, systems that think rationally, and systems that act rationally*" (Russel & Norving, 2021, p. 2).

Unlike traditional machines utilised in factories, AI is devised to utilise not only digital data but also non-numeric information and symbols. This information consists of letters, words, signs, drawings, figures, knowledge, concepts, and reasoning. Just as absolute perfection cannot be expected from humans, absolute perfection cannot be expected from AI. Even the most intelligent AI systems can make mistakes. However, this rate is low (André, 2019, p. 14). AI investments have been increasing since the early 2000s. The current economic market and prospects of AI since 2015 are illustrated in Figure 1 below (André, 2019, p. 16):

Figure 1

Economic market for AI



Note. André, J. C. (2019). Industry 4.0: Paradoxes and conflicts, systems, and industrial engineering series. John Wiley & Sons. p. 16.

AI can also be defined as a machine that can think, act, and be self-aware. From a commercial viewpoint, it can be defined as "*a machine that can conduct tasks that previously required human intelligence, such as decision-making, language translation, visual perception, and speech recognition*". It is adequate to know with human reasoning. It is not an obligation to work in the same way as a human for a machine to have AI (Manners-Bell & Lyon, 2019, p. 59). It is necessary to perceive and solve the problem, establish cause-effect relationships in this direction, act by generating ideas, and reach results using information in AI applications. This is possible with software and programs that make it functional (Cohen, 1987, p. 25). Accordingly, AI has many sub-fields, such as cognitive computing, computer vision, machine learning, deep learning, artificial neural networks, and natural language processing and is not limited to these (Khalil et al., 2020, p. 401; Shave, 2019, p. 40; Vishnukumar et al., 2017, p. 715).

2.4. Autonomous Robots

With the emergence of AI technology, there has been an intense interest in automatic sensing and cognition, and the decrease in the costs of sensors and processors has accelerated the development of autonomous robots and systems (Watson & Scheidt, 2005, p. 370). Afterwards, the concept of collaborating with the operator, almost like a colleague, rather than working with operator intervention, emerged and human-robot cooperation was realised. This has resulted in much more flexible, self-learning, self-configuring, collaborative and efficient systems. These robots and systems have been used in many SC operations, such as manufacturing, logistics, warehousing, and material handling (Rüßmann et al., 2015, p. 56).

Autonomous robots, one of the significant components of 4IR, are a technology that receives data based on IoT technology and transforms it into physical movement. These robots send data to other machines and robots and activate them as well. This technology can be utilised effectively in SCs, especially in storage, handling, transportation, and distribution operations. These processes accelerate the flow by taking direct action. The data obtained by customers ordering from the electronic environment activates the robots in the warehouse. Collector and transporter robots can receive these data directly without operators. These robots can go to the shelf where the product is located, take it from the shelf, and load it by bringing it directly to the transport vehicle to which it will be shipped. The human factor in SC operations is reduced, and therefore, human errors are eliminated with this technologyIt is also a technology that provides extraordinary efficiency in logistics operations (İyigün & Görçün, 2019, p. 128).

In the future, it is expected that all operations within the SC will gain an autonomous character and be carried out without human factors. Optimization approaches and applications will gain a qualification that is conducted every time by robotic systems and can be continuously improved regarding changing conditions and factors. Autonomous robots enhance operational efficiency and competitiveness (Fırat & Fırat, 2017, p. 12; IFR, 2017, p. 2). They enable an enhancement in competitiveness as well as an increase in process quality and manufacturing flexibility in the SC. It is a technology that reduces labour, resource, operation, and waste management costs. It reduces the error rates of the operators they work with (Bugmann et al., 2011, p. 2) and enables improvement of SC processes and optimization of processes. It enhances safety and well-being in the workplace, lessening employees' working hours and removing challenging work. Moreover, it improves working conditions and thus enhances the pleasure of employees (Benotsmane et al., 2019, p. 2; Esmaeilian et al., 2016, p. 80; Linner & Bock, 2012, p. 158). As robots take over the responsibility of mundane duties, employees can focus on improving their competencies (Fitzgerald, 2018; Shamout et al., 2022, p. 578).

2.5. Big Data Analytics (BDA)

Although discussed frequently, BDA is a concept that does not have a certain definition in the literature, like some other DTs. It is often utilised with concepts of business intelligence and data mining. Although the three terms are related to data analysis and advanced analytics, BDA differs from these two concepts. It has unique methods and technologies to solve data in cases where the number of data sources, data volumes and number of transactions are huge and complex. It differs from the characteristics of data mining and business intelligence (Furht & Villanustre, 2016, p. 4).

The concept of BDA refers to the evolution and usage of technologies that enable accurate information at the accurate time to the accurate user from the exponentially growing data mass. It is a technology designed to ensure real-time access to databases. The concept of size in terms of data volume varies according to the relevant field. BDA contains many techniques and technologies together. Therefore, this concept cannot be defined by several technologies (Riahi & Riahi, 2018, p. 524).

Big data (BD) is huge complex datasets, structured and unstructured, that do not operate with traditional techniques and/or algorithms. It is proposed to reveal hidden distributions with BD and the transformation from a model-based science paradigm to a data-based science paradigm is enabled (Taylor-Sakyi, 2016, p. 1). It is crucial for production, machinery, and proactive maintenance/repair activities. Thanks to this technology, businesses can create value at various stages of their production processes. To exemplify, it ensures the preparation of effective maintenance plans that can prevent costly breakdowns and unpredictable long downtimes in machines or production processes. It does this by collecting information about hidden failure and inefficiency situations (Wang et al., 2018, p. 1).

BDA initially has five different characteristics (Salman, 2020, p. 22). They are volume, velocity, variety, veracity, and value. The utilisation cases of BDA are separated into three groups. The first of them is the effectiveness and management of potential risks. This ensures risk maximization in the SC. The second is the implementation of predictive security performance. Another utilisation is the information and services offered to customers. It can be utilised in sales and marketing activities in the SC, product development and optimization of the digital experience (Arena & Pau, 2020, p. 1647).

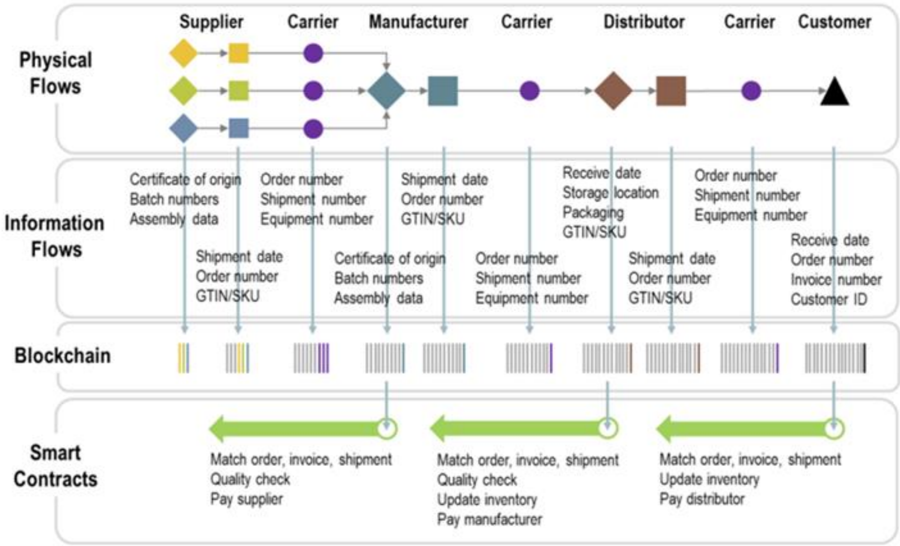
2.6. Blockchain

Blockchain technology is a silent revolutionary technology today, just as many technologies that seem normal to people today were revolutionary when they emerged (Gupta, 2017, p. 53). It does not have a generally accepted definition in literature like many DTs. The concept was initially utilised with Satoshi Nakamoto's term of Bitcoin in 2008. It was defined as blocks of information linked together by encryption at that time (Jacobovitz, 2016, p.2). Although the electronic currency, which is a novel approach in the financial field, was initially developed to enable the security of Bitcoin, its implementation field has expanded over time, and it has started to be utilised in many fields, not just finance (Hackius & Petersen, 2017, p. 4). This technology has recently been utilised in SCs (Zhu et al., 2022, p. 2).

The basis of the blockchain comprises transforming the previously collected and preserved reliable data into a technical schema. This schema comprises blocks generated through encrypting many nodes in the system. Therefore, it is named a chain of blocks. There are many blocks, and they are connected linearly and chronologically to form a chain. They have digital fingerprints that verify the validity of the information (Tian, 2016, p. 25). Blockchain technology significantly contributes to SCs (Rejeb et al., 2021, p. 973; Rana et al., 2021, p. 3471). Information is confirmed, stored, and distributed in a fixed manner with this technology. It lessens the irregularity created by irregular incoming information and non-transparent SC. Transparency and traceability of the entire SC are ensured, and thus SC security is enhanced (Badzar, 2016, pp. 8-12). Accordingly, it makes a significant affirmative contribution to SCM because of its contributions (Hackius & Petersen, 2017). Blockchain implementations in SCM are given in Figure 2 below:

Figure 2

Blockchain implementations in SCM



Note. Rodrigue, J.-P. (2018). Efficiency and sustainability in multimodal supply chains. International Transport Forum Discussion Paper, No. 2018-17, Organisation for Economic Co-operation and Development (OECD), Paris. http://dx.doi.org/10.1787/12f93f71-en

The utilisation of blockchain in the SC consists of four main stages. These are physical flow, smart contracts, blockchain and information flow. Physical flows encompass movements from suppliers to the end user. Information flows encompass information flows in the SC. To exemplify, the order number, global trade item number, and shipping number are information in this flow. Physical flows and information flows in the SC are recorded via blocks. They are connected and turn into a chain. Therefore, this chain contains information about all the SC links. Smart contracts are utilised in the blockchain. They are generated by automatically filling in the agreed contracts utilising the knowledge a blockchain includes. No changes can be made to them without the agreement of the relevant parties (Rodrigue, 2018, p. 23).

2.7. Simulation

Simulation is described as "*the process of designing a model of a real or hypothetical system to describe and analyse the behaviours of the system*" (de Paula Ferreira et al., 2020, pp. 5–6). Product, component, or total system habits can be discovered and tested in a virtual environment. This technology is widely utilised in the computer system industry and in product design processes (Elangovan, 2022, p. 39). It first transfers the data of a physical system extant in the real world to the imaginary environment and then creates an infrastructure to track the properties of the real system. It contributes to the SCs in the way of cost, time, and risk management, thanks to keeping track of the development of the processes. This technology aims to foresee the virtual world's possibilities and plan the essential preparations. Significantly, all data of the physical system can be modelled in the digital climate for this technology because it determines the success of this technology. Due to the preparation of plans for new conditions to be met, it has become a technology utilised in every field today. Production, business management, education and health are just a few of these fields (Bungartz et al., 2014, p.111; Landriscina, 2013, p. 11, 175).

The improvement of simulation-based design technologies has progressed rapidly with the enhancement of computer tools and systems. Modelling methods, virtual reality environments, computational tools, collaborative engineering environment infrastructure and similar tools are enhancing gradually (Bossak, 1998, p. 9). Before the 1970s, the view that industrial design was based on tests in many fields was adopted, and it was widely believed that it would not be possible to observe the results without manufacturing and testing the model. A change occurred with the help of computer systems in the 1980s. Nowadays, computer-aided simulation environments are widely utilised and enable outstanding economic contributions (Garavaglia, 2010, p. 260). Simulation studies are divided into steady-state simulations and original-state simulations. The development of them took place differently from each other. Steady-state simulations have a precise mathematical structure. Original state simulations may not have simple mathematical representations (Banks & Carson, 2004, pp. 9-13).

The development of simulation tools has enhanced rapidly after 1987. Monte-Carlo simulation, reality simulation, Petri-Nets simulation, traffic simulation, and hybrid simulation techniques constituted by their assembly are some of the commonly utilised simulation methods. Simulation tools are widely utilised in many industries (Jahangirian et al., 2010, p. 3). The most significant contribution of the simulation is that it is a cheap, protected, and fast evaluation tool. Real-time simulation technology is utilised in many different industries today. It is a technology that assists the product design group and enables the progress and review of a variety of digital versions of the product. It becomes part of the design process as well as simplifying the product design process by reducing the complexity of product design (Elangovan, 2022, pp. 38-39).

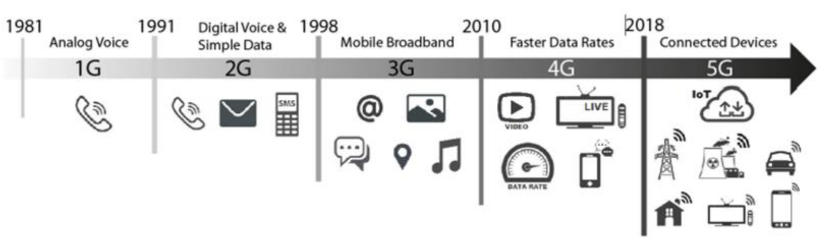
2.8. 5G

Mobile networks have developed gradually over the past two decades. Voice digitization and SMS messaging features first emerged with 2G technology, followed by 3G with multimedia and Internet-based features. Wireless broadband data rates of 100 Mbps have been reached with 4G (Rao & Prasad, 2018, p. 146). Subsequently, the ever connected and hyper-communicative society has moved towards the 5G network. The legacy systems' fragmentation and inability to meet real-time data transmission requirements have led to the transition to 5G (Agiwal et al., 2019, p. 191), a more advanced wireless communication network (Lu, 2017, p. 7). Many intelligent devices can intercommunicate anywhere and at any time with this technology. It is recognized as a novel network solution to cope with the difficulties of further communication requirements. Devices with this technology require exceptional network capabilities, such as near-zero latency and data rates at the Gbps scale. 5G is a significant technology for 4IR and the digital transformation of SCs (Taboada & Shee, 2020, p. 3).

The difference between 5G and existing 4G networks is that it can communicate with many communication tools and technologies that 4G cannot. These involve IoT, cloud computing and autonomous robots. Communication with them will be vital to the services in future times (Zikria et al., 2018, p.2). The evolution of mobile communication from 1G to 5G is given in Figure 3 (Guevara & Cheein, 2020, p.2). 5G technology contributes to the realisation of autonomous driving in transport activities. The contributions of this technology include enhancing communication between vehicles and enabling smart navigation and remote-controlled driving. It enables the transportation system to become intelligent, resulting in enhanced traffic safety, increased fuel efficiency and improved driver comfort (Guevara & Cheein, 2020, p. 5). Its contributions are not limited to transportation activities.

Figure 3

Evolution of mobile communication from 1G to 5G



Note. Guevara, L., & Cheein, F. A. (2020). The role of 5G technologies: Challenges in smart cities and intelligent transportation systems. *Sustainability, 12,* 1-15. doi:10.3390/su1216646. p.2.

5G contributes to SCs at various levels. These are divided into three groups: strategic, operational, and cross-discipline level. The contribution of these capabilities to SCs is to improve operations and make SCs more intelligent. At the strategic level, 5G contributes to identifying new business models, establishing digital SC ecosystems, and ensuring resilience and sustainability in the SC. At the operational level, it enables demand forecasting analytics, intelligent capacity planning, automated warehouse and inventory management, digital manufacturing planning and control, cloud production-based scheduling, and smart fleet management. At the cross-discipline level, it allows autonomous and connected vehicles, autonomous SC operations, smart cities, and smart homes as part of the SC ecosystem, e-health and SCM. As a result of these levels, 5G technology contributes to ecosystem-oriented business models, smart operations and digital SC strategies based on customer and SC connectivity, creating a dynamic network, enabling SC reconfigurability and end-to-end visibility (Dolgui & Ivanov, 2022, p. 447).

3. Implementations during COVID-19

Coronavirus (COVID-19) is a pandemic that initially emerged in Wuhan, China, at the end of 2019 and then spread worldwide (Kraemer et al., 2020, p. 493). From December 2019 to May 25, 2023, there have been approximately seven hundred million cases and approximately seven million deaths worldwide (Center for Disaster Philanthropy, 2023). The pandemic not only affected people but also created many serious adverse effects on companies, the economy, and ,thus, SCs (Araz et al., 2020, p. 1318). The vital significance of the SC has been better comprehended with the COVID-19 pandemic, and SCM has now become a more highlighted concept by both researchers and practitioners (MacCarthy & Ivanov, 2022, p. 3).

Global SC lines, from raw material procurement to product delivery, have been heavily impacted by the outbreak, and disruptions have occurred at all stages of SC (Xu et al., 2020, p. 153). The pandemic has highlighted the need for organizations to significantly change their SC strategies to enhance SC resilience and adapt to the "*new normal*". Nowadays, more emphasis is placed on SC design, management, and control (Alicke et al., 2021). Enhancing SC resilience or improving the ability to respond quickly to SC disruptions is key to coping with the effects of the pandemic. Many firms have recognized the importance of resilience investments today (Maharjan & Kato, 2023, p. 1). 4IR technologies, also known as DTs, alleviate the pandemic's adverse impacts (Iqbal et al., 2022, p.14). SCs that use DTs are better able to deal with crises than those that use them at a lower level. DTs are technologies that enhance resilience in the SC (Pellicelli, 2023, p. 58).

DTs have not only been utilised effectively to enhance SC resilience and mitigate the effects of SC disruptions but also to deal with the pandemic. China is one of the pioneer countries in utilising DTs effectively to deal with the pandemic. To illustrate, while AI and BDA technologies responded to public health problems, blockchain technology enabled the openness of information, transparency, and traceability of developments in the pandemic. The first pandemic tracking platform based on blockchain was established by a technology firm in China, and it was ensured to be informed about the progress of the pandemic in all states of the country. In this way, false rumours about the course of the pandemic were lessened. Technological support was provided to relevant institutions by some cloud computing companies to accelerate the development of new vaccines and drugs. In addition, cross-border online communication and collaboration were facilitated through cloud computing, AI, and BDA. Another example is the development of a voice scanning system utilising AI, cloud and blockchain technologies. Thanks to that system, it contributed to preventing the pandemic and controlling the spread. Since there were not enough radiologists in some regions of the country, an intelligent image-reading system was developed thanks to AI. That facilitated the diagnosis, treatment planning and follow-up of doctors. The construction sites of newly built hospitals were monitored in real-time by establishing 5G base stations in the country. 5G patrol robots were generated by a robotics company with the integration of IoT, AI, cloud computing and BDA. The robots gave some warnings to citizens (e.g., washing their hands and wearing masks) during the pandemic. They were also capable of detecting and alerting if a human had a high body temperature (Deloitte, 2020, pp. 7-8). Some examples of DT practices carried out in the course of the COVID-19 pandemic are presented in Table 2 below:

Table 2

DT implementations during COVID-19 pandemic

Type of DT	Implementation of DT
IoT	Ensuring compliance with patient quarantine requirements.
	Remote monitoring of patients.
AI	Automatic detection of COVID-19 cases.
	Diagnostic and prognostic analysis.

	Analysing epidemic situations.
	Early triage of dramatically ill COVID-19 patients.
	Early detection and diagnosis.
Autonomous robots	Delivery of food and medicines.
	Disinfecting the rooms.
	Treating patients.
BDA	Pursuing people's movements.
	Understanding epidemic trends.
	Control and regulation of pharmaceutical materials.
Blockchain	Development of "*digital identity*" for healthy people.
	Processing of claims.
	Making purchases.
3D printers	Production of protective masks.
	Making test swabs.

Note. Adopted from He, W., Zhang, Z. J., & Li, W. (2021). Information technology solutions, challenges, and suggestions for tackling the COVID-19 pandemic. *International Journal of Information Management*, *57*(April), 1-8. https://doi.org/10.1016/j.ijinfomgt.2020.102287

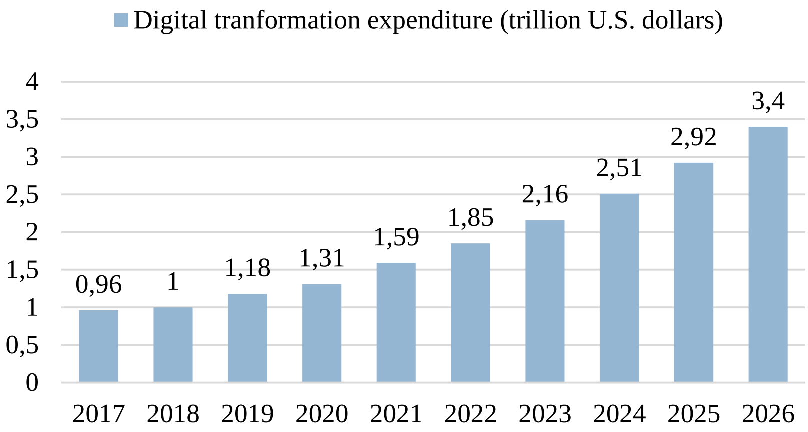
The COVID-19 pandemic functioned as a catalyst to accelerate the adoption and spread of DTs in society. They helped to adapt to changing consumer preferences and meet demands in that process. Moreover, they contributed to meeting social distancing requirements and supporting working from home (Mat Aripin & Brougham, 2023). Accordingly, new ways were found to be able to deliver from anywhere (usually from home), sustain relationships with suppliers, and proceed to serve clients with the lowest physical contact (The Economist, 2020). Businesses have enhanced their use of digital tools, automation, and AI during the pandemic to adapt to the changing conditions. When the implementation examples around the world were investigated, Philips widely utilised its previously developed teleradiology technology solution during the pandemic. Thanks to the technology based on AI, the needs of patient beds can be predicted, and models can be created accordingly. It was able to estimate how many patients needed an intensive unit or ventilator with the information gathered about the patients (KPMG, 2020, pp. 5-22).

HP launched a project based on automating whole business processes utilising AI and machine learning, aiming to become a more agile company and achieve faster return on investment (ROI). American Express Finance enhanced its investments in chatbots and natural language processing solutions. In this way, it could answer 70-80 percent of customer questions received via e-mail and other digital channels. Microsoft's AI team provided control panels and cloud computing resources to academic institutions, governments, and nonprofits to support informed decision-making during the pandemic (KPMG, 2020, pp. 5-22). There was an increase in the utilisation of robots to manage the enhancing demand for e-commerce in the retail industry. The robots enabled the selection, sorting, and monitoring of products in warehouses. McKinsey predicts that continued use of DTs will enhance annual productivity by 1 percent each year through 2024 (McKinsey, 2021).

According to Statista (2023a) data, digital transformation expenditures are expected to enhance to $1.85 million in 2022 and to reach $3.4 million in 2026. The change in digital transformation expenditures over the years is given in Figure 4. The part of the data consists of actual expenditures until 2023, and the part for 2023 and beyond consists of expenditure estimates. As can be seen, there has been a significant increase in digital transformation expenditures since the emergence of the pandemic. When the estimations for the next three years are examined, it is comprehended that a significant enhancement is expected. The point to be noted here is that it is not just a study on the usage of DT. Digital transformation refers to whole technologies utilised to digitize business processes and services. However, information and communication technologies and DTs are utilised together to enable the end-to-end integration of the SC in 4IR (de Paula Ferreira et al., 2020, p. 2). This enables higher contributions to the SCP (Hahn, 2020, p. 1426).

Figure 4

Spending on digital transformation technologies and services worldwide



Note. Statista, (2023a). *Spending on digital transformation technologies and services worldwide from 2017 to 2026 (in trillion U.S. dollars)*. https://www.statista.com/statistics/870924/worldwide-digital-transformation-market-size/.

According to the findings of another study executed by Statista (2023b), in which the sample size of 908 participants was formed, the demand for AI technology has risen significantly because of the COVID-19 pandemic. 46.4% of respondents highlighted that their organization has seen a significant increase in demand for advanced analytics. Using DTs is an effective way to deal with disruptions in the SC. It enhances visibility, resiliency and performance and significantly contributes to SCs (Pellegrino & Gaudenzi, 2023, p. 14). Furthermore, it contributes to combating the event that caused the disruption. Undoubtedly, the COVID-19 pandemic is not the initial event that accelerated DT investments. World War I and World War II were the first events that accelerated technological progress in the world. The Russia-Ukrainian War is also an example from today. The usage of DTs is crucial not only for mitigating the COVID-19 pandemic's effects but also for the SCs of the future (Pellicelli, 2023, p. 59).

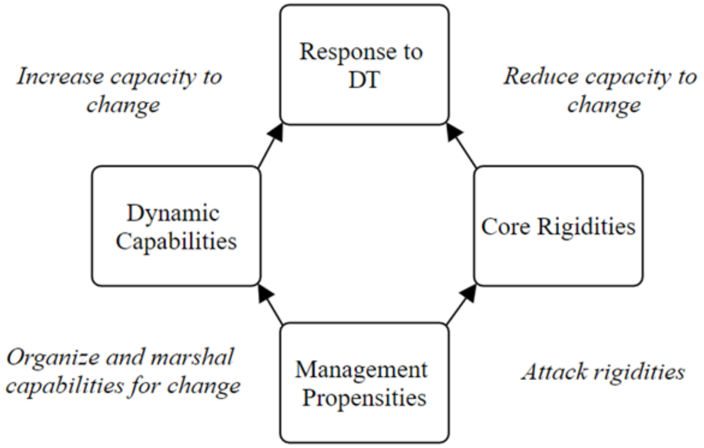
4. Critical Points for Their Achievements

Some crucial points should be considered during and after the DTs' implementations. One is the need to identify key orders, priority customers, and attractive new product ideas for using them (Lucas & Goh, 2009, p. 47). Adapting organizational culture to alteration is another significant point because it must be altered at every managerial level when a company implements a DT. Employees should be convinced of technology change by their managers (Rouleau, 2005, p. 1414; Balogun, 2006, p. 30). Otherwise, resistance to alteration may be encountered (Özkanlısoy & Akkartal, 2021, p. 48). The organizational structure, the beliefs of the employees and the communication among the employees should be reshaped by considering the requirements of DTs (Schein, 1983, p. 15).

As companies implement DTs, they engage in a struggle for change. They try to overcome the fundamental rigidities in the companies, strive to change the company's dynamic capabilities and successfully realise the change process. For this reason, companies have some managerial tendencies. This structure is given regarding a conceptual framework in Figure 5. As the companies implement DTs, they face a challenge for the change. Employees are firmly rooted in their core competencies and may not be willing to accept dynamic capabilities to cause change. This refers to the possibility of employees to resist alteration. In this respect, company administrators are responsible for managing change (Lucas & Goh, 2009, p. 47).

Figure 5

A framework for responding to disruptive change



Note. Lucas Jr, H. C., & Goh, J. M. (2009). Disruptive technology: How Kodak missed the digital photography revolution. *The Journal of Strategic Information Systems, 18*(1), 46-55. https://doi.org/10.1016/j.jsis.2009.01.002

Dynamic capabilities are described as "*the firm's ability to integrate, to create external competencies to address rapidly changing environments.*" (Teece et al., 2007, p. 1320). They do not always provide a company to restructure its business in answer to an outward threat. Core capabilities consist of four elements. These are knowledge-related employee capabilities, technical systems, management systems, and values and norms. A convenient core capability in one situation may not be appropriate in another. Core rigidities are challenges in core capabilities. They are barriers to learning, both at the individual and the company level (Lucas & Goh, 2009, p. 48). Management propensities are a bridge between core rigidities and dynamic capabilities in technology transformation. It is critical in achieving technology transformation (Castanias & Helfat, 2001, p. 662; Holcomb et al., 2009, p. 458).

Company managers must develop strategies for the response to DTs, which must be implemented across the company (O'Reilly, 1989, p. 10). Managers must have information about DTs. Moreover, they must highlight the necessity of transformation and lead the transformation process (Sherif & Menon, 2004, p. 248). They should inform and guide the employees in this direction and witness that they have learned the vision of change. Several challenges may arise in the process of responding to disruptive change. This is a situation that can be perceived in different ways by different managerial levels (Gavetti, 2005, p. 600).

Culture is defined as "*a pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration – a pattern of assumptions that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to these problems.*" (Schein, 1983, p. 14). The role of organizational culture in technology transformation is essential. Organizational culture is a concept developed and taught by company founders between the founders' actions and organizational processes (Schein, 1985, p. 2). The role of senior management is critical in making up organizational culture (Balogun & Johnson, 2004, p. 525). Organizational culture affects the change process in organizations from various aspects. They are acceptance, management, and prevention of change (Burke, 2002, p. 212). Since bureaucratic structures result in organizational inertia (Merton, 1957, p. 177), companies with an organizational culture supporting hierarchy and maintaining the current situation will encounter resistance when using DT (Lucas & Goh, 2009, p. 49). After a long period of achievement, the companies' core competencies transform into their core rigidities. This is an issue that makes change difficult. For technological change to be successful, managers should not avoid risks in this regard and should not be a bureaucratic organization. Management should have detailed information about the opportunities and threats of the technologies to be utilised (Lucas & Goh, 2009, p. 49).

Successful and widely adopted technologies can ossify. This makes it challenging to introduce new capabilities. Likewise, if existing technology moves in its way, it becomes more difficult to replace it with better technology (Peterson et al., 2003, p. 59). There are steps to follow to facilitate the generation of DTs. First, candidate technologies are identified as alternatives. Second, the high-priority ones are determined among these technologies. Afterwards, necessary technical and managerial disciplines to generate alternative technologies are determined and included in the development plan. Finally, various approaches are utilised to determine the strengths and weaknesses of the technologies. The approaches are implemented to take advantage of the strong ones and eliminate the weak ones. Some of them are the path-based approach, dual literature, and workshop (Kostoff et al., 2004, p. 145).

It may focus on using a completely new technology for DTs, or a combination of different technologies may be utilised (Walsh & Linton, 2000, p. 24). When multiple DTs are utilised together, determining the technology mix is complex. Performance targets and planning processes are considered in this process. When determining the DTs, long-term low risk/return balance, technology's contribution to sustainability, long-term profitability, current strategic planning, and management processes are evaluated. Companies that adopt DTs tend to displace companies that do not adopt them. This threatens companies that do not utilise them (Christensen, 2000, p. 233). Therefore, it is crucial for companies to follow the DTs used in the industries in which they operate and to bring themselves closer to the usage level of these technologies. Before utilising them, the liabilities, legal aspects, and ethical and insurance issues that will arise should be evaluated (Tjahjono et al., 2017, p. 1176).

The main challenges of DTs can be divided into three groups: cost, data security and legal issues, and human resources issues (Rad et al., 2022, pp. 276-277). Cyber risks and vulnerabilities are crucial examples of risks related to data security and legal issues. Cyber risks lead to operations and management data breaches and endanger the data records of suppliers, customers, and employees (Boyson, 2014, p. 344). Therefore, it is significant to take cybersecurity measures (Thames & Schaefer, 2017, p. 2). Otherwise, it is inevitable to encounter fraud, intellectual property theft, failure of information technology infrastructure and unavailability of critical services (Riglietti & Aguada, 2018). Another challenge regarding data security is controlling and ensuring the accuracy of data collected by using these technologies (Özkanlısoy & Akkartal, 2021, pp. 48-49). Another challenge is the collection and personalization of data. It is difficult to understand which data collected in SC processes can be utilised in analysis and the quality of the data (Heavin & Power, 2018, pp. 2-3; Tiersky, 2017).

The human resources challenges posed by DTs relate to customers and employees. First, adopting any technology, whether technology has a disruptive effect or not, launching to utilise a novel technology for the first time in the company reveals the need for higher employee skills and the need to safeguard the privacy of employees and customers (Collier & Evans, 2020, p. 90). Employees need to be trained during the technology adaptation process. Reaching enough qualified workforces adapted to relevant technologies is another challenge. Moreover, as the level of technology utilisation enhances, dependence on employees will decrease, which will cause anxiety among employees (Özkanlısoy & Akkartal, 2021, pp. 48-49). Second, implementing DTs may encounter resistance from customers, failing to implement them. Customer requirements should be considered in technology selection and implementation (Walsh, 2004, p. 163). Besides, it creates anxiety for employees as it causes their creative potential to lessen and their dependence on information to increase (Melnyk et al., 2019, p. 36).

Before DTs are implemented, their ROI needs to be analysed accurately due to their high investment cost. The company must be at the same level of technological maturity as other SC members apart from cost, data privacy and legal issues, and human resources challenges because having different maturity levels makes it difficult to establish a systemic infrastructure. Before implementing them, creating a roadmap of the opportunities and challenges they enable is key to their achievement (Özkanlısoy & Bulutlar, 2022, p. 1340). Another point to consider is to keep the implementations constantly updated. Interruption of the functioning of technologies lessens operational efficiency. Therefore, existing applications based on DTs must be constantly monitored and updated (Özkanlısoy & Akkartal, 2021, pp. 48-49).

5. Conclusion

SC is a dynamic structure that must comply with perpetual alteration (Katsamakas & Georgantzas, 2010, p. 218). Therefore, SC approaches vary depending on the current period or situation (Christopher, 2021). The COVID-19 pandemic has highlighted the necessity to reappraise prevailing approaches and rebuild them (Ivanov, 2020, p. 3). DTs are the revolutionary novel technologies of the modern era (Tushman & Anderson, 2018, p. 346) and have numerous positive impacts on the SCs in terms of many aspects (Fatorachian & Kazemi, 2021, p. 64). The pandemic has demonstrated the critical role of using DTs in dealing with SC disruptions and creating more resilient SCs (Dolgui & Ivanov, 2020, p. 2). The usage of DTs is crucial not only for mitigating the COVID-19 pandemic's effects but also for the SCs of the future (Pellicelli, 2023, p. 59).

The basis of the concept of DT presented by Christensen is based on the concept of creative destruction introduced by Schumpeter, and the using DTs in SCs causes creative destruction in SCM by altering business processes and replacing existing technologies. In this regard, "*the using disruptive technology (UDT)*" variable discussed in this study can also be called "*the process of creative destruction*" in further studies, if desired, because the technologies of the age that cause this alteration are revolutionary Industry 4.0 technologies, also named as the 4IR technologies offered by the current IR. These technologies are also accepted as emerging technologies (Shen et al., 2022, pp. 1-2; Sodhi et al., 2022, p. 2517), advanced technologies (Azevedo et al., 2021; Simonetto et al., 2022, pp. 7-10), new technologies (Reyes et al., 2020, p. 157) and novel technologies (Amani & Aghamohammadi, 2024, p. 5008) as well as 4IR technologies in the extant literature. Accordingly, these concepts can also be utilised instead of the concept of DT.

Undoubtedly, the COVID-19 pandemic is not the initial event that accelerated DT investments. World War I and World War II were the first events that accelerated technological progress in the world. The Russia-Ukrainian War is also an example of today (Pellicelli, 2023, p. 59). The COVID-19 pandemic functioned as a catalyst to accelerate the adoption and spread of DTs in society (Mat Aripin & Brougham, 2023). This study aims to promote DT practices and thus create more effective SCs by presenting DT implementations carried out during the COVID-19 period and the critical factors that should be taken into account for their achievement. The widely utilized technologies in that period were AI, autonomous robots, BDA, IoT, blockchain and 3D printers (He et al., 2021, p. 2).

Effective SCM enables significant benefits not only to SC stakeholders but also to regions and countries (Silvestre, 2015, p. 156). In this regard, governments have significant duties, as do companies and their SC managers. They need to make the necessary investments to create digital infrastructure, develop guidelines and ethical frameworks for DTs, develop workforce skills, and exchange knowledge and experience on utilising DTs with other countries (UNCTAD, 2021). The significance countries attach to the issue will raise the achievement of DT implementations and their contribution to SCs.

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BÖLÜM 4

Export Performances of Countries Classified Under Varieties of Capitalism

Ertuğrul Deliktaş[1] & Mehmet Fatih Acar[2]

[1] İzmir Katip Çelebi Üniversitesi, ORCID: 0000-0003-1999-8176
[2] Doç. Dr., İzmir Katip Çelebi Üniversitesi, ORCID: 0000-0002-7388-8720

1. Introduction

Export has a meaningful impact on individual and social welfare due to economic growth and development. Therefore specialization and doing trade in the most comparatively advantageous areas or goods may cause world-wide welfare increases. In this context, foreign trade plays a critical role for the economic development of countries (Malkowska & Malkowski, 2021).In order for this to work fairly, the countries of the world should be in harmony or in peace. However, some poltical and manegerial desires or conflicts prevent this and serious development gap and deteration in world income distribution emerge. On the the hand, political structures, cultural structures, economic structures, institutions or effectiveness of the governments and geographical locations in which the countries are locared can also affect the form and volume of commercial activities. Dollar and Kraay (2002) examined the role of instiutions and international trade in economic development. They stated that countries grow faster through tarde when they have quality instutions. The one of the most important factors that affects export performance of countries is the business structures. The world countires may have differrent business structures and institutional criteria of market economies . This diferences can affect the economic activities positively or negatively.

Hall and Soskice (2001) define the Varieties of Capitalism that explain the institutional criteria of market economies that condition the strategic interactions among orgaznizations. According to their theory, firms should develop relationships to resolve coordination problems in five aspects, these are; industrial relations, vocational training and education, corporate governance, inter-firm relations, and relations with employees. One of the most important research in the Varieties of Capitalism is the study of Witt et al. (2018) who describe nine main types of business systems: Highly Coordinated, Coordinated Market, Liberal Market, European Peripheral, Advanced Emerging, Advanced City, Arab Oil-Based, Emerging, and Socialist Economies in their research.

This study examines export performances of the countries as classifed under the heading of Varieties of Capitalism using non-parametric Meta Frontier Analysis and parametric regression analysis over the period 2007 -2022 for 46 countries. For this purpose, six different sub-dimensions of logistic performance index (LPI), information communication technologies (broad bandwidth and mobile cellular), industrial production, real effective price index, and government effectiveness index are considered as inputs and export volume is assumed as an output for the countries.

With the increase of the importance of global trade, logistics operations have become crucial criteria for exporters and importers (Chu et al., 2015). So, organizations should give importance to logistics operations to respond quickly to the business market. Additionally, firms and governments need to pay attention to supply chain operations to be more productive in terms of time and cost, Therefore, Logistics Performance Index which is published by World Bank provides serious information about export performance for countries. The LPI has six sub-dimensions: "customs", "infrastructure", "international shipment", "quality of logistics services", "tracking/tracing" and "timeliness" for foreign trade have been frequently emphasized in the literature. With the globalization, the increasing international trade volume has especially promoted the importance of logistics activities, therefore in the recent years, policy makers have been making efforts regarding the logistics activities of their own countries.

The main finding of the study indicates that average annual export performance of liberal economies is higher than the other countries. Additionally according to panel regression estimation, logistic performance index, fixed broadband subscriptions, mobile cellular subscriptions, industry value added and real exchange rates have statistically significant positive impact on export performance of countries.

2. Literature Review

Logistics based foreign trade efficiency is a highly debated issue in recent years. Most of the research in the literature has examined logistics operations at the micro level. However, studies discussing logistics efficiency at the macro level are limited (Rashidi and Cullinane, 2019).

This study considers the theory of competitive advantage to show the importance of foreign trade for economies. Porter's (1990) theory basically depends on the a country's competitive advantage in international markets (Ren and Ma, 2018). The reason why we focus on logistics is that it gives institutions and states a competitive advantage in global trade. Bhatnagar and Teo (2009) considered logistics management as a part of the value chain proposed by Porter (1985). In this context, countries' foreign trade-logistics efficiency creates a competitive advantage for all countries, especially developing countries. In this context, Puertas et al. (2014) stated that logistics is very important criteria in exporting countries.

As mentioned above, LPI has been published by the World Bank since 2007, and many studies in the literature take these data into account (Marti et al., 2017; Önsel Ekici et al., 2019; Rashidi and Cullinane, 2019). Quariguasi et al. (2008)

discussed logistics networks and their efficiency in Germany, taking into account environmental and economic conditions. Additionally, Kabak et al. (2019) investigated the relationship between countries' logistics performance and competitiveness, and the methodology they used includes Bayesian Net (BN), Partial Least Squares (PLS) and Importance-Performance Map Analysis (IPMA). This study highlighted the importance of “Business Sophistication”, “Financial Market Development”, “Infrastructure”, “Good Market Efficiency” and “Higher Education and Training” as the factors that most influence logistics performance. Fechner (2010) argued that infrastructure has critical importance for improving logistics operations in countries. In addition, Marti et al. (2014) examined the effects of LPI subscales on trade performance for developing countries, and the study showed the importance of all LPI subscales on international trade. D'Aleo and Sergi (2017) investigated the relationship between LPI and Global Competitiveness Index (GCI) using panel data analysis. Sternad et al. (2018) used DEA to show the logistics efficiency of EU countries. Additionally, Luttermann et al. (2020) emphasized that there is a positive relationship between logistics performance and foreign direct investment as a result of panel data analysis for 20 Asian countries.

Additionally, Coto-Millán et al. (2013) investigated the relationship between countries' logistics performance and economic growth. Ekici et al. (2019) evaluated the effects of the Global Competitiveness Index (GCI) on the LPI and showed to policymakers the importance of digitalization and supply chain analytics in improving logistics performance. Similarly, Erkan (2014) examined the impact of technology with the Global Competitiveness Index (GCI) and LPI and pointed out the importance of technological infrastructure and market size for trade broad bandwidth and mobile cellular), industrial production, real effective price index, and government effectiveness index are considered as inputs and export volume is assumed as an output for the countries. Recently the logistics performance index (LPI) published by the World Bank provides serious information about export performance for countries. The LPI has six sub-dimensions: "customs", "infrastructure", "international shipment", "quality of logistics services", "tracking/tracing" and "timeliness" for foreign trade have been frequently emphasized in the literature. With the globalization, the increasing international trade volume has especially promoted the importance of logistics activities, therefore in the recent years, policy makers have been making efforts regarding the logistics activities of their own countries.

The main finding of the study indicates that average annual export performance of liberal economies is higher than the other countries. Additionally according to panel regression estimation, logistic performance index, fixed broadband subscriptions, mobile cellular subscriptions, industry value added and real exchange rates have statistically significant positive impact on export performance of countries.

3. Data

Data set contains the exports of goods and services (constant 2015 US$), fixed broadband subscriptions plus mobile cellular subscription as an indicator of ICT, government effectiveness (percentile rank), industry (including construction) value added (constant 2015 US$), logistics performance index: overall (1=low to 5=high), and real effective exchange rate index (2010 = 100) for 46 countries over the period 2007 and 2022. All data were obtained World Bank. The data are caregorized into dependent and indepededent variables to measure expoert performance of countries by using data envelopment analysis. In our study, dependent variable is the exports of goods and services (constant 2015 US$) and independent variablaes are the rest of the other variables mentioned above.

4. Methodology

We use non-parametric metafrontier aprroach based on data envelopment analysis to determine technical efficiency scores of decision making units (DMUs) regarding to metafrontier and sub-group level frontiers. The technical efficiency scores determined according to metafrontier covering all countries and sub-groups frontiers will allow us to make comparison between metafrontier technical efficiency scores and sub-groups technical efficiencey scores. In this way, technology gaps between sub-groups will be determined.

Metafrontier approach based on metaproduction function was defined Hayami and Ruttan (1971). This function or frontier envelops all sub-groups frontiers. Metafrontiers and sub-groups frontier to measure technical efficiency levels of DMUs can also be estimated using parametric methods, such as stochastic frontier approıach, SFA. Hovewer, in this study we preferred data envelopment analysis (DEA) to measure technical efficiency scores of the DMUs. The DEA is one kind of methods for determining the best production frontier. It is used more commonly in efficiency measurement because it doesn’t include any restriction on production function. For this, the non-parametric model have the high benefit of no requiring a particular functional form/shape for the frontier (Deliktas et al. 2013). However, in this study we also used regression analysis to see the relationship between the dependent variablers and the independent variables in terms of statistical significance and the magnitute of each independent variable on the dependent variable (see appendix). All independent variables except for real exchange rate are statistically significant (at 90 and 99 percent).

The concept of efficiency measurement by using DEA metafrontier framework was gradually developed by Rao, O'Donnell, & Battese (2003). The DEA metafrontier works to assess efficiencies of firms/units in different regions that operate under different technologies. This is a threshold concept for measuring country-side efficiency differences (Battese, Rao, & O' Donnell, 2004).

In metafrontier analysis the DMUs are divided into at least two sub groups in which it is assumed that each group operates under different production technology levels. If there is non-negative input and output vectors and the dimension of each sup groups are $(N \times 1)$ and $(M \times 1)$ respectively and y and x are non-negative real output and input vectors of dimension M x 1 and N x 1 respectively, then the metatechnology set contains all input-output combinations that are technologically feasible.

T = { } ( ) x, y : x ≥ 0;y ≥ 0 (1)

Where, x can produce y that the metatechnology is associated with input and output sets. The output set is determined by any input vector, x, as: P(x) = {y :(x,y)∈T}.

Starting from the general definition of the technology, the technolgy set of the g[th] group that meets all the necessary assumption can be defined as follows (Rambaldi et all. (2007), Rao et all (2003))

$$T^g = \{(x,y): x \in \Re_+^N, y \in \Re_+^M, x, y \text{ can produce}\} \quad (2)$$

Input and outpt sets related to production tecnology can also be defined as follows:

$$L^g(y) = \{x : (x,y) \in T, \text{each } y \in \Re_+^M\} \quad (3)$$

$$P^g(x) = \{y : (x,y) \in T, \text{each } x \in \Re_+^N\} \quad (4)$$

Because of each sub group is defined according to different technology level, the meta technology is defined as the sum of the sub group technolgies. That is,

$$T^m = Convex\,Hull\{T^1 \cup T^2 \cup ... \cup T^K\} \quad (5)$$

Then, the input-output cominations defined under each group technolgy constutes sub technolgies of metatechnogy.

Output distance function defined according to output set can be used to measure technical efficiency in the output oriented model. (See, O'Donnell et all. (2008), Battese et all.(2004)).

$$TE_t^g = D_t^g(x, y) \qquad (6)$$

$$TE_t^m = D_t^m(x, y) \qquad (7)$$

Under the meta-frontier or group-specific frontier if and only if when the observed (x, y) combination, $D(x, y) = 1$, it will be tecnically efficient.

As defined above, because of group technologies are the sub set of metafrontier technolgy

$$D_t^g(x_t, y_t) \geq D_t^m(x_t, y_t) \text{ will be.} \qquad (8)$$

Technical gap rate (TGR) can be defined as follows:

$$TGR_t(x_t, y_t) = \frac{D_t^m(x_t, y_t)}{D_t^g(x_t, y_t)} = \frac{TE_t^m(x_t, y_t)}{TE_t^g(x_t, y_t)} \qquad (9)$$

The technical efficiency score of the group-k is no greater than the technical efficency score under the metafrontier for the same decicion making units. Because the metafrontier will lie above any of the group frontiers because it envelops all the group frontiers. Therefore, the TGR cahnges between 0 and 1.

Tecnical efficiency scores for both metafrontier and group frontiers can be obtained with the DEA and SFA. Hovewer, this study used the DEA approach following O'Donnell ve Rao (2008).

5. Data Envelopment Analysis (DEA)

Data envelopment analysis is a non-parametric method based on linear programming techniques. A convex metafrontier and group frontiers are obtained by applying the DEA method to all the observed inputs and outputs of countries in each group and the whole sample. It is possible to construct a convex group-k frontier and metafrontier by applying the DEA method to all the observed inputs and outputs of firms in that group. If there are input and output data on groups including L_k firms for the T periods, the VRS (variable returns to scale) output oriented DEA problem as follows (O'Donnell and et all. 2008).

$max \ \emptyset_{it}$

$\emptyset_{it}, \lambda_{it}$

S.t. $\emptyset_{it} y_{it}$ - $y'\lambda_{it} \leq 0$

X λ_{it}-$x_{it} \leq 0$

$J'\lambda_{it} = 1$ and $\lambda_{it} \geq 0$ (10)

where

y_{it} is the output quantity for the *i*th country in the *t*th period;

x_{it} is the N × 1 vector of input quantities for the *i*th country in the tth period;

y is the $L_kT \times 1$ vector of output quantities for all L_k countries in all T periods;

X is the $N \times L_kT$ matrix of input quantities for all L_k countries in all T periods;

j is an $L_kT \times 1$ vector of ones;

λ_{it} is an $L_kT \times 1$ vector of weights; and

$\emptyset_{it}$ is a scalar.

The value of φit that solves the group-k problem can be shown to be no greater than the value of φit that solves the metafrontier problem. A meta-frontier representig the best practice technologyr is the envelope of all group frontiers, and provides a homogenous boundary for all heterogeneous groups (O'Donnell and et all. 2008).

6. Emprical Results

The group frontiers and the meta frontier scores were obtained the regarding to DEA model given by Eq. (10) using DEAP 2.1 sowtware (see Coelli 1996b). The technical efficiency score takes a value between 0 and 1. While zero means full inefficiency, 1 means full efficiency. The full efficiency indicates that the DMU uses resources efficiently and produces maximum output as given input set (output oriented case). Alternatively, it means that the DMU is producing the given output in a minimum set of input (input oriented case). Therefore, In the output-orientated case, while the DEA method holds inputs constant and seeks the maximum possible proportional increase in outputs, in the input-orientated case, DEA defines the frontier by holding output levels constant and seeking the maximum proportional reduction in input usage that is compatible with the technology set. The two measures give the same technical efficiency scores if the technology exhibits constant returns-to-scale, but different scores when the technology exhibits variable returns-to-scale (O'Donnell, and et all, 2008).

Since the meta-frontier envelops the all-group frontiers, the meta-efciency is lower than the group efciency, and the gap between the meta-frontier and group frontier means the diference between the group technology and the meta-technology. If the decision making units have different production technologies or economic structures, technological gap may ocur between metafrontier technology including whole sampel and group frontiers including sub samples. Technical gap ratio (TGR) is a distance measurement between the group frontier and the metafrontier. In the orher words, the TGR is the ratio of metafrontier technical efficiency score to group frontier technical efficency for each DMU (see equation 9). In this ratio, the higher the score of TGR indicates the smaller the gap between the group fontier (technology) and metafrontier (technology) . Therefore, As the TGR closes to 1 , it means that the best practice group frontier approaches to the best practice metafrontier. In other words, the group frontier technology more closely approaches the metafrontier technology. In contrast, the lower the score of TGR is the larger the gap between the group fontier (technology) and the metafrontier (technology). In other words, the group technology is farther away from the meta technology (Ming and Chen, 2020).

According the DEA model given in equation (10), the annual average technical efficiency scores under metafrontier technology and group frontier technology are given in Tables 1-4 for varieties of capitalist economies, such as emerging countries, coordinated countries, european peripheral countries and liberal economies respectively.

Table 1: Metafrontier, group frontier technical efficiency scores and technical gap ratios for Emerging Countries, 2007-2022

Country	MTE	ECTE	ECTGR
Algeria	0,146	0,161	0,909
Brazil	0,369	0,527	0,700
Bulgaria	0,105	0,106	0,997
Chile	0,141	0,150	0,935
China	1,000	1,000	1,000
Colombia	0,115	0,126	0,912
Hong Kong	1,000	1,000	1,000
Iran	0,226	0,293	0,773
Israel	0,205	0,206	0,996
Korea Rep.	0,591	0.944	0,573
Malaysia	0,382	0,429	0,890
Mexico	0,547	0,782	0,700
Phillippens	0,194	0,216	0,899
Russian	0,607	0,860	0,706
Pakistan	0,150	0,171	0,875
Singapur	1,000	1,000	1,000
South Africa	0,222	0,242	0,917
Türkiye	0,347	0,452	0,769
Ukraina	0,299	0,313	0,955
Mean	**0,402**	**0,446**	**0,901**

MTE is metafrontier technical efficency score; ECTE is technical efficency scores of emerging countries under group technology; ECTGR is technology gap ratio for emerging countries

Regarding to metafrontier technolog, China, Hong Kong, Singapur, Germany, United States of America are relatively full efficient (1.00) during to the entire period as given in the first column of Table 1-4. These countries determine the best practice frontier. On the other hand, Bulgaria and Colombia are less efficient respectively. If we compare average technical efficiency scores according to classification of countries, liberal countries have the highest average technical efficiency (0.626), secondly coordinated countries have 0.568, thirdly emerging countries have 0.402 and fourthly european peripheral countries have 0.362 scores under metafrontier technolgy.

Table 1 shows technical efficiency scores for emerging countries (group frontier) and TGRs. As considering group frontier, China, Hong Kong, Singapur are full efficient. They determine the best practice frontier for this group. Bulgaria and Colombia are less egfficent countries among emerging countries as in metafrontier technolgy. The third column shows technical gap ratios for emerging countries. China, Hong Kong, Singapur don't have technical gap. The rest of other countries have technical gaps at a different level. Hovewer, Korean Republic has the highest tehcnical gap (0.573) while Bulgaria and Isreal have less technical gap ratio, respectiveley. This TGR for Korea Rep. indicates that, given the input vector, the maximum output that could be produced by Korea Rep. is 57% of the output that is feasible using the metatechnology.

Table 2: Metafrontier, group frontier technical efficiency scores and technical gap ratios for Coordinated Countries, 2007-2022

Country	MTE	CCTE	CCTGR
Austria	0,378	0,589	0,641
Belgium	0,674	0,983	0,685
Denmark	0,361	0,734	0,493
Finland	0,203	0,402	0,504
Germany	1,000	1,000	1,000
Japan	0,579	0,632	0,917
Netherland	0,943	1,000	0,943
Norway	0,347	0,616	0,563
Sweden	0,410	0,566	0,724
Switzerland	0,785	1,000	0,785
Mean	**0,568**	**0,752**	**0,755**

MTE is metafrontier technical efficency score; CCTE is technical efficency scores of coordinated countries under group technology; CCTGR is technology gap ratio for coordinated countries

In Table 2, Germany has a full eficiency for the entire period regarding to metafrontier tehnology and group frontier tecnology. Therefore, there is no tecnological gap for Germany. In this group the bet practice frontier is determined by Germany, Netherland and Switzerland. Hovewer, Nerherland and Switzerland have inefficiency regarding to metafrontier, therefore they face tecnological gap. In this group, the technolgy gap is high for Denmark, Finland and Norway. The technology gap is small for Japan and Netherland.

Table 3: Metafrontier, group frontier technical efficiency scores and technical gap ratios for European Peripheral Countries,2007-2022

Country	MTE	EPCTE	EPCTGR
Czechia	0,297	0,999	0,298
France	0,747	1,000	0,747
Greece	0,155	0,623	0,248
Hungary	0,251	1,000	0,251
Iceland	0,323	1,000	0,323
Italy	0,651	0,965	0,675
Poland	0,409	0,851	0,480
Portugal	0,165	0,659	0,250
Romania	0,199	0,556	0,358
Slovakya	0,255	0,996	0,256
Spain	0,527	0,869	0,607
Mean	**0,362**	**0,865**	**0,418**

MTE is metafrontier technical efficency score; EPCTE is technical efficency scores of european peripheral countries under group technology; EPCTGR is technology gap ratio for european peripheral countries

Table 3 represents technical efficiency sores under metafrontier technology and group frontier technolgy. It also shows technolgy gap ratio for the European peripheral countries. Under metatechnology no country is full efficient but regarding to group frontier technology France, Hungary and, Iceland are full efficient. It means that they determine the best practice frontier for this group. Due to differences in technical efficiency scores under both technolgy, there is a tecnology gap. Greece, Hungary, Slovakya and Czechia have a higher technolgy gap respectively. France has the smallest technolgy gap.

Table 4: Metafrontier, group frontier technical efficiency scores and technical gap ratios for Liberal Countries,2007-2022

Country	MTE	LCTE	LCTGR
Australia	0,374	0,492	0,760
Canada	0,646	0,935	0,691
Ireland	0,834	1,000	0,834
New Zealand	0,149	0,413	0,362
United States of America	1,000	1,000	1,000
United Kingdom	0,755	1,000	0,755
Mean	**0,626**	**0,807**	**0,776**

MTE is metafrontier technical efficency score; LCTE is technical efficency scores of liberal countries under group technology; LCTGR is technology gap ratio for liberal countries

Table 4 shows the technical efficiency sores under metafrontier technology and group frontier technolgy. It also shows technolgy gap ratio for the Liberal countries The United States has also full efficiency under metafrontier tehnology and group frontier tecnology for the entire period. That is there is no technological gap for USA. While the USA is one of the countries that determine the best prectice frontier under meta technology, the USA, UK and Iceland are relatively full efficient countries determining the best practice group frontier. According to the technolgy gap ratio, column 4, New Zeland has the biggest technolgy gap, while Ireland has the smallest technology gap.

7. Conclusion

In this study, we examined export performances of the countries classified under variaties of capitalism using metafrontier approach based on data envelopment analysis over the period 2007-2022. To measure export performance, we used some explanatory variables, such as industrial value (in costant dollar), number of broadband subscription and mobile cellular, overal logistic performance inex, real exchange rate index, and government effectiveness, and one explained variable, nameley export volume in constant dollar.

Under metafrontier technology each country has a diferenet technical efficiency level. However, liberal countries has the highest technical efficiency score or the highest export performance compared to other classes, on average. Secondly coordinated countries, thirdly emerging countries have the hghest technical efficiency scores or export performances. The lowest technical eficiency score is belong to european peripheral countries, on average. On the other hand, the group frontiers indicate that there is a significant technological gap ratio (TGR) among countries regarding to export performance. The TGR is highest for the european peripheral countries on average. Secondly coordinated countries and thirdly liberal countries have a higher TGR on average. The emerging countries has the lowest TGR on average. It means that group frontier technology is more closely approaches the metafrontier technology for emerging economies.

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Appendix

Regression Estmation

Dependent Variable: LOG(EXP)
Method: Panel Least Squares
Date: 06/18/24 Time: 12:50
Sample: 2007 2022
Periods included: 7
Cross-sections included: 46
Total panel (unbalanced) observations: 322

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.674132	0.540000	12.35951	0.0000
LOG(END)	0.421380	0.052086	8.090154	0.0000
LOG(FBMB)	0.260078	0.058121	4.474754	0.0000
GEF	0.006862	0.003583	1.915322	0.0564
RER	0.001267	0.001466	0.864174	0.3882
LPG	0.971440	0.128158	7.579994	0.0000

Effects Specification

Period fixed (dummy variables)

R-squared	0.848742	Mean dependent var	25.97563
Adjusted R-squared	0.843375	S.D. dependent var	1.203969
S.E. of regression	0.476481	Akaike info criterion	1.391779
Sum squared resid	70.38072	Schwarz criterion	1.532446
Log likelihood	-212.0764	Hannan-Quinn criter.	1.447938
F-statistic	158.1344	Durbin-Watson stat	0.181936
Prob(F-statistic)	0.000000		