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Açık Erişim	Open Access
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Yayın Dili	Publication Language
Türkçe / İngilizce	Turkish / English
Ücret Politikası	Price Policy
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AMAÇ VE KAPSAM

Amaç

Selçuk Üniversitesi Sosyal ve Teknik Araştırmalar Dergisi, akademisyenler ve araştırmacılar tarafından sunulan; özgün, kaliteli ve bilimsel öneme sahip yayınlar yayınlarak, açık erişim yoluyla bilime, ilgili kurum ve kuruluşlara katkıda bulunmayı amaçlamaktadır. Dergi yayın sürecinde bağımsız ve çift kör hakem uygulaması ile değerlendirilen özgün makaleler, açık erişimli olarak çevrim içi yayınlanmaktadır. Gönderilen makaleler daha önceden yayınlanmamış ve başka bir yerde yayınlanmak üzere gönderilmemiş, özgün çalışmalar olmalıdır. Dergi kapsamına, gönderim ve yazım kurallarına uygun olarak gönderilen çalışmalar, öncelikle biçimsel ve alan uygunluğu açısından ilgili editörler tarafından değerlendirilir. Çalışma konusu, benzerlik oranı ve yazım kuralları açısından uygun olan makaleler, alanında uzman en az iki hakeme bilimsel değerlendirme için gönderilir. Makale yayınlanmasına ilişkin nihai karar, editör kurulu değerlendirmeleri ve hakem yorumları dikkate alınarak baş editör tarafından verilir. Selçuk Üniversitesi Sosyal ve Teknik Araştırmalar Dergisi'nin Yayın Kurulu, International Council of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME) ve Committee on Publication Ethics (COPE) kriterlerine uymayı taahhüt eder.

Kapsam

Selçuk Üniversitesi Sosyal ve Teknik Araştırmalar Dergisi, sosyal ve teknik alanda, belirtilen çalışma alanlarında özgün, araştırma ve tarama makaleleri, derlemeler ve kısa bildiriler gibi özgün bilimsel çalışmaları yayımlayan akademik bir dergidir.

Konu Kategorisi

Sosyal Bilimler: İşletme, Ekonomi, İletişim, Uluslararası İlişkiler, Kamu Yönetimi, Sosyal Konular, Kentsel Çalışmalar

Teknik Bilimler: Otomasyon & Kontrol Sistemleri, Bilgisayar Bilimi, İnşaat ve Yapı Teknolojisi, Mühendislik, Uzaktan Algılama Bilim Alanı: Sosyal Bilimler, Teknoloji

Yayın Dili

Tam Metin Yayın Dili:

- Birincil Dil: Türkçe
- İkincil Dil: İngilizce

Türkçe ve Latin Alfabesiyle Yazılan İçerik:

- Makale Başlığı: Türkçe & İngilizce
- Yazar Adı: (Latin Alfabesinde)
- Yazar Adresi: Türkçe & İngilizce (Latin Alfabesinde)
- Anahtar Kelimeler: Türkçe & İngilizce
- Kaynakça: Türkçe (Latin Alfabesinde) Tam Metin: Türkçe (Latin Alfabesinde)

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- Yazar Adı: (Latin Alfabesinde)
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- Kaynakça: İngilizce (Latin Alfabesinde) Tam Metin: İngilizce (Latin Alfabesinde)

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Selçuk Üniversitesi Sosyal ve Teknik Araştırmalar Dergisi yılda iki (2) kez olmak üzere Haziran ve Aralık aylarında yayınlanan hakemli bilimsel bir dergidir. Gönderilecek makaleler, derginin amaç ve kapsamına uygun, özgün çalışmalar olmalıdır. Bir yazardan aynı yayın döneminde birden fazla makale kabul edilmez. Son gönderim tarihinden sonra gönderilen çalışmalar kabul edilmez. Daha önceden yayınlanmamış, başka bir dergide değerlendirme sürecinde olmayan ve tüm yazarlar tarafından içeriği ve onaylanmış orijinal makaleler değerlendirmeye alınır.

Okur Kitlesi

Selçuk Üniversitesi Sosyal ve Teknik Araştırmalar Dergisi'nin hedef kitle; akademisyenler, uzmanlar, araştırmacılar, doktora, yüksek lisans ve uzmanlık öğrencileri yanı sıra bu alanlarla ilgili faaliyet gösteren kişilerdir. Dergi, söz konusu alanlarla ilgili akademik ve mesleki çalışmalarda araştırma ve sürekli geliştirme kültürünün yaygınlaşmasına katkı sağlamayı hedefler.

Ücret Politikası

Dergide makale yayını ve makale süreçlerinin yürütülmesi ücrete tabi değildir. Dergiye gönderilen ya da yayın için kabul edilen makaleler için hiçbir ad altında işleme ücreti ya da gönderim ücreti alınmaz. SosyoTeknik dergisi yayın politikaları gereği sponsorluk ve reklam da kabul etmemektedir. SosyoTeknik dergisinin tüm giderleri Yayıncı tarafından karşılanmaktadır.

Makalelerin Özgünlüğü

SosyoTeknik Dergisi daha önceden başka yerde yayınlanan çalışmaları kabul etmez.

Hakemlik Türü

Çift Körleme: İntihal kontrolünden sonra, uygun olan makaleler baş editör tarafından orijinallik, metodoloji, işlenen konunun önemi ve dergi kapsamı ile uyumluluğu açısından değerlendirilir. Editör, makalelerin adil bir şekilde çift taraflı kör hakemlikten geçmesini sağlar ve makale biçimsel esaslara uygun ise, gelen yazıyı yurtiçinden ve /veya yurtdışından en az iki hakemin değerlendirmesine sunar, hakemler gerek gördüğü takdirde yazıda istenen değişiklikler yazarlar tarafından yapıldıktan sonra yayınlanmasına onay verir. Editörler, hakemler ile yazarlar arasındaki tüm etkileşimlere aracılık eder.

COPE'un En İyi Uygulama İlkeleri

SosyoTeknik Dergisi, araştırma ve yayın etiği konusunda ulusal ve uluslararası standartlara bağlıdır. Basın Kanunu, Fikir ve Sanat Eserleri Kanunu ile Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi'ne uymaktadır. SosyoTeknik, Committee on Publication Ethics (COPE), Directory of Open Access Journals (DOAJ), Open Access Scholarly Publishers Association (OASPA) ve World Association of Medical Editors (WAME) tarafından yayınlanan Uluslararası Etik Yayıncılık İlkeleri'ni benimsemiştir. Ayrıca Türkiye Editörler Çalıştay Kararlarına da uymayı taahhüt eder.

İntihali Önleme

Bu dergi, incelenmeye sunulan çalışmalarda intihal olup olmadığını kontrol eder: Ön kontrolden geçirilen makaleler, iThenticate yazılımı kullanılarak intihal için taranır. İntihal/kendi kendine intihal tespit edilirse yazarlar bilgilendirilir. Editörler, gerekli olması halinde makaleyi değerlendirme ya da üretim sürecinin çeşitli aşamalarında intihal kontrolüne tabi tutabilirler. Yüksek benzerlik oranları, bir makalenin kabul edilmeden önce ve hatta kabul edildikten sonra reddedilmesine neden olabilir. Bu oranın %20'den az olması beklenir.

Düzeltilme, Geri Çekme, Endişe İfadesi

Editörler, yayınlanan makalede, bulguları, yorumları ve sonuçları etkilemeyen küçük hatalar tespit edilirse düzeltme yayınlamayı düşünebilirler. Editörler, bulguları ve sonuçları geçersiz kılan büyük hatalar / ihlaller söz konusu olduğunda, makaleyi geri çekmeyi düşünmelidir. Yazarlar tarafından araştırma veya yayını kötüye kullanmaya yönelik olasılık söz konusu ise; bulguların güvenilir olmadığına ve yazarların kurumlarının olayı soruşturmadığına dair kanıtlar var veya olası soruşturma haksız veya sonuçsuz görünüyorsa, editörler endişe ifadesi yayınlamayı düşünmelidir. Düzeltme, geri çekme veya endişe ifadesi ile ilgili olarak COPE ve ICJME yönergeleri dikkate alınır.

Hakem Raporlarının Saklanması

SosyoTeknik makale inceleme sürecine ait tüm kayıtları arşivlemekte ve korumaktadır.

Öz ve Anahtar Kelimeler

Makaleler, elektronik aramayı kolaylaştırmak için 150-200 kelimelik özet ve 3-5 arası anahtar kelime içermelidir.

Yazarlık ve Katkıda Bulunma

Makale yayınlanmak üzere Dergiye gönderildikten sonra yazarlardan hiçbirinin ismi, tüm yazarların yazılı izni olmadan çıkarılamaz ve yeni bir isim eklenemez. Ayrıca yazar sırası değiştirilemez.

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SosyoTeknik Dergisi yayın kuralları gereğince, Etik Kurul İzni/yasal/özel izin gerektiren çalışmalarda, Etik Kurul İzni'nin nereden, hangi kapsam, hangi tarih ve sayı numarasında alındığını belirten ifadeyi, makalenin Dergiye sunulması esnasında makale içerisinde mutlaka belirtilmesi gerekmektedir.

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ETİK İLKELER VE YAYIN POLİTİKASI

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SosyoTeknik dergisi, araştırma ve yayın etiği konusunda ulusal ve uluslararası standartlara bağlıdır. Basın Kanunu, Fikir ve Sanat Eserleri Kanunu ile Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi'ne uymaktadır. SosyoTeknik, Committee on Publication Ethics (COPE), Directory of Open Access Journals (DOAJ), Open Access Scholarly Publishers Association (OASPA) ve World Association of Medical Editors (WAME) tarafından yayınlanan Uluslararası Etik Yayıncılık İlkeleri'ni benimsemiştir. Ayrıca Türkiye Editörler Çalıştay Kararlarına da uymayı taahhüt eder.

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•SosyoTeknik Dergisi'ne gönderilen makalelerin tüm değerlendirme aşamalarında makale yazarları ile makaleyi değerlendiren hakem kimlikleri çift körleme ile gizlenmektedir. Makalelerin yayınlanması için iki olumlu hakem raporu gereklidir.

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•SosyoTeknik Dergisinin Yayın Kuralları gereğince, yazarlardan makale gönderim ve yayın ücreti alınmamaktadır. Dergimizde makale gönderimi ücretsizdir.

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•SosyoTeknik dergisine gönderilen makaleler Yazar(lar) tarafından kişisel kullanıma açık olan iThenticate yazılımı ile kaynaklar hariç olmak üzere intihale karşı kontrol edilmektedir. Yapılan kontrollerde benzerlik oranının %20'nin altında olması ve tek kaynak benzerlik oranının %5'i geçmemesi gerekmektedir.

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AIMS AND SCOPE

Aim

SosyoTeknik aims to contribute to science and related institutions and organizations through open access by publishing original, quality and scientifically significant studies presented by academics and researchers. Original articles evaluated by independent and double-blind referee application during the publication process of the journal are published online as open access. Submitted articles must be original works that have not been previously published or submitted for publication elsewhere. Studies submitted to the scope of the journal in accordance with the submission and spelling rules are primarily evaluated by the relevant editors in terms of format and field suitability. Articles that are suitable in terms of study subject, similarity rate and spelling rules are sent to at least two referees who are experts in their fields for scientific evaluation. The final decision regarding the publication of the article is made by the editor-in-chief, considering the evaluations of the editorial board and the comments of the referees. The Editorial Board of SosyoTeknik undertakes to comply with the criteria of the International Council of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME) and Committee on Publication Ethics (COPE).

Scope

SosyoTeknik is an academic journal that publishes original scientific studies in the social and technical fields, such as research and survey articles, reviews and short papers in the specified fields of study.

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SELÇUK ÜNİVERSİTESİ SOSYAL VE TEKNİK ARAŞTIRMALAR DERGİSİ

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SELÇUK ÜNİVERSİTESİ SOSYAL VE TEKNİK ARAŞTIRMALAR DERGİSİ

Endüstri 4.0'ın Görsel Haritalama Tekniği ile Bibliyometrik Analizi

Utku Tevfik GÜLEÇ 

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Öz

Bu araştırmada Web of Science (WoS) veri tabanından sağlanan Endüstri 4.0 ile ilgili makalelerin görsel haritalama tekniği kullanılarak bibliyometrik analizi yapılmıştır. Araştırmada toplam 9763 adet makalenin performans analizi yapıldıktan sonra görsel haritalama için VOSviewer paket programı kullanılarak bibliyometrik analizi yapılmıştır. Endüstri 4.0 konusunda en çok makale ve atıf sayısının 2022 yılında olduğu tespit edilmiştir. Bu konuda en çok makale yayımlayan ülkenin İtalya olduğu saptanmıştır. Bu alanda en çok makale yayımlayan yazarın “Kumar, A” olduğu belirlenmiştir. Bu konuda en çok atıf alan yazarın “Wan, J.” olduğu saptanmıştır. Bu araştırma alanında en çok atıf alan kaynağın “International Journal of Production Research” olduğu tespit edilmiştir. Endüstri 4.0 makalelerinde en çok kullanılan anahtar kelimelerin “Endüstri 4” ve “Nesnelerin İnterneti” olduğu belirlenmiştir. Bu konuda en çok ortak atıf alan yazarın “Tao, F” olduğu tespit edilmiştir.

Anahtar Kelimeler

Endüstri 4.0, Bibliyometrik Analiz, Görsel Haritalama, VOSviewer.

Atıf Bilgisi

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Bibliometric Analysis of Industry 4.0 with Visual Mapping Technique

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Abstract

In this research, bibliometric analysis of Industry 4.0 related articles from the Web of Science (WoS) database was conducted using visual mapping technique. After the performance analysis of a total of 9763 articles, bibliometric analysis was performed using the VOSviewer package program for visual mapping. It was found that the highest number of articles and citations on Industry 4.0 was in 2022. It was found that Italy was the country that published the most articles on this topic. It was determined that the author who published the most articles in this field was "Kumar, A". It was determined that the most cited author in this field is "Wan, J". It was determined that the most cited source in this field is "International Journal of Production Research". It was determined that the most commonly used keywords in Industry 4.0 articles are "Industry 4" and "Internet of Things". It was found that the author who received the most co-citations on this topic is "Tao, F".

Keywords

Industry 4.0, Bibliometric Analysis, Visual Mapping, VOSviewer.

Citation

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Giriş

Son zamanlarda, neredeyse bütün sektörlerdeki işletmeler, güncel teknolojileri keşfetmek ve bunlardan faydalanmak amacıyla birtakım girişimlerde bulunmaktadır. Bu çoğunlukla temel iş operasyonların dönüştürülmesini kapsamakla birlikte ürün, süreç, örgüt yapısı ve yönetimle ilgili kavramları da dönüştürebilmektedir. İşletmelerin bu karmaşık dönüşümleri yönetmek amacıyla yönetim uygulamaları oluşturması gerekli olmaktadır. İşletmeler kendi bünyelerindeki dijital dönüşümlerin koordinasyonunu, önceliklendirmesini ve uygulamasını bütünleştirmek amacıyla bir dijital dönüşüm stratejisini formüle etmesi önemli olmaktadır. Dijital dönüşüm stratejileri farklı bir perspektifi benimsemekle birlikte farklı hedefleri de takip edebilmektedir. Dijital dönüşüm stratejileri olarak ürünlerde, hizmetlerde, iş modellerinde dijital teknolojilerin kullanılmasıyla birlikte aynı zamanda müşteri tarafında da dijital uygulamaları kapsamaktadır (Matt vd., 2015: 339-340).

Endüstri 4.0 sadece endüstri ile ilgili olmamaktadır. Bununla birlikte dijital entegrasyon ve akıllı mühendislik sistemleri aracılığıyla gerçekleştirilen dijital dönüşümle de ilgilidir. Endüstri 4.0, farklı teknolojiler aracılığıyla makinelerin birbirleriyle iletişim kurarak ilgili işlevleri gerçekleştirmesi şeklinde açıklanmaktadır (Muhuri vd., 2019: 218). Günümüzde işletmelerin, üniversitelerin ve araştırma merkezlerinin çalışmalarını Büyük Veri, Bulut Bilişim, 3D Baskı, Siber Güvenlik, Otonom Robot, Nesnelerin İnterneti, Artırılmış Gerçeklik, Simülasyon vb. gibi farklı teknolojilerin entegrasyonunu kapsayan Endüstri 4.0 üzerine yoğunlaştırdığı görülmektedir. Bundan dolayı Endüstri 4.0 son dönemlerde işletmelerin ve kuruluşların iş ve üretim süreçlerinde dönüşüm sağlamaktadır. Bu dönüşüm, sanal ve fiziksel ortam arasındaki sınırları ortadan kaldıran, çalışanları, makineleri, ürünleri, üretim sistemleri ve süreçleri bütünleştiren yıkıcı teknolojik gelişmelerden oluşmaktadır. Bu dönüşümün işletmelere ve kuruluşlara sağladığı faydalar; üretim süreçlerini gerçek zamanlı olarak izleme, üretim süreçlerini iyileştirme, verimliliği artırma, üretkenliği artırma, çevikliği artırma, tedarik zincirini gerçek zamanlı takip edebilme, daha yüksek iş sürekliliği, tüketicilere kişiselleştirme ve özelleştirme imkânı sunma, sürdürülebilirlik ve yeni iş modelleri geliştirme olanağı sağlama şeklinde ifade edilmektedir. Endüstri 4.0 ve onu mümkün hâle getiren teknolojilerin hızlı gelişimi sebebiyle araştırmacıların hangi konulara odaklandığının analiz edilmesi ve görselleştirilmesi bu dönemde gelişme ve ilerleme için gerekli olmaktadır (Cobo vd., 2018: 364-365; Pereira ve Romero, 2017; Gedik, 2021).

Bibliyometrik analiz; belli bir araştırma alanına yönelik literatürdeki mevcut eğilimleri analiz etmeye olanak sağlayan, gelecekteki araştırmalar için rehber olan ve motivasyon sağlayan bir analiz türü olmaktadır. Esasen bu analiz, bir araştırma alanının genel bir taslağını ve genel bir yapısını sunmaktadır (Muhuri vd., 2019: 218). Bu araştırmanın amacı, Endüstri 4.0 konusunun Web of Science (WoS) veri tabanında 2013-2023 yılları arasındaki yayımlanan makaleler üzerinden bibliyometrik olarak analiz edilmesidir. Bu çerçevede araştırma, Endüstri 4.0 alanında son yıllarda artan akademik ilgiyi sistematik biçimde ortaya koymak amacıyla WoS veri tabanındaki yayınlar üzerinden görsel haritalama teknikleriyle desteklenen bir bibliyometrik analiz sunmaktadır. Endüstri 4.0 alanında yapılan araştırmaların bibliyometrik analiziyle ilgili literatürde bir boşluk olduğu belirlenmiştir. Literatürde bu kapsamda yapılmış araştırmalar sınırlı olup (özellikle Türkiye merkezli), bu araştırma disiplinler arası ve uluslararası eğilimleri nicel olarak belirleyerek bu boşluğu doldurmayı hedeflemektedir. Bu araştırmadan elde edilen sonuçlar, Endüstri 4.0 alanında çalışma yapacak araştırmacılara alana dair bütünsel bir öngörü sunmaktadır. Aynı zamanda uygulayıcılara da Endüstri 4.0'ın gelişimine yönelik bir perspektif sağlamaktadır.

1. Kavramsal Çerçeve

Endüstri kavramı, çok fazla mekanik ve otomatikleştirilmiş bir şekilde maddi ürünler üreten bir ekonominin bir bölümünü oluşturmaktadır. Sanayileşmenin başlamasından beri teknolojik sıçramalar son yıllarda endüstriyel devrim olarak isimlendirilen paradigma değişimlerine sebep olmuştur. Birinci Endüstri Devrimi, makineleşme anlamında ortaya çıkmıştır. İkinci Endüstri Devrimi, elektrik enerjisinin yoğun bir şekilde kullanımıyla ortaya çıkmıştır. Üçüncü Endüstri Devrimi, dijitalleşme anlamında ortaya çıkmıştır. Son olarak Dördüncü Endüstri Devrimi ortaya çıkmıştır. Böylelikle, fabrikalar içindeki gelişmiş internet teknolojilerinin ve geleceğe yönelik teknolojilerin akıllı nesneler alanındaki birleşimi, yeni bir paradigma değişimine yol açmıştır. Gelecekteki üretim vizyonu, modüler ve verimli üretim sistemlerini içermektedir. Bununla birlikte ürünlerin kendi üretim süreçlerini kontrol ettiği senaryoları kapsamaktadır. Bu durumda seri üretimin ekonomik koşulları korunmakla birlikte tek tek ürünlerin bir parti boyutunda üretimini gerçekleştirmesi beklenmektedir (Lasi vd., 2014: 239).

Xu (2018), endüstri devrimlerini kısaca açıklamıştır. Birinci Endüstri Devriminde su ve buhar gücünden faydalanılarak mekanik üretim tesisleri meydana çıkmıştır. İkinci Endüstri Devriminde elektrik enerjisi yoluyla

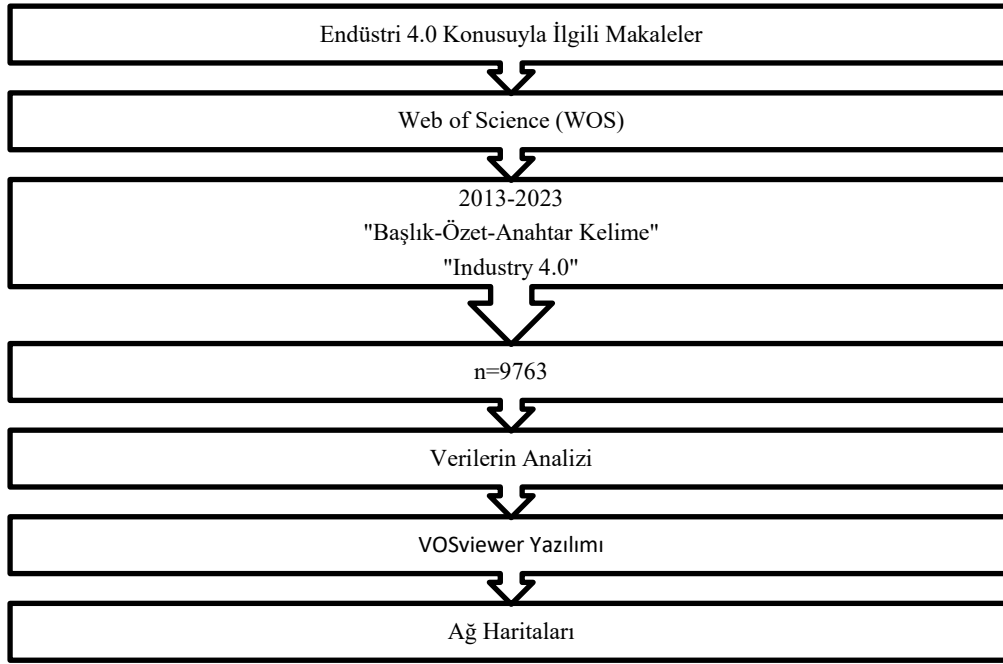
seri üretim ortaya çıkmıştır. Üçüncü Endüstri Devriminde üretim otomasyonunu geliştiren elektronik ve bilgi teknolojileri ortaya çıkmıştır. Dördüncü Endüstri Devriminde siber-fiziksel sistemlerin (CPS) kullanılmasıyla birlikte endüstride paradigma değişimi harekete geçmiştir (Xu vd., 2018: 2941-2942). Dördüncü Endüstri Devrimi ile birlikte akıllı fabrikalar ve her şeyin interneti (IoE) konuları gündeme gelmiştir. Böylelikle insanları, nesneleri (makineler ve ürünler gibi) ve verileri bir araya getirerek endüstriyel süreçleri düzenlemenin ve yürütmenin yeni yolları ortaya çıkmaktadır (Hermann vd., 2016: 3929).

Endüstri 4.0, ürünlerin ve makinelerin tamamının internete bağlandığı, birbirleriyle iletişim kurduğu, veri alışverişi yaptığı, verileri topladığı ve analiz ettiği ve süreçleri dağıtılmış bir şekilde düzenlediği fabrikaları ve tedarik zincirlerini kapsamaktadır. Bu veri odaklı bütünleşmiş sistem, gelecekte daha esnek fabrikalarının oluşmasını sağlamakla birlikte üretimde müşteri isteklerine daha iyi cevap verebilmeyi sağlamaktadır. Aynı zamanda Endüstri 4.0 anlayışı; gerçek zamanlı kontrol, entegre bakım, daha iyi uyarlanabilirlik, tedarik zinciri boyunca gelişmiş iş birliği, daha iyi takip ve izleme yetenekleri, daha akıllı ürünler ve yeni iş modellerini sağlamaktadır (Branke vd., 2016: 263-264). Endüstri 4.0 kavramının temelini oluşturan teknolojiler; Büyük Veri ve Analitik, Otonom Robotlar, Simülasyon, Yatay ve Dikey Sistem Entegrasyonu, Endüstriyel Nesnelerin İnterneti, Siber Güvenlik, Bulut Teknolojisi, Katmanlı Üretim, Artırılmış Gerçeklik olarak sıralanabilir (Rüßmann vd., 2015: 4). Endüstri 4.0'ın temelini oluşturan teknolojiler; üretim operasyonlarında tek tek ve bütün olarak maliyetleri azaltma, esnekliği artırma, hızı ve kaliteyi artırma gibi olanakları sağlamaktadır. Katmanlı üretim ve robotik, ekonomik üretim için gerekli olan en az maliyeti sağlamakla birlikte esnekliği ve üretimi başlatma hızını artırmaktadır. Nesnelerin interneti, blok zinciri ve dijitalleşme, fabrikalar içinde ve mekânsal olarak dağınık varlıklar arasında uzaktan ve gerçek zamanlı izleme, tanımlama, kontrol ve optimizasyon sağlamaktadır. Böylelikle faaliyetleri dinamik ve hızlı bir şekilde düzenleyebilen, küresel olarak dağıtılmış ve çevik bir üretim ağı mümkün hâle gelmektedir (Olsen ve Tomlin, 2020). Özetle Endüstri 4.0'ın faydaları; üretim esnekliğini artırma, kalite standartlarını iyileştirme, verimliliği ve üretkenliği artırma, kitlesel kişiselleştirmeye imkân sağlama, üretim faaliyetlerinin optimizasyonuna katkı sağlama olarak sıralanabilir (Güleç, 2021).

Pereira ve Romero (2017), Endüstri 4.0'ın Siber-Fiziksel Sistemler ve Nesnelerin ve Hizmetlerin İnterneti olarak iki ana itici gücünün olduğunu tespit etmiştir. Cañas vd. (2021), Endüstri 4.0'ın tasarım ilkelerinin; ara bağlantı/bağılantısallık, merkezi olmayan karar verme, insan faktörü, zeka/farkındalık, birlikte çalışabilirlik, bilgi şeffaflığı, teknoloji, organizasyon, kavramsal çerçeveler ve üretim planlaması olduğunu belirlemiştir. Ghobakhloo (2020), Endüstri 4.0'ın üretim verimliliği ve iş modeli inovasyonu gibi ekonomik sürdürülebilirlik işlevlerini gerçekleştirme noktasında katkı sağladığını tespit etmiştir. Oztemel ve Gursev (2020), Endüstri 4.0'ın temel gereksinimleri olarak yenilikçi üretim ortamı, akıllı mobilite, bulut bilişim yetenekleri ve bilgi güvenliğinin kabul edilebileceğini ifade etmiştir. Hizam-Hanafiah vd. (2020), Endüstri 4.0'ın en önemli hazırlık boyutlarını; teknoloji, insan, strateji, liderlik, süreç ve inovasyon olduğunu tespit etmiştir. Sony ve Naik (2020), kuruluşların/organizasyonların Endüstri 4.0'a hazır olup olmadığını değerlendirmeye yönelik bileşenleri; üst yönetimin katılımı ve bağlılığı, Endüstri 4.0'a çalışanların uyumluluğu, akıllı ürün ve hizmetler, tedarik zincirinin dijitalleşmesinin kapsamı, organizasyonel stratejinin hazırlığı, organizasyonun dijitalleşme düzeyi olarak belirlemiştir. Çetinkaya (2021), işletmelerin Endüstri 4.0 farkındalığının inovasyon düzeyini artırdığını saptamıştır. Alkış vd. (2020), işletmelerde Endüstri 4.0 uygulamalarının taşıma yönetiminde operasyonel verimliliği artırdığını tespit etmiştir. Javaid vd. (2022), Endüstri 4.0'ın işletmelerde ürünleri daha iyi verimlilikle üretmeyi ve kaynak tüketimini azaltmayı sağlaması açısından çevresel olarak sürdürülebilir bir teknoloji olduğunu ifade etmiştir. Bai vd. (2020), Endüstri 4.0 teknolojilerinden olan nanoteknoloji, mobil teknoloji, simülasyon ve dronların otomotiv, elektronik, gıda ve içecek, tekstil, hazır giyim ve ayakkabı sektörlerinde sürdürülebilirlik üzerinde en yüksek etkiye sahip olduğunu tespit etmiştir.

2. Yöntem

Bu araştırmanın amacı, popüler hâle gelen Endüstri 4.0 konusunun Web of Science veri tabanında 2013-2023 yılları arasındaki yayımlanan makaleler üzerinden bibliyometrik olarak analiz edilmesidir. Web of Science (WoS) veri tabanında araştırma yapılırken "Industry 4.0" anahtar kelimesiyle arama yapılmıştır. Bu aramada doküman türü olarak sadece makaleler taranmıştır. Sonuç olarak 9763 adet makale bu araştırmanın verisi olmuştur. Bu veriler aracılığıyla bibliyometrik analiz yapılırken performans analizi ve görsel haritalama yöntemlerinden faydalanılmıştır. Bu araştırmanın akış şeması Şekil 1'de gösterilmektedir.



Şekil 1. Araştırmanın akış şeması

Bibliyometri, bilimsel araştırmaların bibliyografik unsurlarından sağlanan bilgilerin sayısal olarak analizler ve istatistikler aracılığıyla incelenmesidir. Bibliyometrik analizler tanımlayıcı nitelikte olarak yani belli bir yılda yayımlanan araştırma sayısının tespit edilmesi için yapılabilmektedir. Aynı zamanda bibliyometrik analizler değerlendirici nitelikte olarak yani bir araştırmanın kendisinden sonra gelen araştırmaları ne şekilde etkilediğini belirlemek için de yapılabilmektedir (Zan, 2019: 502). Bibliyometrik araştırmalar, araştırılan bilim dalına, ülke ve/veya ülke gruplarına, kurumlara ya da yazarlara yönelik olarak bilimsel araştırmaların değerlendirilmesine ve mevcut duruma ait tespitlerde bulunulmasına imkân sağlamaktadır. Bu tespitler ve bulgular çerçevesinde araştırılan bilim dalı, ülke, kurum vb. için gelişmeler ve geçmiş durum ile birlikte gelecekteki durumlarına ait değerlendirmeler gerçekleştirilebilmektedir (Şakar ve Cerit, 2013: 38).

Bibliyometrik araştırmalar bir bilimsel alandaki yeni araştırmacıların bir konunun kapsamını, oluşan eğilimlerini ve zaman içindeki gelişimini belirlemelerine yardımcı olmaktadır. Bu araştırmalar klasik bir literatür taramasından farklı olmaktadır. Bibliyometrik analizler Web of Science gibi kapsamlı veri tabanları sayesinde yapılabilmektedir. Bu veri tabanı, Clarivate Analytics tarafından yönetilen bir atıf indeksleme hizmeti sunmaktadır. Aynı zamanda Web of Science 1898 yılından itibaren başlayan indeksleme kapsamıyla dergi, konferans bildirisi gibi dokümanların seçici bir listesini sağlamaktadır (Merediz-Solà ve Bariviera, 2019: 294). Bibliyometrik analiz, bibliyografik veriler üzerinden nicel yöntemle bilimsel literatürü analiz etmek amacıyla kullanılmaktadır. Aynı zamanda bu analizde bilimsel alanlar, dergiler, ülkeler vb. ayrıntılı olarak analiz edilebilmektedir (Imani vd., 2019: 4). Bibliyometrik analiz, nicel bir gösterge olmakla birlikte bu analizde incelenen araştırmalardaki yayınların kalitesi ve içeriği üzerine yorum yapılamamaktadır (Estabrooks vd., 2004: 302). Bibliyometrik analizde belirli bir alanın durumunu analiz etmek amacıyla iki önemli yöntem kullanılmaktadır. Bunlar performans analizi ve bilimsel/görsel haritalama yöntemi olmaktadır. Performans analizi esasen dergilerin, ülkelerin, kurumların ve yazarların atıf ve literatür dağılımlarını değerlendirmektedir. Görsel haritalamada ise veriler farklı görselleştirme teknikleri aracılığıyla doğrudan sunulmaktadır (Tang vd., 2018: 1403). Yani görsel haritalama, bilimsel alanların, konuların, yayınların ve yazarların birbirleriyle nasıl ilişkili olduklarının görsel bir temsiliyi ortaya koymaktadır (Small, 1999: 799).

Son yıllarda bilgisayarların ve internetin gelişmesiyle birlikte bibliyometrik bir araştırma yapmak çok daha ekonomik hâle gelmiştir. Zira toplanan veriler çevrim içi olarak mevcuttur ve farklı bilgisayar yazılımları aracılığıyla bibliyografik verilerden ilginç sonuçlar çıkarılabilmektedir. Bu araştırmada VOSviewer programının kullanılması sebebi, bibliyografik verilerin görsel ve bilgilendirici haritalarını güçlü bir şekilde sunmasıdır. Ayrıca VOSviewer programı, ortak atıf, bibliyografik eşleşme, anahtar kelime gibi analizleri kolayca yaparak bu analiz sonuçlarının sınıflandırılmasını mümkün hâle getirmektedir (Rialp vd., 2019).

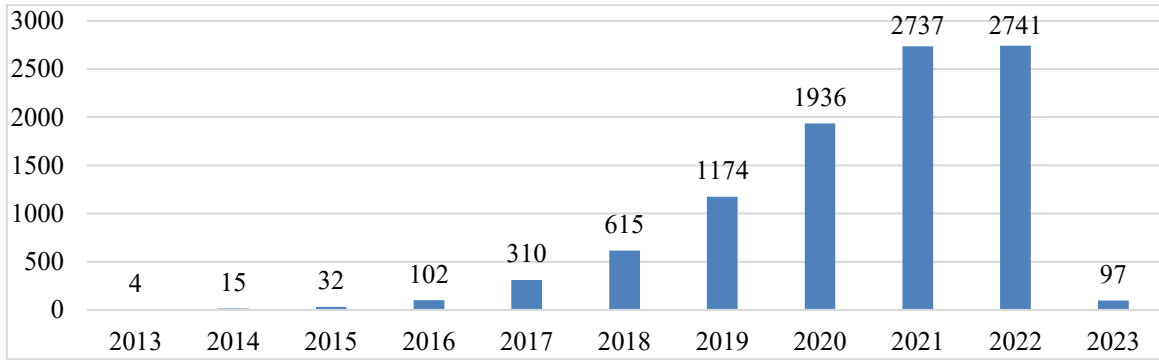
3. Bulgular

Bu bölümde ilk olarak Web of Science (WoS) veri tabanından elde edilen makalelere yönelik verilerin performans analizi bulguları sunulmuştur. Bu bulgular; yıllara göre yayımlanan makale sayıları, yıllara göre atıf sayıları, en fazla makale yayımlayan ilk 10 ülke, en fazla makale yayımlanan ilk 10 alan, en fazla makale yazar ilk 10 yazar, en çok atıf yapılan ilk 10 makale olmaktadır. Daha sonra VOSviewer programı aracılığıyla elde edilen görsel haritalama bulguları sunulmuştur. Bu bulgular; ortak yazar ağ haritası, yazar atıf ağ haritası, kaynak atıf ağ haritası, ülke atıf ağ haritası, anahtar sözcük ağ haritası, dokümanların bibliyografik eşleşme ağ haritası, yazarların ortak atıf ağ haritası olmaktadır.

3.1. Performans Analizi Bulguları

3.1.1. Yıllara Göre Yayımlanan Makale Sayıları

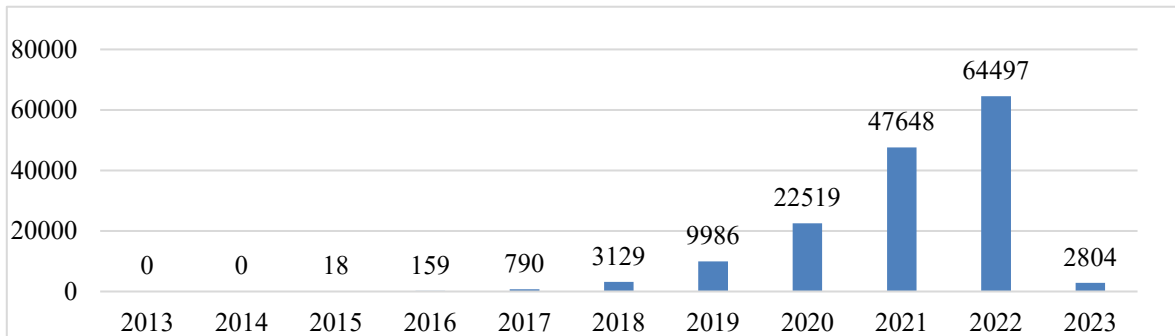
Endüstri 4.0'a ilişkin yıllara göre yayımlanan makale sayıları Şekil 2'de yer almaktadır. Dünya genelinde Endüstri 4.0 ile ilgili 2013-2023 (2023 yılı sadece ocak ayı) yılları arasında toplam 9763 adet makale yayımlanmıştır. Bu konuda ilk makale 2013 yılında yayımlanmıştır. En çok makale yayımlanan yıl, 2022 yılı olmuştur. Bu yılda 2741 adet makale yayımlanmıştır. Böylelikle bu konuyla ilgili makalelerin son yıllarda artış gösterdiği gözlemlenmiştir. 2023 yılında da söz konusu artışın devam edeceğini söylemek mümkündür. Böylelikle literatürde bu konuya yönelik ilginin artacağı söylenebilir.



Şekil 2. Yıllara göre yayımlanan makale sayıları

3.1.2. Yıllara Göre Atıf Sayıları

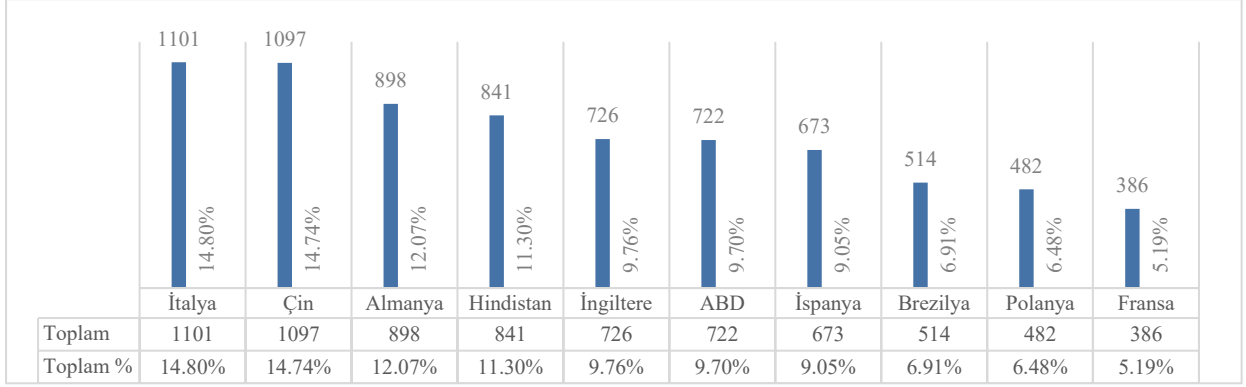
Endüstri 4.0'a ilişkin yıllara göre atıf sayıları Şekil 3'de yer almaktadır. 2014 yılından itibaren atıf sayılarında düzenli bir artış eğilimi görülmektedir. Bu artış eğilimi 2019 yılından itibaren daha da hızlanmıştır. 2023 yılında da bu artış eğiliminin devam edeceği söylenebilir. Endüstri 4.0 konusuna yönelik makaleler artıkça atıf sayılarının da arttığı tespit edilmiştir.



Şekil 3. Yıllara göre atıf sayıları

3.1.3. En Fazla Makale Yayımlayan İlk 10 Ülke

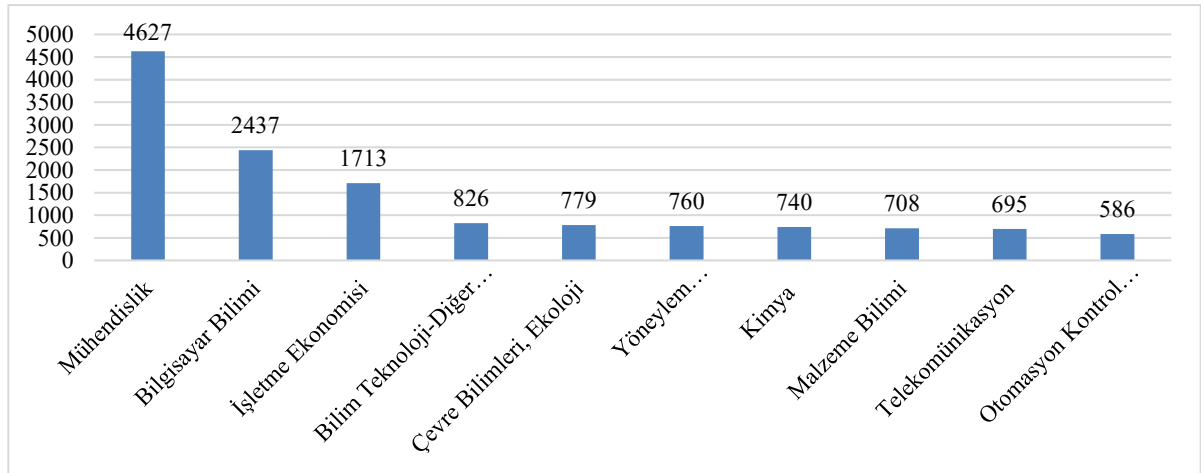
Endüstri 4.0'a ilişkin en fazla makale yayımlayan ilk 10 ülke Şekil 4'te verilmiştir. En fazla makale yayımlayan ülkeler incelendiğinde; ilk sırada 1101 makale (%14,80) ile İtalya, ikinci sırada 1097 makale (%14,74) ile Çin, üçüncü sırada ise 898 makale (%12,07) ile Almanya yer almaktadır. Literatürde Endüstri 4.0 alanına en çok katkı yapan ülkenin İtalya olduğu tespit edilmiştir. Gelişmiş ülkelerin Endüstri 4.0 konusuna yönelik ilgisinin yüksek olduğu söylenebilir.



Şekil 4. En fazla makale yayımlayan ilk 10 ülke

3.1.4. En Fazla Makale Yayımlanan İlk 10 Alan

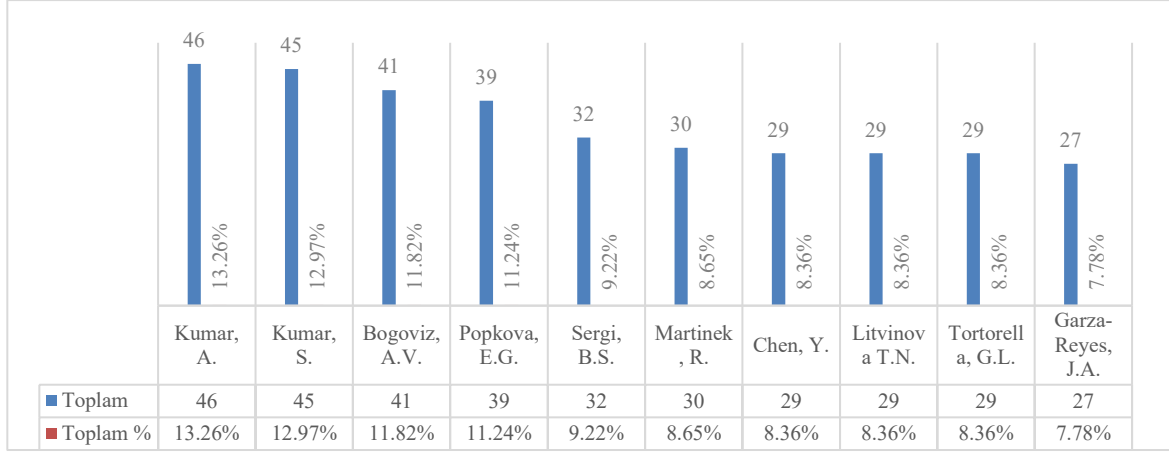
Endüstri 4.0'a ilişkin en fazla makale yayımlanan ilk 10 alan Şekil 5'te yer almaktadır. Endüstri 4.0 konusunda birçok alanda çeşitli araştırmalar yapılmıştır. En fazla makale yayımlanan alanlar incelendiğinde; ilk sırada 4627 makale ile mühendislik, ikinci sırada 2437 makale ile bilgisayar bilimi, üçüncü sırada 1713 makale ile işletme ekonomisi alanları bulunmaktadır. Literatürde Endüstri 4.0 konusuna yönelik makalelerin büyük çoğunluğunun mühendislik alanında yayımlandığı tespit edilmiştir.



Şekil 5. En fazla makale yayımlanan ilk 10 alan

3.1.5. En Fazla Makale Yayımlayan İlk 10 Yazar

Endüstri 4.0'a ilişkin en fazla makale yayımlayan ilk 10 yazar Şekil 6'te gösterilmiştir. En fazla makale yayımlayan yazarlar incelendiğinde; ilk sırada 46 makale (%13,26) ile A. Kumar, ikinci sırada 45 makale (%12,97) ile S. Kumar, üçüncü sırada ise 41 makale (%11,82) A. V. Bogoviz bulunmaktadır. Böylelikle Endüstri 4.0 alanında en çok makale yayımlayan kişinin A. Kumar olduğu ortaya çıkmıştır.



Şekil 6. En fazla makale yayımlayan ilk 10 yazar

3.1.6. En Çok Atıf Yapılan İlk 10 Makale

Araştırma kapsamında WoS'tan elde edilen makalelerin toplam atıf sayısı 66623 olmuştur. Yine WoS aracılığıyla ilgili yazarların kendine yaptıkları atıf sayıları hariç tutulduğunda toplam atıf sayısı 60073'e düşmüştür. WoS'a göre makale başına düşen ortalama atıf 15,52 olmuştur. WoS'a göre h-index ise 146 olmuştur. Tablo 1'de Endüstri 4.0'a ilişkin en çok atıf yapılan ilk 10 makalenin ilgili bilgileri (araştırma adı, yazar adı/adları, yıl, dergi adı, atıf sayısı) yer almaktadır. Buna göre en çok atıf alan makale, 1175 atıf ile Xu, L. D. vd. tarafından 2018 yılında yayımlanan "Industry 4.0: state of the art and future trends" adlı makale olmuştur.

Tablo 1. En çok atıf yapılan ilk 10 makale

Araştırma Adı	Yazar Adı/Adları	Yılı	Dergi Adı	Atıf Sayısı
Industry 4.0: state of the art and future trends	Xu, Li Da; Xu Eric L. ve Li Ling	2018	International Journal of Production Research	1175
Intelligent Manufacturing in the Context of Industry 4.0: A Review	Zhong, Ray Y.; Xu, Xun; Klotz, Eberhard; Newman, Stephen T	2017	Engineering	1008
Past present and future of Industry 4.0-a systematic literature review and research agenda proposal	Liao, Yongxin; Deschamps, Fernando; Rocha Loures, Eduardo de Freitas; Pierin Ramosi, Luiz Felipe	2017	International Journal of Production Research	814
Industrial Internet of Things: Challenges, Opportunities and Directions	Sisinni, Emiliano; Saifullah, Abusayeed; Han, Song; Jennehag Ulf; Gidlund, Mikael	2018	IEEE Transactions on Industrial Informatics	783
Industry 4.0: A survey on technologies applications and open research issues	Lu, Yang	2017	Journal of Industrial Information Integration	774
Industry 4.0 technologies: Implementation patterns in manufacturing companies	Frank, Alejandro German; Dalenogare, Lucas Santos; Ayala, Nestor Fabian	2019	International Journal of Production Economics	760
Industry 4.0 and the current status as well as future prospects on logistics	Hofmann, Erik; Rüsch, Marco	2017	Computers in Industry	691
Digital Twin in Industry: State- of-the-Art	Tao, Fei; Zhan, He; Liu, Ang; Nee, A. Y. C.	2019	IEEE Transactions on Industrial Informatics	685
Towards smart factory for industry 4.0: a self-organized multi-agent system with big data based feedback and coordination	Wang, Shiyong; Wan, Jiafu; Zhang, Daqiang; Li, Di; Zhang, Chunhua	2016	Computer Networks	651
Smart Manufacturing: Past Research Present Findings and Future Directions	Kang, Hyoungh Seok; Lee, Ju Yeon; Choi, SangSu; Kim, Hyun; Park, Jun Hee; Son, Ji Yeon; Kim, Bo Hyun; Noh, Sang Do	2016	International Journal of Precision Engineering and Manufacturing-Green Technology	613

3.2. Görsel Haritalama Bulguları

3.2.1. Ortak Yazar Analizi

Ortak yazar analizi, yazarların bir dizi değişkene göre yayın hacmini ve birbirleri ile nasıl bağlantı kurduklarını ortaya koyan bir bibliyometrik analiz türüdür (Mulet-Forteza vd., 2018: 3). Bu bibliyometrik analiz türü, bilim insanlarının bilimsel yayınlarla ilgili iş birliği yaparak oluşturdukları sosyal ağların incelenmesine imkân tanımaktadır. Ortak yazarlık yapmanın bilimsel yayınlarda bir iş birliği ölçütü olduğu belirtilmektedir. Bununla birlikte ortak yazarlık, diğer ilişkililik ölçütlerine nazaran daha güçlü sosyal bağlantıları ortaya çıkarmaktadır. Böylelikle ortak yazarlık, araştırma alanlarının entelektüel yapılarından daha çok sosyal ağları incelemek için elverişli olmaktadır. Ortak yazar analizinde bibliyografik veriler ilgili yazarların kurumsal bağlantılarına ve coğrafi konumlarına ilişkin bilgileri kapsadığından, kurumlar ve ülkeler açısından da iş birliği konuları incelenebilmektedir. Ortak yazar analizi; (i) bilimsel yayın birlikte yazıldığında yazarları birbirine bağlayabilmesi, (ii) ilgili iş birliğine yönelik kanıt sağlayabilmesi, (iii) ilgili alanın sosyal yapısını ortaya çıkarabilmesi gibi faydalar sağlamaktadır (Zupic ve Čater, 2015: 433-435).

En çok ortak araştırma yapan yazarlar arasındaki bağlantı/ilişki gücü (yazarlar arasındaki iş birliği ilişkilerinin gücü) Şekil 7'da yer almaktadır. Ortak yazar ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda bir yazarın minimum doküman sayısı olarak "2" değeri ve bir yazarın dokümanına minimum atıf sayısı olarak ise "2" değeri seçilmiştir. En çok ortak araştırma yapan yazarların; Martinek (30 makale, 172 atıf, 124 bağlantı/ilişki gücü), Wan (23 makale, 3058 atıf, 93 bağlantı gücü) ve Kumar (21 makale, 454 atıf, 81 bağlantı gücü) olduğu tespit edilmiştir. Ortak araştırmalar bu yazarlar etrafında yoğunlaşmaktadır.



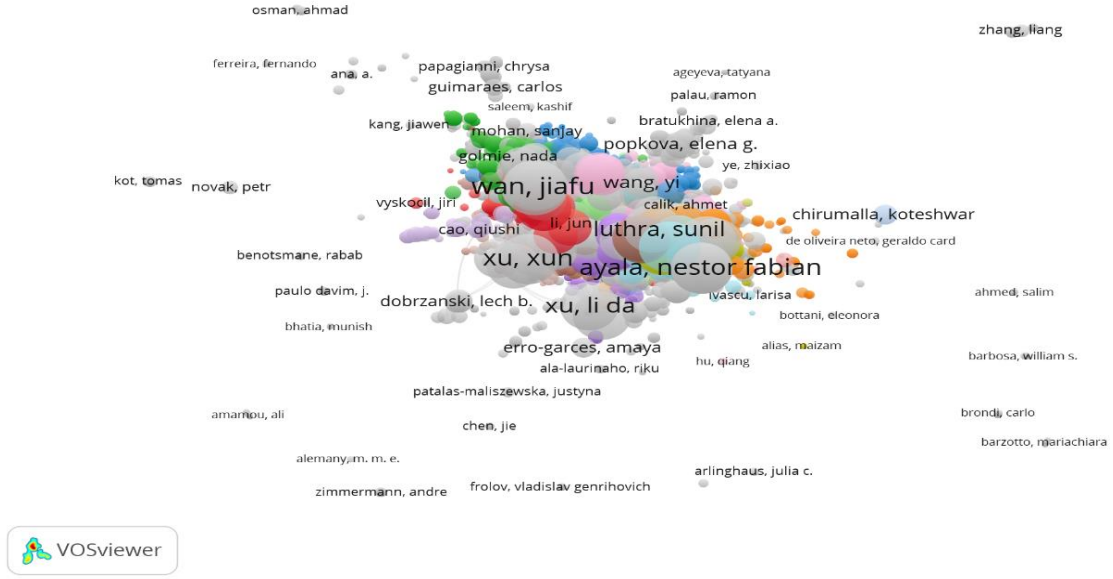
Şekil 7. Ortak yazar ağ haritası

3.2.2. Atıf Analizi

Atıf sayısı, araştırma kalitesinin bir kriteri olmaktadır. Aynı zamanda atıflar, yayınlanan bir araştırmanın ilgi düzeyi ve önemini esas bir göstergesidir (Glynn vd., 2010: 4). Atıf analizi, en önemli veri analitiği yöntemlerinden biri olmaktadır. Bu analiz, yazarların etkisini tespit etmek için objektif bir gösterge olarak karşımıza çıkmaktadır. Yani atıf analizi, bir yazarın belli bir araştırma konusuna, metodolojiye ya da araştırma alanına yönelik etkisini belirlemede fayda sağlamaktadır. Bununla birlikte atıf analizi; (i) konuyla ilgili akademik katkıları ve bilgi kaynaklarını değerlendirme, (ii) konuyla ilgili literatür kullanımını inceleme, (iii) bilgi yayılımını takip etme, (iv) bilgi temsili ve bilgi çıkarımını kolaylaştırma, (v) araştırma alanının entelektüel/düşünsel yapısını ortaya çıkarma gibi faydalar sunmaktadır (Rejeb vd., 2022: 11).

3.2.2.1. Yazar Atıf Analizi

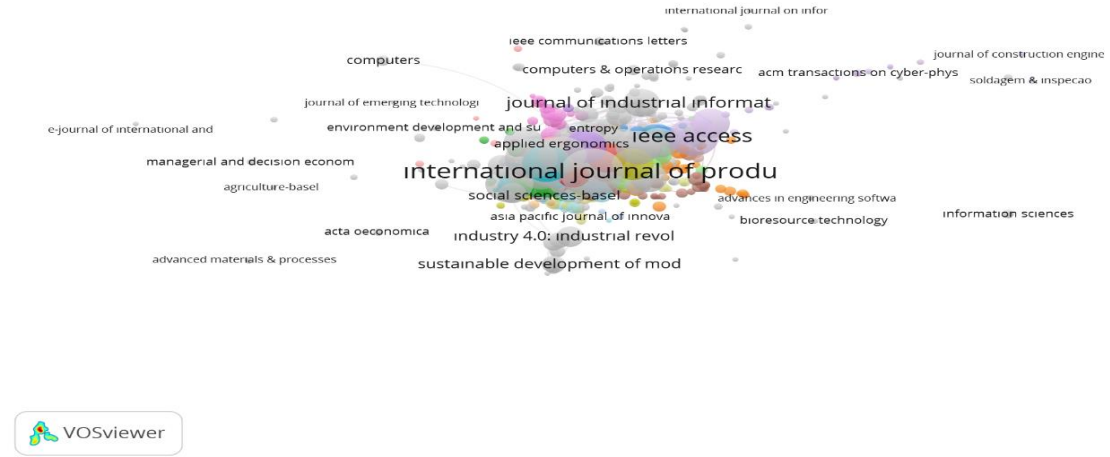
En çok atıf alan yazarlar arasındaki bağlantı gücü Şekil 8'de yer almaktadır. Yazar atıf ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda bir yazarın minimum doküman sayısı olarak "2" değeri ve bir yazarın dokümanına minimum atıf sayısı olarak ise "2" değeri seçilmiştir. En çok atıf alan yazarların; Wan (23 makale, 3058 atıf, 2589 bağlantı gücü), Xun Xu (26 makale, 2972 atıf, 2114 bağlantı gücü) ve Ayala (7 makale, 1542 atıf, 2197 bağlantı gücü) olduğu saptanmıştır.



Şekil 8. Yazar atıf ağ haritası

3.2.2.2. Kaynak Atıf Analizi

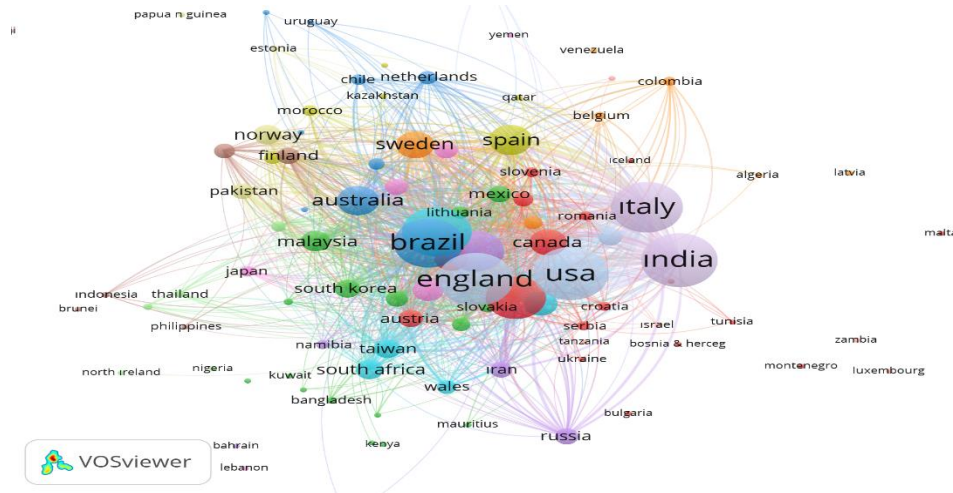
Endüstri 4.0 alanında en çok atıf alan dergiler/kaynaklar arasındaki bağlantı gücü Şekil 9’de yer almaktadır. Kaynak atıf ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda kaynakların minimum doküman sayısı olarak “2” değeri ve kaynakların minimum atıf sayısı olarak ise “2” değeri seçilmiştir. En çok atıf alan kaynakların; International Journal of Production Research (158 makale, 10205 atıf, 4949 bağlantı gücü), IEEE Access (285 makale, 7537 atıf, 2198 bağlantı gücü) olduğu tespit edilmiştir.



Şekil 9. Kaynak atıf ağ haritası

3.2.2.3. Ülke Atıf Analizi

Endüstri 4.0 konusunda en çok atıf alan ülkeler arasındaki bağlantı gücü Şekil 10’da yer almaktadır. Ülke atıf ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda ülkelerin minimum doküman sayısı olarak “2” değeri ve ülkelerin minimum atıf sayısı olarak ise “2” değeri seçilmiştir. En çok atıf alan ülkelerin; ABD (721 makale, 20880 atıf, 13240 bağlantı gücü), İngiltere (721 makale, 20690 atıf, 13162 bağlantı gücü), İtalya (1098 makale, 20152 atıf, 12248 bağlantı gücü) ve Hindistan (838 makale, 13895 atıf, 13690 bağlantı gücü) olduğu saptanmıştır.

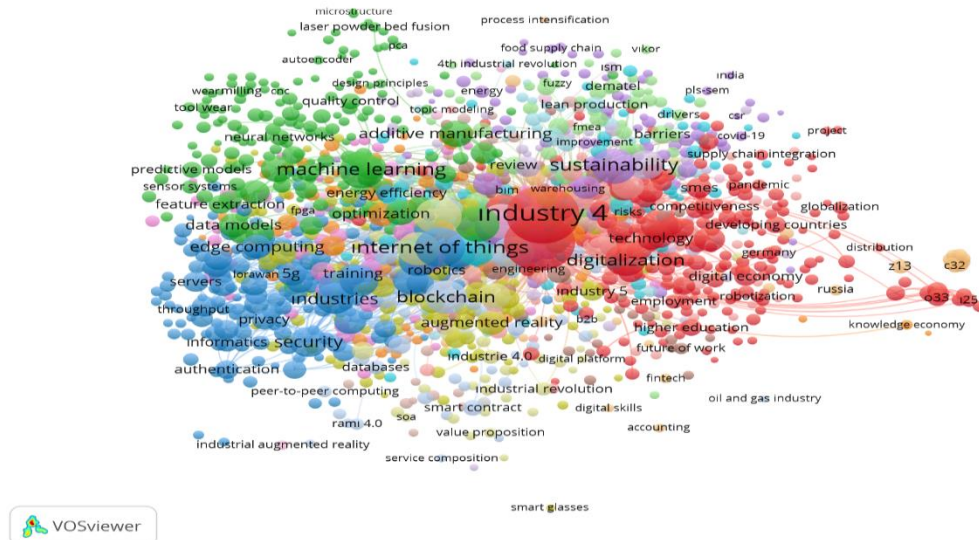


Şekil 10. Ülke atıf ağ haritası

3.2.3. Anahtar Sözcük Analizi

Anahtar sözcük analizi, yayınlarda kullanılan en yaygın anahtar kelimeleri analiz etmektedir (Mulet-Forteza vd., 2018: 3). Yani anahtar sözcük analizi araştırmaların anahtar kelimeleri arasındaki ilişkileri/bağlantıları ve etkileşimleri bütünsel bir şekilde incelemeye olanak sağlamaktadır (Li vd., 2020: 2).

Endüstri 4.0 konulu makalelerde en çok kullanılan anahtar kelimeler arasındaki bağlantı gücü Şekil 11’da gösterilmektedir. Anahtar sözcük ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda bir anahtar kelimenin minimum kullanılma sayısı olarak “5” değeri seçilmiştir. En çok kullanılan anahtar kelimelerin; Endüstri 4 (1770 tekrar sayısı, 7123 bağlantı gücü), Nesnelerin İnterneti (438 tekrar sayısı, 1837 bağlantı gücü), sürdürülebilirlik (371 tekrar sayısı, 1313 bağlantı gücü), Makine Öğrenmesi (359 tekrar sayısı, 1323 bağlantı gücü), dijitalleşme (290 tekrar sayısı, 1048 bağlantı gücü), Blok Zincir (251 tekrar sayısı, 1103 bağlantı gücü) olduğu tespit edilmiştir.



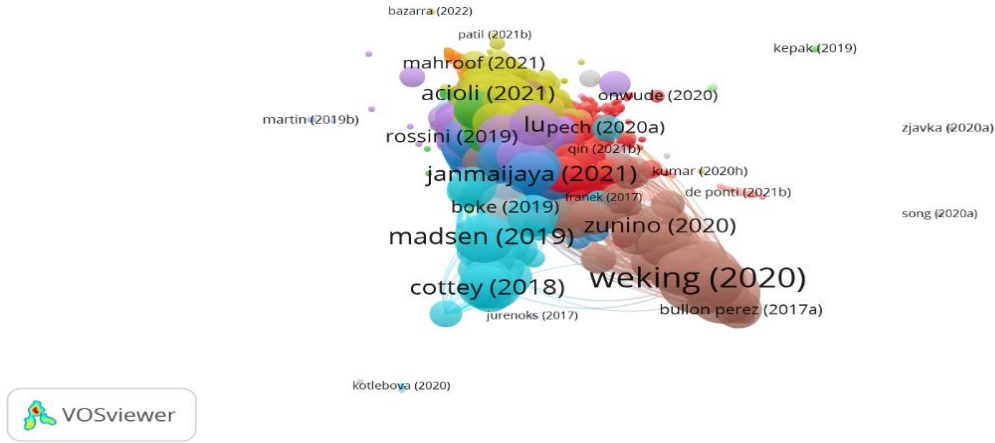
Şekil 11. Anahtar sözcük ağ haritası

3.2.4. Dokümanların Bibliyografik Eşleşme Analizi

Bibliyografik eşleşme kavramını Fano ortaya atmıştır. Fakat bu kavramı popüler hâle getiren araştırmacı Kessler'dir. Bibliyografik eşleşme analizinde iki yayın arasındaki eşleşme birimi, bu iki yayın tarafından kullanılan bir atıf unsuru olmaktadır. İki yayının bibliyografik olarak eşleşmesi için böyle bir atıf unsurunun olması gerekmektedir. Buna göre bibliyografik eşleşme bağlantı güçleri, ortak referansların sayısına bağlı

olmaktadır (Egghe ve Rousseau, 2002: 349). Kısaca iki yayın aynı üçüncü bir yayına atıfta bulunduğu bibliyografik eşleşme meydana gelmektedir (Mulet-Forteza vd., 2018: 3).

Endüstri 4.0 konusunda dokümanlara göre yazarların bağlantı gücü Şekil 12’de yer almaktadır. Dokümanların bibliyografik eşleşme ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda bir dokümanın minimum atıf sayısı için “2” değeri seçilmiştir. Endüstri 4.0 konusunda bibliyografik eşleşme sayısı en çok olan yazarların dokümanları; Weking (2020) (71 atıf, 47887 bağlantı gücü), Madsen (2019) (36 atıf, 17742 bağlantı gücü), Cottey (2018) (4 atıf, 12786 bağlantı gücü), Janmajaya (2021) (5 atıf, 12457 bağlantı gücü) olarak saptanmıştır.

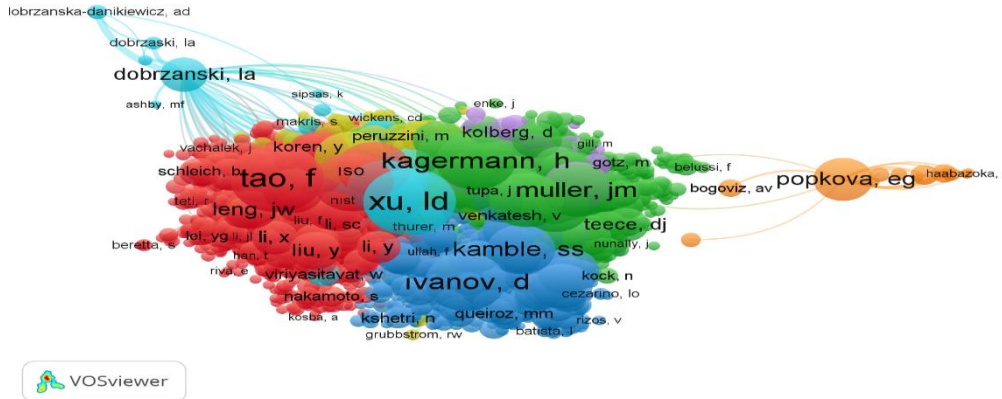


Şekil 12. Dokümanların bibliyografik eşleşme ağ haritası

3.2.5. Yazarların Ortak Atıf Analizi

Ortak atıf analizi, bilimsel araştırmaların benzer ilişkilerini ortaya koymak amacıyla 1973 yılında Henry Small tarafından ortaya atılmıştır (Arslan, 2022: 37). Her iki yayın da üçüncü bir yayının referans listesinde bulunuyorsa, bu iki yayına birlikte veya ortak atıf yapıldığı belirtilmektedir. Bununla beraber ortak atıf sıklığı ise iki yayının birlikte atıf yapılma sıklığı şeklinde açıklanmaktadır. Bibliyografik eşleşme analizinde bir yayına atıf yapılan makale gruplarına odaklanıldığı; ortak atıf analizinde ise genellikle çiftler hâlinde gelen referanslara odaklanıldığı ifade edilmektedir (Egghe ve Rousseau, 2002: 349).

Endüstri 4.0 konusunda atıf yapılan yazarların bağlantı gücü Şekil 13’de gösterilmektedir. Yazarların ortak atıf ağ haritasını oluşturabilmek için VOSviewer programı kullanılmıştır. Bu programda bir yazarın minimum atıf sayısı için “20” değeri seçilmiştir. En çok ortak atıf alan yazarlar; Tao (1315 atıf, 56716 bağlantı gücü), Xu (1289 atıf, 55597 bağlantı gücü) Ivanov (963 atıf, 48924 bağlantı gücü), Kagerman (943 atıf, 37338 bağlantı gücü), Muller (797 atıf, 38233 bağlantı gücü), Kamble (695 atıf, 37660 bağlantı gücü) olarak tespit edilmiştir. Söz konusu bu 6 yazarın Endüstri 4.0 alanında önde gelen yazarlar olduğu ve ilgili alandaki diğer yazarları etkilediği söylenebilir.



Şekil 13. Yazarların ortak atıf ağ haritası

Tartışma, Sonuç ve Öneriler

Son yıllarda dünya genelinde Endüstri 4.0 hem akademik hem de pratik uygulama noktasında yaygınlaşmaktadır. Literatürde Endüstri 4.0 ile ilgili farklı yöntemlerle yapılan araştırmalar bulunmaktadır. Ancak Endüstri 4.0'ın gelişimini bütüncül olarak inceleyen bibliyometrik araştırmalara gereksinim duyulmaktadır. Dünyada son zamanlarda Endüstri 4.0 konusunu bibliyometrik olarak analiz eden araştırmalar (Cobo vd., 2018; Trotta ve Garengo, 2018; Muhuri vd., 2019; Ahmi vd., 2019; Kipper vd., 2020 Lopes ve Martins, 2021; Grabowska ve Saniuk, 2022; Teixeira ve Tavares-Lehmann, 2023) artmakla birlikte Türkiye’de bu araştırmalar oldukça sınırlıdır. Bunun için bu araştırmada Endüstri 4.0 alanında yayımlanan makalelerin bibliyometrik analizi yapılmıştır.

Bu araştırmada bibliyometrik analiz, performans analizi ve görsel haritalama olmak üzere 2 başlık altında gerçekleştirilmiştir. Performans analizi sonucunda; Endüstri 4.0 ile ilgili en çok makale ve atıf sayısının 2022 yılında gerçekleştiği, en çok makale yayımlayan ülkenin İtalya olduğu, en çok makale yayımlanan alanın mühendislik olduğu, en fazla makale yayımlayan yazarın “Kumar, A.” olduğu tespit edilmiştir. Görsel haritalama tekniği ile gerçekleştirilen bibliyometrik analiz sonucunda; Endüstri 4.0 ile ilgili en çok ortak araştırma yapan yazarın “Martinek, R.” olduğu, en çok atıf alan yazarın “Wan, J.” olduğu, en çok atıf alan kaynağın “International Journal of Production Research” olduğu, en çok atıf alan ülkenin ABD olduğu, en çok kullanılan anahtar kelimelerin “Endüstri 4” ve “Nesnelerin İnterneti” olduğu, en çok ortak atıf alan yazarın “Tao, F.” olduğu, bibliyografik eşleşme sayısı en çok olan yazarın dokümanı ise Weking (2020) olduğu saptanmıştır.

Araştırmanın sonuçları Cobo vd. (2018) ve Muhuri vd. (2019) gibi önceki araştırmaların sonuçlarıyla örtüşmektedir. Buna göre en fazla yayın yapan yazarların büyük çoğunluğunun mühendislik ve bilgisayar bilimleri gibi teknik disiplinlerden geldiği görülmektedir. Bu bulgu, Endüstri 4.0 çalışmalarının ağırlıklı olarak teknik temelli ilerlediğini ve bu konudaki bilimsel üretimin büyük ölçüde uygulamalı alanlarda yoğunlaştığını göstermektedir. Ayrıca ABD, İngiltere ve Çin gibi ülkelerin bu alanda baskın olması, bu ülkelerdeki yüksek araştırma yatırımlarıyla ilişkilendirilebilir. Bu bağlamda Endüstri 4.0 literatürünün teknik odaklı gelişmekte olduğu, sosyal ve yönetsel boyutlarının ise hâlâ gelişime açık olduğu söylenebilir.

Bu araştırma sonuçlarının Endüstri 4.0 ile ilgili çalışma yapacak araştırmacılara ve uygulayıcılara yol göstermesi beklenmektedir. Araştırmanın verileri Web of Science (WoS) veri tabanından elde edilmiştir. Dolayısıyla Scopus, TR Dizin gibi veri tabanlarında yer alan veriler kapsam dışı bırakılmıştır. Bu durum araştırmanın kısıtını oluşturmaktadır. Gelecekte yapılacak bibliyometrik araştırmalarda farklı veri tabanları ve farklı anahtar kelimeler kullanılarak bu araştırmanın sonuçları karşılaştırılabilir. Araştırma kapsamında sadece Endüstri 4.0 ile ilgili makalelerin incelenmesi amaçlandığından diğer doküman türleri (konferans bildirileri, kitap vb.) kapsam dışı bırakılmıştır. Bu durum araştırmanın diğer kısıtını oluşturmaktadır. Gelecekte yapılacak araştırmalarda diğer doküman türleri de eklenerek daha detaylı sonuçlar elde edilebilir. Araştırmada bibliyometrik analiz, VOSviewer programı aracılığıyla yapılmıştır. Gelecekte yapılacak araştırmalar, farklı programlar (SciMAT, BibExcel, Bibliometrix, R-Studio) kullanılarak yapılabilir. Böylece Endüstri 4.0 farklı bibliyometrik özellikler çerçevesinde incelenebilir.

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SELÇUK ÜNİVERSİTESİ
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DERGİSİ

**Artificial Intelligence and Image Processing for Semi-finished Goods Inventory
Management in Textile Industry**

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Abstract

This study investigates the application of artificial intelligence (AI) and image processing technologies within the textile industry, specifically focusing on optimizing production processes. The primary aim was to assess the impact of AI and image processing systems on inventory management of semi-finished products, production efficiency, and labor optimization. Findings indicate substantial improvements, including a decrease in stock discrepancies, higher on-time tracking rates, significant time savings in production, and reduced labor costs. Further analysis highlights the financial advantages of technological integration, particularly in lowering production expenses. This research contributes to the literature by demonstrating the practical benefits of these technologies in production management, offering insights that could be applicable across other manufacturing sectors. Future research should explore the wider adoption of AI and image processing technologies across various industries and investigate their potential environmental impacts within production processes.

Keywords

Digital Transformation, Production Management, Artificial Intelligence, Image Processing, Textile Industry

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Tekstil Sektöründe Yarı Mamul Stok Yönetimi İçin Yapay Zekâ ve Görüntü İşleme Uygulaması

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Öz

Bu çalışmada, yapay zekâ (AI) ve görüntü işleme teknolojilerinin tekstil endüstrisine entegrasyonunu ve üretim süreçlerinin optimizasyonuna odaklanılmıştır. Bu araştırmanın temel amacı, yapay zekâ ve görüntü işleme sistemlerinin uygulanmasını takiben yarı mamul envanter yönetimi, üretim verimliliği ve işgücü optimizasyonundaki gelişmeleri incelemektir. Sonuçlar, stok hatalarında önemli azalmalar, zamanında takip oranlarının arttığını, çeşitli üretim süreçlerinde önemli zaman tasarrufu sağladığını ve işçilik maliyetlerinde kayda değer bir azalma olduğunu ortaya koymuştur. Ayrıca üretim maliyetleri düşmüştür ve bu da teknolojik entegrasyonun olumlu finansal etkisini göstermiştir. Bu araştırma, üretim yönetiminde yapay zekâ ve görüntü işlemenin pratik bir uygulamasını sağlayarak, bu teknolojilerin operasyonel verimliliği nasıl artırabileceğini ve maliyetleri nasıl azaltabileceğini göstererek mevcut literatüre katkıda bulunmaktadır. Bulgular, diğer imalat sektörlerinin de benzer teknolojik gelişmelerden yararlanabileceğini ve hem araştırmacılar hem de endüstri uygulayıcıları için değerli bilgiler sağlayabileceğini göstermektedir. Gelecekteki araştırmalar, bu teknolojilerin farklı endüstrilerde daha geniş uygulamalarına odaklanmanın yanı sıra, üretim süreçlerinde yapay zekâ ve görüntü işlemenin çevresel etkilerini keşfetmeye odaklanabilir.

Anahtar Kelimeler

Dijital Dönüşüm, Üretim Yönetimi, Yapay Zekâ, Görüntü İşleme, Tekstil Endüstrisi

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Introduction

The textile industry is a critical economic sector on a global scale. It is therefore imperative that it undergoes significant transformation, especially about sustainability, given its substantial environmental impact (Rathore, 2022, p. 234). This transformation encompasses objectives such as enhancing resource efficiency and minimizing waste, particularly in production processes. Technological advancements are increasingly pivotal in achieving sustainable development goals, including economic growth, environmental protection, and social equity, by enhancing production efficiency and reducing environmental harm (Stock et al., 2018, p. 255; Akhtar et al., 2022, p. 650).

The management of semi-finished goods stocks in the textile sector is widely regarded as being quite challenging. Conventional monitoring techniques frequently result in an oversight of errors and inefficiencies. This oversight can lead to initial time losses and increased costs over time. Indeed, the utilization of conventional methodologies frequently engenders delays in production, thereby impeding businesses' capacity to align with contemporary production methodologies. (Kaur, 2017, p. 40).

Conversely, contemporary production technologies, particularly those augmented by artificial intelligence, have the capacity to address the intricacies inherent in all production processes with greater efficiency and ease. The integration of artificial intelligence within production processes has been shown to enhance efficiency by facilitating the processing of substantial data sets (Kaur, 2017, p. 40). Furthermore, advancements in image processing technology, in conjunction with the development of artificial intelligence, have led to significant progress in the field of error detection (Mohiuddin Babu et al., 2024, p. 2095). This technological breakthrough has been shown to provide significant industrial benefits, increase production workflow, and reduce operational losses and damage.

In this study, artificial intelligence and image processing technologies are utilized to overcome the difficulties in the management of semi-finished stocks in a textile factory. On the other hand, the effective role of the improvements brought by these technologies to production processes in sustainable development goals is also emphasized. In the application phase, the data obtained from the integration of artificial intelligence and image processing technology are analyzed and the effect of these technologies on optimizing production workflows is emphasized. The findings made us realize the importance of the integration of technological integration in the textile industry, especially in promoting sustainable development. The study also provides insights on how the application of these technologies can improve production efficiency and greatly reduce environmental impacts.

1. Literature

The main objective of sustainable development is the long-term balanced operation of social, environmental and economic paradigms. By minimizing environmental degradation and making the best use of natural resources, we can leave a cleaner world for future generations. To achieve this, businesses aim to contribute to the process by renewing their production processes with modern technologies while being environmentally friendly. Especially in industrial production, technologies such as automation systems, data analytics and artificial intelligence come to the fore in this context. In addition, while reducing waste, errors and inefficiencies, it also develops technical solutions in terms of sustainability as it ensures efficient use of energy resources (Syafurudin et al., 2024, p. 1).

The textile industry generally has a production structure that progresses with semi-finished stock. The overall production processes for semi-finished products, which are considered unfinished, must be managed effectively. The use of traditional manual tracking systems for this leads to problems such as human errors, inefficiencies and unwanted waste of time. At the same time, these manual methods lead to delays in production and complexity in inventory management. Therefore, there are difficulties in managing and tracking production processes (Kaur, 2017, p. 40).

In response, the incorporation of modern technologies, in particular artificial intelligence (AI) and image processing, offers great opportunities for textile production improvement. AI enables the processing of large datasets, which results in improved production methods and better efficiency of resource allocation. Simultaneously, image processing technologies that make use of visual data recorded by sensors and cameras are essential to accurate monitoring of inventories, efficient quality control, and timely identification of errors on

production lines (Mohiuddin Babu et al., 2024, p. 2095). When combined, all these technologies are likely to notably improve the administration of half-completed inventories, optimize production processes, and minimize delays in operations.

This article explores the challenges associated with the management of semi-finished product inventories within textile manufacturing facilities and examines the potential contributions of artificial intelligence and image processing technologies in addressing these challenges. Furthermore, it highlights the improvements these technologies provide to production methodologies and their significance in advancing sustainable development. Through a comprehensive analysis of data derived from the implementation of AI and image processing, this paper aims to demonstrate how these technologies can enhance the efficiency of production workflows. The results demonstrate the great potential of the application of technology in the textile sector, especially in promoting sustainable development. The research also delivers key messages about how the application of these technologies can enhance the efficiency of production while substantially reducing environmental effects. The key objective of sustainable development is the attainment of long-term equilibrium among social, environmental, and economic factors. With the reduction of environmental degradation and maximum utilization of natural resources, the objective is to make the world cleaner for future generations. To do this, companies are adopting innovative technologies that enhance manufacturing processes with ecological sustainability preserved. Notably, in the industrial production sector, technologies like automation systems, data analysis, and artificial intelligence (AI) emerge as major tools to attain sustainable development goals. Moreover, advancements in technology play a critical role in reducing waste, limiting errors, and eliminating inefficiencies, as well as promoting the utilization of renewable energy sources where feasible (Syafudin et al., 2024, p. 1).

The textile industry, while globally significant (Haber, 2014, pp. 128-140), faces considerable environmental challenges. Textile production contributes to excessive natural resource consumption, water pollution, chemical waste, and substantial energy use (Naqvi et al., p. 426). Therefore, developing a sustainable management approach is crucial. Recent strategies to mitigate the environmental impact include using recyclable materials, enhancing energy efficiency, reducing water consumption, and implementing effective waste management systems (Hasanbeigi & Price, 2015, p. 30-33). These efforts require optimizing energy usage and minimizing carbon emissions while maintaining efficient processes. Technological integration plays a pivotal role in this transformation (Hassan et al., 2024, pp. 5-7).

In the context of production systems, semi-finished products – defined as items that have not yet reached their final state (Stendahl & Eliasson, 2014, p. 14) – assume a pivotal role. However, the management of these intermediate goods presents numerous challenges. The precise monitoring of semi-finished inventories is imperative for ensuring efficiency and effective planning (Najlae et al., 2020, p. 1255). Conventional methods, which frequently depend on manual tracking techniques, are susceptible to human error and inefficiencies that can result in production delays (Sanders et al., 2016, p. 823). Inaccurate tracking hinders the identification of bottlenecks in processes and the optimization of production processes, leading to resource wastage and extended waiting times (Colledani et al., 2014, p. 777). This underscores the imperative for the adoption of more sophisticated inventory management techniques.

The use of artificial intelligence (AI) and image processing technologies in business activities presents attractive opportunities for improving the efficiency of operations. AI assists in managing big data, which means more precise forecasting, better process optimization, and faster decision-making. Meanwhile, image processing plays a role in quality control and inventory management by creating comprehensive conclusions from visual information (Peres et al., 2020, pp. 122–123).

In the context of the textile industry, the integration of artificial intelligence with image processing technologies has led to significant advances in the field of inventory management for semi-finished products. By using cameras and sensors to capture real-time visual data, manufacturers can inspect every stage of the production process with exceptional precision. Subsequently, AI algorithms interpret these data streams to provide real-time assessments of the condition of semi-finished products, enabling immediate detection of disruptions or overstocking, and facilitating timely interventions (Sarkar et al., 2023, pp. 200–230). These technologies improve inventory tracking and control, preventing overproduction and optimizing production processes. Additionally, they ensure that bottlenecks in production lines are detected in a timely manner, reducing delays. This level of technological application is crucial for the transition to more efficient, sustainable and environmentally friendly production processes. The integration of artificial intelligence and image processing in the textile industry is central to

improving production processes as well as achieving sustainable development goals (Pawlicka and Bal, 2022, pp. 20-21). In addition, the current digitalization of the textile industry is important for aligning production processes with sustainability goals. Digitalization plays a dual role of reducing production costs, mitigating environmental impacts, increasing competitiveness, and consequently reducing environmental footprints, as well as increasing labor productivity. In conclusion, the application of artificial intelligence and image processing technologies in the management of semi-finished inventories is crucial to compensate for production inefficiencies and improve the trend towards sustainability (Merli et al., 2024, pp. 2–3).

The forward-looking effects of these technological innovations on the industry are significant. Likewise, Waqar et al. (2024) investigated the applications of AI-powered image analysis and pattern recognition algorithms (IAPRA) to drive digital transformation in the concrete industry. While the investigation unlocked IAPRA's potential in terms of concrete detection, power assessment, and lifespan prediction, it also revealed obstacles such as complexities in implementation, economic and regulatory issues, and technology integration issues. The SEM analysis implied that removing these barriers would greatly improve quality control, allow for predictive maintenance, and increase overall productivity.

Kim et al. (2022) presents a comprehensive work that explores the use of artificial intelligence in manufacturing. In this work, the authors shed light on how artificial intelligence has the potential to revolutionize conventional manufacturing processes in the framework of Industry 4.0. Given the limitations of artificial intelligence at present, it is stated that research remains focused on enhancing its convergence with various engineering fields, precision engineering, and manufacturing. The research seeks to encapsulate the astounding success of artificial intelligence in the most productive and lucrative manufacturing industries. Here, the potential of artificial intelligence to revolutionize the manufacturing industries is emphasized.

Amza and Cicic (2015) presented an artificial intelligence-based approach for defect detection in radiographic images of industrial products. In the study, a novel two-stage algorithm based on feature analysis of X-ray images is presented. In the first stage, an automatic decision whether an object is a defect or not is made based on geometric criteria. In the second stage, a final decision is made using 'logical' criteria based on the quality requirements of the product. The study has shown that fuzzy logic techniques can be used effectively in this process. This approach contributes to improving the accuracy of defect detection in the field of industrial image processing.

Zhang and Dong (2021) addressed the challenges of effective use of information technology and customized label management in the manufacturing sector. The study identified hidden rules through artificial intelligence models using approval form data on customized labels of an electronics manufacturer. The authors applied the iterative testing method to address imbalances in time characteristics and data distribution and improved the effectiveness of AI models by optimizing model parameters. The research aimed to speed up the decision-making process and reduce the error rate by creating a warning system when the user's settings do not match the predicted results. As a result, the accuracy rate of the AI model increased from 80% to 95%, line downtime was reduced from 4 to 1 per month, and the cost of downtime at full capacity was reduced.

Tarachkov, Tolstel and Kalabin (2023) dealt with the development and evaluation of the effectiveness of an algorithm used in the process of preparing semi-finished products for packaging. The aim of the study was to ensure the correct placement of frozen nugget products transported in open cartons on a high-speed conveyor line. Product orientation was performed using the DR-1 robotic manipulator from Intelligent Robotics LLC. The system also includes a carton detector and conveyor speed sensor. The application of the algorithm enabled the totes to be aligned automatically, increasing productivity and reducing the number of faulty products. This approach makes an important contribution to the automation of production processes.

2. Method

This research aims to examine the effects of artificial intelligence and image processing technologies on the monitoring and management of semi-finished product stocks in the textile industry. The methods, data collection processes, analysis techniques and application areas used for the purpose of the research will be explained in detail.

2.1. Research Model and Design

The main purpose of this study is to understand how the integration of artificial intelligence and image processing technologies into production processes in the textile industry affects the management of semi-finished product stocks. In this context, quantitative data includes indicators that measure costs, changes in inventory management, production speed and efficiency.

The research consisted of three main phases:

- Data Collection Phase: Literature review related to the sector will be conducted and application-based data will be collected.
- Technological Integration Phase: Integration of artificial intelligence and image processing technologies into production processes will be ensured and data collection systems will be commissioned.
- Data Analysis Stage: The collected data will be evaluated by statistical analysis and the results will be interpreted.

2.1.1. Data Collection Techniques

In textile mills, on-site observations will be made to evaluate the use of technology in production processes, focusing on semi-finished product tracking and its impact on production efficiency. Cameras and image processing modules will monitor the location, size, and condition of semi-finished products, with artificial intelligence algorithms analyzing the collected data to identify bottlenecks, shortages, and optimize inventory management. This data collection and analysis will offer insights into improvements in efficiency, inventory management, and cost savings, and provide tangible evidence of the effects of technological integration on production processes.

2.1.2. Data Analysis Methods

In this research, data will be used to improve production processes in textile mills by focusing on condition assessment, optimization and decision-making. The goal is to improve production efficiency and optimize inventory management by using insights gained throughout these processes to guide decisions.

Condition Assessment: The first step involves a thorough assessment of the current production processes. Key data points such as stock levels, production times, machine status, and semi-finished product tracking will be analyzed to identify inefficiencies, bottlenecks, and disruptions. This stage is crucial for identifying areas for improvement and identifying where technological solutions can be implemented.

Optimization: In the second stage, the collected data will be analyzed to optimize various production parameters. This will include improving inventory management and reducing production times. Strategies will be developed for better production planning, and the most effective solutions will be determined for each step of the process, considering factors such as machine efficiency and stock management.

Decision Making: The final stage will use data to inform decision-making processes. The goal is to eliminate inefficiencies, speed up production, and optimize stock levels while reducing costs. Decisions will be supported by technological interventions such as artificial intelligence and image processing that will enable timely, data-driven choices that improve overall production efficiency

2.1.3. Application Area and Sample Selection

This research focuses on the integration of artificial intelligence and image processing technologies in a textile production facility in Turkey. The study examines the effects of these technologies on increasing the efficiency of production processes, especially in the textile industry. As a pilot application, the technological integration process was carried out in the sewing workshop and the improvements in the production processes were analyzed.

This study focuses on the application in a particular textile mill and the improvements it provides. In this factory, which was selected to evaluate the effects of technological integration on production processes, artificial intelligence and image processing technologies were discussed and the developments in this process were included in the research. The main difficulties in the production processes of the factory were evaluated under headings such as semi-finished stock management, production line arrangements, labor productivity, and production time.

The study examines how these technologies are implemented in the factory and their impact on costs, labor utilization, production time, and inventory management. In addition, issues such as the arrangement of the production line, the optimization of transport processes and improvements in the handling of semi-finished products are among the focus of the research. The data obtained during the implementation process are evaluated comparatively in terms of both the efficiency of the production processes and the costs, and conclusions are drawn on the success of the improvements made.

3. Improvement & Comparative Results

In this section, the improvements and gains achieved after the integration of artificial intelligence and image processing technologies into the production processes in the textile factory will be discussed. As the first step of technological integration, thanks to the pilot application carried out in the sewing workshop, the improvements achieved in terms of management of semi-finished product stocks, optimization of production processes and labor productivity were examined in detail.

3.1. Management and Follow-Up of Semi-Finished Product Stocks

Previously, the factory had to manually track semi-finished product stocks, and significant challenges were encountered in these processes. Determining the location of semi-finished products, determining their stage, and regularly checking stock levels were done in a time-consuming and error-prone method. This situation caused disruptions in the production process and overstock. However, with the integration of artificial intelligence and image processing technologies, it has become possible to monitor each semi-finished product in the production process and stock levels have started to be monitored in real time. Cameras and image processing software detect the instantaneous position, size and condition of each semi-finished product, and this data is transferred directly to the production management system. Thus, the traceability of the production process has been increased, and accurate and timely control of stock levels has been ensured.

Table 1. Inventory management and tracking of semi-finished products - before and after comparison

Semi-Finished Product Type	Stock Error (Before)	Stock Error (After)	On-Time Follow-Up Rate (Before)	On-Time Follow-Up Rate (After)
Fabric	18%	6%	55%	92%
Sewing Needle	22%	8%	50%	88%
Pant Cut	14%	5%	60%	95%

According to Table 1, stock errors in semi-finished products have decreased significantly and there has been a significant increase in timely follow-up rates. For example, the inventory error of the fabric decreased from 18% to 6%, while the on-time tracking rate increased from 55% to 92%. The stock error of the sewing needle increased from 22% to 8%, and the timely follow-up rate increased from 50% to 88%. The stock error of trouser cutting has decreased from 14% to 5%, while the on-time tracking rate has increased from 60% to 95%. These data show that stock management and tracking processes have improved considerably, production processes have become more efficient, and the capacity to respond to customer demands in a timely manner has increased.

3.2. Time Saving in Production Processes

The time savings in production processes reveal the positive effect of technological integration on productivity increase.

Table 2. Comparison of production time savings - before and after technological integration

Production Process	Before (Hours)	After (Hours)	Time Savings (%)
Semi-Finished Product Tracking	8	2	75%
Production Line Inspection	5	2.5	50%
Total Production Time	12	8	33%

Table 2 demonstrates significant reductions in production time across various processes. Semi-finished product tracking time has decreased from 8 hours to 2 hours, reflecting a remarkable 75%-time savings. Similarly, the production line inspection time has been halved, from 5 hours to 2.5 hours, leading to a 50%-time reduction. Overall, the total production time has been reduced from 12 hours to 8 hours, resulting in a 33%-time savings. These reductions indicate improvements in process efficiency and optimization, helping the company to operate more effectively and potentially increase production capacity.

3.3. Labor Productivity and Human Resource Savings

Thanks to the integration of artificial intelligence and image processing technologies, an increase in labor productivity has been achieved and labor savings have been achieved.

Table 3. Workforce efficiency and labor savings through technological integration

Workforce Count	Before (People)	After (People)	Workforce Savings (%)
Semi-Finished Product Tracking	15	7	53%
Production Control	10	5	50%
Total Workforce	600	570	5%

Table 3 highlights significant workforce reductions across various processes, demonstrating improved efficiency. Semi-finished product tracking saw a reduction from 15 to 7 people, resulting in 53% of workforce savings. Similarly, the production control workforce was reduced from 10 to 5, yielding 50% savings. On a broader scale, the total workforce decreased from 600 to 570, reflecting a 5% overall reduction. These reductions in workforce numbers suggest that the company has managed to optimize its human resources, likely through automation, process improvements, or better task management, thereby enhancing operational efficiency while maintaining productivity.

3.4. Saving on Production Costs

The impact of technological integration on costs is clearly demonstrated by the reduction in the operating budget.

Table 4. Reduction in production costs - before and after technological integration

Cost Item	Before (USD)	After (USD)	Cost Reduction (%)
Stock Management Cost	50,000	20,000	60%
Labor Cost	514,286	385,714	25%
Total Production Cost	542,857	461,428	15%

Table 4 demonstrates substantial cost reductions across key production areas. Stock management costs have decreased by 60%, from 50,000 USD (1,750,000 TL) to 20,000 USD (700,000 TL), indicating a significant

improvement in inventory handling efficiency. Labor costs have been reduced by 25%, from 514,286 USD (18,000,000 TL) to 385,714 USD (13,500,000 TL), which could suggest more efficient workforce utilization or the introduction of automation. Overall, total production costs have decreased by 15%, from 542,857 USD (19,000,000 TL) to 461,428 USD (16,142,000 TL). These reductions highlight the success of the company's technological integration and process optimizations in enhancing operational efficiency and profitability while maintaining production effectiveness. All calculations are based on the exchange rate of 1 USD = 35 TL as of December 2024.

The results of the data show how challenging the manual, time-consuming and error-prone techniques previously used were. Old processes had low efficiency and high error rates, especially in critical areas such as the management and tracking of semi-finished stocks. This was due to systems that required constant manual intervention, as well as old methods that made accurate and timely data tracking difficult. With the introduction of new technology and automation systems, errors have been significantly reduced, and processes have accelerated. Inventory errors, production control and labor utilization have become efficient, enabling previously time-consuming processes to be performed more quickly and accurately. For example, previously, to correct stock errors and supervise the production process, employees were making great efforts and manual operations that could take days. With the new system, these processes can be quickly managed in a digital environment, minimizing human errors, reducing production costs and increasing labor productivity. The reduction in the number of labor forces and the decrease in production costs with the effect of technology reveal the inadequacy of the old systems and clearly demonstrate how effective the improvement provided by the data is.

Discussion

The findings of this study show that the integration of artificial intelligence and image processing technologies into production processes in textile factories leads to significant productivity gains and provides operational improvements. Improvements in critical areas such as the management of semi-finished stocks, monitoring of production processes and labor productivity have eliminated the shortcomings of traditional production methods and clearly demonstrated the benefits of technological integration.

First of all, the improvements made in the management and tracking of semi-finished stocks are quite remarkable. In the old system, manual monitoring and mismanagement of stocks led to high error rates and time losses. However, thanks to the new system, data such as the instantaneous location, status and size of each semi-finished product can be automatically monitored through image processing software and these data are instantly transferred to the production management system. This has resulted in a significant reduction in stock errors, while a significant increase in on-time tracking rates has been achieved. For example, the inventory error of the fabric increased from 18% to 6%, and the on-time tracking rate increased from 55% to 92%. These improvements increase the traceability of production processes, while at the same time allowing for faster and more accurate responses to customer demands.

Saving time is one of the most obvious consequences of technological integration. Reducing time losses in production processes allows the company to work more efficiently and flexibly. Semi-product follow-up time was reduced by 75% from 8 hours to 2 hours. In addition, the time spent on production line inspection was cut in half, and the total production time was reduced by 33%. This data shows that the company's production capacity can increase, and operational efficiency is greatly improved thanks to the fact that processes are becoming faster and more efficient.

The increase in labor productivity is also an important finding to be considered. The integration of artificial intelligence and image processing technologies has led to a significant reduction in the number of workforces. There has been a 53% decrease in the number of employees in the semi-finished product tracking process and a 50% decrease in production control. While this data shows the effective savings that technology provides on the workforce, it also makes it possible to direct employees to more strategic and creative jobs. The ability to do more work with fewer employees contributes to the company's both reducing costs and increasing its efficiency.

Finally, the reductions in production costs are also noteworthy. Inventory management costs were reduced by 60% and labor costs by 25%. This shows that technological integration also provides significant benefits in financial terms and increases the profitability of the company. There was a 15% reduction in total production

cost. This suggests that improving cost-effectiveness strengthens the company's competitive advantage and will help it gain a stronger position in market conditions.

The findings of this study show that the integration of artificial intelligence and image processing technologies in the textile industry not only increases production efficiency but also provides significant improvements in critical areas such as inventory management, labor efficiency and cost control. However, for technological integration to be successfully implemented, companies need to invest in their infrastructure and provide the necessary training to adapt employees to these new technologies. Future research may examine the wider applications of these technologies and their potential benefits in other manufacturing sectors.

Conclusion

This study revealed that artificial intelligence and image processing technologies play a key role in improving production processes in the textile industry, and this integration helps to reduce costs by increasing efficiency. The results highlight the effectiveness of technological solutions, especially in key areas such as semi-finished stock management, production line control, labor productivity and optimization of total production costs. The improvements have contributed to a broader understanding of the potential benefits of such technologies in manufacturing sectors and have filled existing gaps in literature.

From a scientific point of view, this study makes an important contribution in the fields of production management and digital transformation. Research on the integration of artificial intelligence and image processing technologies is often only at the theoretical level, not supported by practical examples. The applied data provided by this study concretely illustrates how these technologies operate in real-world scenarios and transform the operational performance of businesses. In this respect, a unique contribution has been made to literature, and it is one of the first in-depth analysis made specifically for the textile industry.

The results of the research offer several recommendations for future research. First, this study includes an applied analysis conducted on only one textile factory. Future studies may examine the integration of similar technologies in different industries and larger-scale production facilities. In addition, research on the sustainability and environmental impacts of such technologies will further deepen the knowledge in this field. Secondly, since the focus of this study is operational efficiency and cost optimization, research can be done that focuses more on human factors such as employee satisfaction and organizational culture. The long-term effects of technological transformation on the workforce need to be examined in more depth for both employees and managers.

There are also limitations to this study. First, the analysis was limited to only a specific textile mill, so the generalizability of the findings is limited. It is important to conduct similar research in companies with different business structures or in textile sectors in different countries to test the accuracy of these findings in a broader framework. In addition, practical difficulties such as the high installation and maintenance costs of artificial intelligence and image processing technologies used in the study were not considered. Future studies investigating the feasibility of such technologies should also consider the implications of these costs and technological infrastructure requirements.

Finally, this research provides important insights into the digital transformation process in the textile industry and provides data supported by practical examples, creating a valuable resource for both academics and professionals in the industry. This study aims to be a reference point for researchers who want to learn more about how artificial intelligence and image processing technologies can be used efficiently in their production processes. Technological innovations and digital transformation are expected to inspire further research across cross-industry boundaries.

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SELÇUK ÜNİVERSİTESİ
SOSYAL VE TEKNİK ARAŞTIRMALAR DERGİSİ

**The Impact of E-Government Systems and Anti-Corruption Measures on
Provincial Tax Revenue in Indonesia**

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Abstract

Several provincial administrations in Indonesia have significantly used technology. Technological developments are anticipated to enhance the efficiency and effectiveness of governmental operations. Furthermore, technology has the capacity to diminish occurrences of corruption. This results in an increase in provincial income. The objective of this research is to examine the impact of electronic government systems and anti-corruption measures on tax revenue. This study's sample included 34 distinct provinces in Indonesia. This analysis utilizes data from the year 2023. This inquiry using STATA version 17 to do multiple regression analysis. The test results demonstrate the impact of electronic government systems on curbing corruption and generating tax revenue among the populace. The enhancement of electronic government systems and anti-corruption initiatives in a certain area will significantly impact tax collecting increases. The findings of this research may be used by Indonesian provincial governments to enhance their governance.

Keywords

E-Government, Anti-Corruption, Tax Revenue, Provincial

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Endonezya'da E-Devlet Sistemlerinin ve Yolsuzlukla Mücadele Önlemlerinin İl Vergi Gelirleri Üzerindeki Etkisi

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Öz

Endonezya'daki birçok il idaresi teknolojiyi önemli ölçüde kullanmıştır. Teknolojik gelişmelerin hükümet operasyonlarının verimliliğini ve etkinliğini artırması beklenmektedir. Ayrıca, teknoloji yolsuzluk olaylarını azaltma kapasitesine sahiptir. Bu da il gelirlerinin artmasıyla sonuçlanır. Bu araştırmanın amacı, elektronik devlet sistemlerinin ve yolsuzlukla mücadele önlemlerinin vergi gelirleri üzerindeki etkisini incelemektir. Bu çalışmanın örneklemini Endonezya'daki 34 farklı ili içermektedir. Bu analizde 2023 yılına ait veriler kullanılmıştır. Bu çalışmada çoklu regresyon analizi yapmak için STATA sürüm 17 kullanılmıştır. Test sonuçları, elektronik hükümet sistemlerinin yolsuzluğu engelleme ve halk arasında vergi geliri yaratma üzerindeki etkisini göstermektedir. Elektronik hükümet sistemlerinin ve yolsuzlukla mücadele girişimlerinin belirli bir alanda geliştirilmesi, vergi toplama artışlarını önemli ölçüde etkileyecektir. Bu araştırmanın bulguları Endonezya il yönetimleri tarafından yönetişimlerini geliştirmek için kullanılabilir.

Anahtar Kelimeler

E-Devlet, Yolsuzlukla Mücadele, Vergi Geliri, İl

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Introduction

In Indonesia, the problem of corruption has not been resolved. Using the Corruption Perceptions Index, Indonesia has received a score of 37 out of a possible 100 points (Transparency International, 2024). When the score is greater, it suggests that the amount of corruption in the country is lower. On the other hand, a lower score is associated with a larger number of instances of corruption that occur inside any given country. According to the rankings, Indonesia is rated 99th out of 180 countries with a score of 37. This result is lower than the average score for the whole world. In terms of the prevalence of corruption, Indonesia is one of the countries that ranks among the top in the world. If this problem is not addressed in a timely manner, it will have a negative impact on the state's budget. There is a negative correlation between increased levels of corruption and declining tax receipts (Yamen, A., 2021). The compliance of taxpayers is negatively impacted when there is a high degree of corruption (Khaltar, O., 2023). The development of cynicism among taxpayers toward the government leads to a reluctance on their part to fulfill their required tax obligations. The primary source of income for Indonesia is derived from taxes. According to the Central Statistics Agency of Indonesia (2023), taxes take up eighty percent of the total revenue of the government.

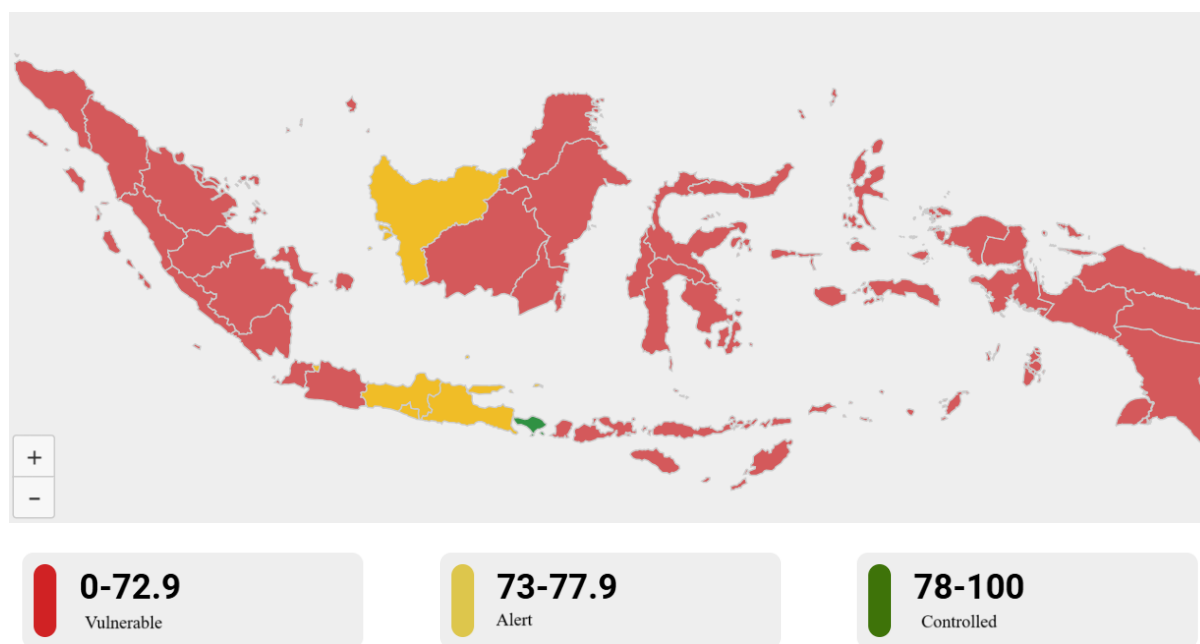


Figure 1 Each Indonesian province's vulnerability and corruption prevention efforts
Source: Jaga.id

Corruption cases in Indonesia transpire at both the national and provincial government levels. According to information from the Indonesian Corruption Eradication Commission on its website, jaga.id, in 2023, just one of the 34 provinces in Indonesia is classified under the green zone. Three provinces are classified in the yellow zone, while the other provinces are designated in the red zone, as seen in Figure 1. Of the 34 provinces of Indonesia, only one province is capable of effectively managing corruption within its jurisdiction. Figure 1 elucidates the value reported by the Corruption Perceptions Index for Indonesia.

In 2018, the Indonesian government, under the Ministry of Empowerment of State Apparatus and Bureaucratic Reform, initiated an e-government system known as the Electronic-Based Government System (EBGS). EBGS was established to achieve clean, efficient, transparent, and responsible government, together with high-quality public services. The use of this method aims to diminish the incidence of corruption cases in Indonesia. Prior research has demonstrated a substantial correlation between the adoption of e-government and the prevalence of corruption (Purnamasari, P., Frendika, R., Amran, N., Nor, M., & Ismail, M., 2022; Zhao, H., Ahn, M., & Manoharan, A., 2021; Jameel, A., Asif, M., Hussain, A., Hwang, J., Sahito, N., & Bukhari, M., 2019; Rustiari, N., 2019). EBGS is a legitimate initiative by the Indonesian government to adapt to the age of information and communication technology (ICT) revolution. The execution of EBGS requires yearly monitoring and evaluation. Consequently, annually, the Ministry of State Apparatus Empowerment and Bureaucratic Reform publishes a report on the present state of EBGS implementation within each Central Agency and Provincial Government. Each Central Agency and Provincial Government will undergo evaluation and get a designation. The predicates are Satisfactory, Very Good, Good, Sufficient, and Insufficient. In 2023, the average province in Indonesia

attained a score of 3, classified as Good. This indicates that many local governments are unable to adopt technology inside their administration.

The author intends to do research on the implementation of e-government, the enforcement of anti-corruption measures, and the generation of tax income. The purpose of this project is to put electronic government to use in the fight against bribery and to investigate the influence that it has on the collection of taxes. There have been other studies that have conducted research that is comparable; nevertheless, this study makes use of a particularly unique combination of elements and data. This study makes use of information obtained from studies about the implementation of electronic government systems, reports concerning efforts aimed at preventing corruption, and statistics concerning the collection of provincial tax income. The sample for the research consisted of 34 different provinces in Indonesia.

1. Literatur Review

Corruption is a significant issue that necessitates attention in several places worldwide. The country's economy may deteriorate if this issue is not promptly resolved (Binaj, I., 2015). Corruption will adversely affect tax collection, as well as the economy. Obaid and Udin's 2020 study indicates that corruption exacerbates the severity of tax evasion. Corruption may diminish taxpayers' trust in the government. Taxpayers might express their dissent towards the government by failing to fulfill their tax duties. Taxpayers who fail to fulfill their duties result in a reduction in tax revenue (Ajaz, T. and Ahmad, E., 2022; Picur, R. and Riahi-Belkaoui, A., 2006).

Khelif, H., and Amara, I. (2019) discovered a substantial correlation between tax revenues and occurrences of corruption in a study including 35 nations. Khaltar, O. (2023) elucidated the findings by examining the correlation among governmental efficacy, regulatory system quality, corruption control, and transparent governance, all of which collaboratively mitigate tax evasion. This study's findings demonstrate that governmental management decisions significantly influence tax revenue. The current federal administration is beginning to align with cutting-edge technological advancements. The government increasingly allocates cash for the development of technology infrastructure, including the execution of e-government initiatives. Gambo, E., Liuraman, Z., Mshelia, A., and Muslimat, A. (2023) assert that the objective of this technical infrastructure is to provide services that are both effective and efficient to the community. Furthermore, e-government may diminish the prevalence of corruption (Purnamasari, P., Frendika, R., Amran, N., Nor, M., & Ismail, M., 2022; Zhao, H., Ahn, M., & Manoharan, A., 2021; Jameel, A., Asif, M., Hussain, A., Hwang, J., Sahito, N., & Bukhari, M., 2019; Rustiarini, N., 2019). E-government may reduce the inherent potential for corruption in manual activities. A different cohort of researchers, Park, C., and Kim, K. (2019), reached same findings. An extensive correlation between e-government and corruption was identified via a study of data from 2003 to 2016 across 214 distinct nations. The increase in tax revenues will be positively impacted by a reduction in corruption levels. On the other side, Basyal, D., Poudyal, N., and Seo, J. (2018) concluded that there was no significant relationship between e-government and corruption.

Priambodo, A., Anwar, N., & Suharno, S. (2024) and Shair, W., Hassan, R., & Iftikhar, R., (2024) Studies indicate that the use of information and communication technology (ICT) via e-government has led to an augmentation in tax revenue. E-government services exemplify the successful use of technology within governmental operations. Kuzey, C., Uyar, A., and Nimer, K. (2024) conducted research of the impact of e-government on tax evasion. This study revealed that a primary objective of implementing e-government is to decrease tax evasion. This research utilizes four proxies for e-government: the long-term vision of public administration, the adaptability of government to change, the supply of online services to citizens, and the establishment of a legal framework for digital commercial services. From 2008 to 2021, Orviská, M., and Ščerba, K. (2023) performed an examination of existing secondary panel data and cross-sectoral data related to EU member states. The results of this study align with the findings of other researchers. Based on the findings of the study, it appears that there may be a relationship between the utilization of e-government and tax avoidance. Furthermore, B. Mititelu, R., and Nişulescu, I. (2023) reached same findings in their study. The government must prioritize the development of e-government to get optimal benefits. To surmount the significant challenges that have arisen, the government must take action. Oye (2013) asserts that the advancement of e-government will be ineffectual if these issues are not addressed.

1.1 Hypothesis Development

E-Government and Corruption

The development of electronic governance is a step that is being taken to reduce instances of corruption. Prior research has established a correlation between e-government and corruption (Purnamasari, P., Frendika, R., Amran, N., Nor, M., & Ismail, M., 2022; Zhao, H., Ahn, M., & Manoharan, A., 2021; Jameel, A., Asif, M., Hussain, A., Hwang, J., Sahito, N., & Bukhari, M., 2019; Rustiarini, N., 2019; Park, C. and Kim, K., 2019). Corruption in governmental activities might be reduced by the use of e-government. E-government makes it easier to carry out activities related to supervision. Consequently, any inconsistency may be found and addressed in a timely manner. As stated in the following, the author provides:

H₁: Evidence that E-Government Contributes to Corruption

E-Government, Corruption, and Tax Revenue

The government's principal concern is the revenue generated via taxation. One of the several strategies used by the government to optimise tax revenue is the implementation of an electronic government system. The e-government system is anticipated to enhance administrative services for the public, resulting in an increase in tax revenue. The government must enhance the administrative system and combat corruption. The government may implement several preventive measures, including risk mitigation and the eradication of activities susceptible to corruption. Research by Khaltar, O. (2023) indicates a correlation between governance and the regulation of corruption and tax revenue. Khlif, H., and Amara, I. (2019) did similar study, revealing a correlation between corrupt behaviours and the volume of tax revenue collected. Research indicates that elevated corruption levels result in diminished tax revenue (Ajaz, T. and Ahmad, E., 2022; Picur, R. and Riahi-Belkaoui, A., 2006). Consequently, the author articulates Hypothesis 2 as follows:

H₂: An Examination of the Impact of E-Government and Corruption on Tax Revenue

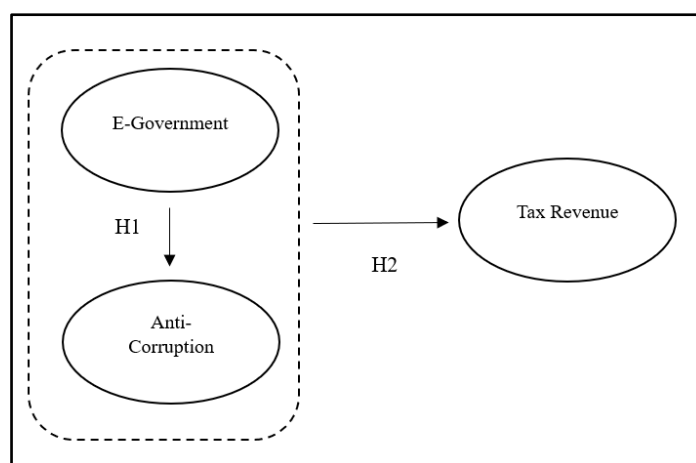


Figure 2 Research model
Source: Processed by the author

2. Methodology

2.1 Data and Variable

Table 1 Data and variable

No	Variable	Definition	Measurement	Source
1	E-Government	Execution of Electronic Government Systems in the Province.	Evaluation scale of 1 to 5. The greater, the superior.	Annual Assessment Report of the Ministry of State Apparatus Empowerment and Bureaucratic Reform www.menpan.go.id
2	Corruption	Corruption Mitigation Initiatives implemented by the Provincial Government.	The evaluation scale ranges from 0 to 100. The greater, the superior.	Annual Integrity Survey Report of the Indonesian Corruption Eradication Commission www.jaga.id
3	Tax Revenue	Provincial Tax Revenue is derived via taxation.	Articulated in Indonesian Rupiah.	Annual Report of the Central Bureau of Statistics of Indonesia www.bps.go.id

Source: Processed by the author

For the purpose of this study, information is gathered from 34 different provinces in Indonesia about the implementation of the Electronic-Based Government System, Corruption Prevention Measures, and Tax Revenue. The reports are derived from annual publications that are distributed by a number of different organisations in Indonesia. The report on the Electronic-Based Government System was sourced from the Annual Assessment Report of the Ministry of State Apparatus Empowerment and Bureaucratic Reform, the report on Corruption Prevention Measures was derived from the Annual Integrity Survey Report of the Indonesian Corruption Eradication Commission, and the report on Tax Revenue was acquired from the Annual Report of the Central Bureau of Statistics of Indonesia. This study uses two independent variables and one dependent variable. The two independent variables are corruption and electronic government. Tax revenue is the dependent variable.

2.2 Analysis Method

Data acquired from several sources will be subjected to regression testing with the STATA Version 17 software. Before doing the regression test, a classical assumption test is performed first. This study utilises classical assumption tests, including the Normality Test, Multicollinearity Test, and Heteroscedasticity Test.

3. Finding

3.1 Assumption Classic Test

Normality Test

Table 2 Normality test result

No	Variable	Obs.	Prob.
1	E-Government	34	0,33806*
2	Corruption	34	0,70570*
3	Tax Revenue	34	0,11895*
Note: * > 0,05			

Source: Processed by the author

A presentation of the results of the normality evaluation may be seen in Table 1. It is common for quality data to be dispersed evenly. In accordance with the results of the normality test, each of the independent and dependent variables had probability values that were more than 0.05. As a consequence of this, one might draw the conclusion that all of the independent and dependent variables have a distribution that is typical.

*Multicollinearity Test***Table 3** Multicollinearity Test Result

No	Variable	VIF	Prob.
1	Corruption	1,57*	0,6386**
2	E-Government	1,57*	0,6386**
Note: *<10, **>0,10			

Source: Processed by the author

A presentation of the findings from the multicollinearity analysis can be found in Table 2. The absence of multicollinearity is a characteristic of an efficient regression model. Each of the independent variables had probability values that were more than 0.10 and VIF values that were less than 10, which indicated that the regression model did not include any instances of multicollinearity.

*Heteroskedasticity Test***Table 4** Heteroskedasticity test

Table 4. Heteroskedasticity test		
No	Variable	Prob.
1	E-Government	0,1014*
2	Corruption	
3	Tax Revenue	
Note: *>>0,05		

Source: Processed by the author

An assessment of heteroscedasticity was performed, and the results are shown in Table 3. A regression model that does not display heteroscedasticity or homoscedasticity constitutes an effective model for regression analysis. Because the computed probability value is 0.1014, which is more than 0.05, it can be concluded that the regression model does not include any heteroscedasticity.

*Descriptive Statistic***Table 5** Descriptive statistic

No	Variable	Obs.	Mean	Std. Dev.	Min.	Max.
1	E-Government	34	3,1855	0,6291	1,91	4,26
2	Corruption	34	69,8779	4,7804	57,19	78,45
3	Tax Revenue	34	9,3647	0,5248	8,5832	10,6386

Source: Processed by the author

Descriptive statistics for each variable are included in the table, which may be seen above. There is a minimum value of 1.91 and a maximum value of 4.26 for the E-Government variable, with an average value of 3.1855, a standard deviation of 0.6291, and a minimum value of 3.1855. Considering these findings, it is clear that there is a disparity in the degree to which different provinces have implemented e-government. This is evident in the fact that one of the provinces earned the lowest value, 1.91, with a predicate of less, and the most outstanding value, which was 4.26, with a predicate of very excellent, both of which were gained by two different provinces. As an additional point of interest, the corruption variable had a mean value of 69.8779, a standard deviation of 4.7804, a minimum value of 57.19, and a maximum value of 78.45. According to these numbers, almost every area in Indonesia is susceptible to engaging in corrupt activities. A clear indication of this may be seen in the presented numbers, which do not demonstrate significant disparities. The average value of the Tax Revenue variable is 9.3647, with a standard deviation of 0.5248, a minimum value of 8.5832, and a maximum value of 10.6386. It is clear from these findings that the average tax income collected by each province is reasonably consistent, except in select regions where there are significant variances.

Table 6 Regression test result

Independent Variable	E-Government	E-Government and Corruption
Dependent Variable	Corruption	Tax Revenue
Constanta	55,328	6,095
Coefficient	4,567	0,3633 and 0,0302
T	4,25	2,52 and 1,59
P-value	0,0002*	0,0003*
R ²	0,3414 / 34,14%	0,3715 / 37,15%
Number of Observation		34
Note: *Significance at the 1% level, **Significance at the 5% level, ***Significance at the 10% level.		

Source: Processed by the author

3.2 Regression Equation

First Regression Equation

$$Y = 55,328 + 4,567 X + e$$

The fixed value of 55.328 indicates that in the absence of the e-Government variable (X), the Corruption variable (Y) will rise by 55.328. The beta coefficient of e-Government (X) is 4.567, indicating that, holding other factors constant, a 1-point rise in variable X results in a 4.567 increase in variable Y; conversely, a 1-point reduction in variable X leads to a 4.567 decrease in variable Y, assuming other variables remain same

Second Regression Equation

$$Y = 6,095 + 0,3633 X_1 + 0,0302 X_2 + e$$

The constant value is 6.095, indicating that in the absence of the e-Government (X₁) and corruption (X₂) variables, the Tax Revenue (Y) variable would rise by 6.095. The beta coefficient for e-Government (X₁) is 0.3633, indicating that, holding other variables constant, a 1-point increase in X₁ results in a 0.3633 increase in variable Y; conversely, a 1-point decrease in X₁ leads to a 0.3633 decrease in Y, assuming other variables remain constant. The beta coefficient for corruption (X₂) is 0.0302, indicating that, holding other variables constant, a 1-point increase in X₂ results in a 0.3633 increase in variable Y; conversely, a 1-point decrease in X₂ leads to a 0.3633 decrease in variable Y, assuming other variables remain constant.

3.3 Hypothesis Testing

The P-value that is obtained from the simple and multiple regression analyses that are shown in Table 6 may be used to evaluate the partial or simultaneous effects that are associated with the variables that are independent and those that are dependent. A P-value of 0.0002 is connected with the relationship between e-Government and corruption. The fact that this value is lower than one percent suggests that Hypothesis 1 is correct. eGovernment has a significant influence on the level of corruption that exists. A P-value of 0.0003 is found for the variables of e-Government, corruption, and tax revenue. The fact that this value is lower than one percent suggests that Hypothesis 2 is correct. Corruption and electronic government both have a significant influence on tax revenue. The value of the R² statistic indicates the degree to which the independent variable is responsible for the variance in the variable that is being depended upon. In the first examination, the R² score that was reported was 0.3414. It is possible that 34.14 percent of the influence of e-Government on corruption may be explained. During the second test, the value of R² that was obtained was 0.3715. A total of 37.15 percent of the variation may be attributed to the influence that e-Government and corruption have on tax revenue.

3.4 Discussion

The results of the hypothesis testing using simple regression reveal that there is a significant influence that e-Government has on political corruption. The establishment of a government system that is based on electronic communication throughout all 34 provinces in Indonesia has an influence on their ability to fight corruption. There seems to be a positive association between the two, according to the results of the test. Therefore, it is possible to draw the conclusion that the Electronic-Based Government System has a stronger impact on the prevention of corruption in proportion to the degree to which it is implemented successfully. Bali is one of the

provinces that has received the highest scores for its ability to prevent corruption. With a score of 78.45, Bali was able to successfully avoid corruption. Within the whole of Indonesia, this province is the only one that is categorized as a green zone. It is essential that this be done in order to successfully deploy an electronic-based government system. The implementation of the electronic-based government system was given a score of 4.07, which indicates that Bali enthusiastically supports the adoption of the system. On the other hand, the province that had the lowest grade for its ability to combat corruption also had the lowest value for its electronic-based government system. This sample provides further evidence that the results of the test using STATA version 17 are accurate. In light of these findings, the Indonesian government need to strengthen the Electronic-Based Government System in every province in order to reduce the number of instances of corruption. This methodology, which has been tested and may be further enhanced in its implementation, is not the sole method for reducing instances of corruption; nonetheless, it is one of the strategies that has been tested. The results of this study are corroborated by prior research, which identified a relationship between e-Government and corruption (Purnamasari, P., Frendika, R., Amran, N., Nor, M., & Ismail, M., 2022; Zhao, H., Ahn, M., & Manoharan, A., 2021; Jameel, A., Asif, M., Hussain, A., Hwang, J., Sahito, N., & Bukhari, M., 2019; Rustiari, N., 2019; Park, C. and Kim, K., 2019).

An examination of the influence that e-Government and corruption have on tax income was the subject of the second study, which was a multiple regression test. The results of the test reveal that e-government and corruption have a significant impact on the amount of money collected in taxes. This influence has been proved to be helpful in nature. The boost in tax revenue will be of greater significance in proportion to the degree to which the Electronic-Based Government System is implemented with greater efficiency. The results suggest that in order for the government to improve tax collection, it must simultaneously prioritize the optimization of the Electronic-Based Government System and fight corruption at the same time. It is imperative that the government take action to strengthen the Electronic-Based Government System and reduce instances of corruption, given that taxes significantly increase the amount of money collected by the state. The province of Jawa Tengah is a highly excellent province that excels in all three of these attributes. Jawa Tengah has received the highest rating in Indonesia for the implementation of the Electronic-Based Government System, which is a laudable achievement. It is among the provinces in Indonesia that have the highest tax revenue, in addition to having a solid score for the prevention of corruption, which is only surpassed by Bali. The findings of this study are consistent with those of previous studies that have shown a connection between the influence of corruption on tax revenues and the governance of the government (Khaltar, O., 2023; Ajaz, T. and Ahmad, E., 2022; Khlif, H., and Amara, I., 2019; Picur, R. and Riahi-Belkaoui, A., 2006).

Conclusion

The purpose of this study is to investigate the impact that e-Government has on the enforcement of corruption, as well as the synergistic effect that e-Government and corruption enforcement have on the total tax collections in Indonesia's 34 provinces. It is clear that e-Government has a substantial impact on corruption, as shown by the conclusions of basic regression analysis and the data acquired from a large number of institutional reports in Indonesia in the year 2023. In addition, the findings of the multiple regression analysis suggest that elements such as e-Government and corruption have a substantial impact on the amount of money collected in taxes. When it comes to the enforcement of corruption, provinces that have high e-government adoption ratings also often have high corruption enforcement metrics, and vice versa. There is a correlation between provinces that have high values in both measures and considerable tax revenue, and vice versa. According to the findings of the research, in order to increase tax collections, provincial governments need to strengthen their commitment to the implementation of the Electronic-Based Government System and strengthen their anti-corruption activities. It is imperative that the government make improvements to the infrastructure in order to support a government framework that is driven by technology. If this method is effective, it may be possible to improve the prevention of corruption, which would result in an increase in the amount of taxes collected.

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SELÇUK ÜNİVERSİTESİ
SOSYAL VE TEKNİK ARAŞTIRMALAR
DERGİSİ

Determinants of Turkish Firms' Sales Revenue: An Empirical Analysis

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Abstract

This study investigates the key determinants of firm-level sales performance in Türkiye, based on data from the 2024 World Bank Enterprise Survey. Employing an ordinary least squares (OLS) regression model on a cross-sectional dataset comprising 1,000 firms, the analysis demonstrates how firm-specific, institutional, and managerial characteristics influence sales outcomes. The empirical findings indicate that firm age and size, as well as the educational attainment of managers and managerial experience, are positively and significantly associated with sales performance. Conversely, the presence of a female top manager is found to be negatively associated with firm sales, highlighting potential structural and institutional barriers that may hinder women in executive leadership positions. Moreover, research and development (R&D) spending, new product innovation, the use of foreign technology, and international certification exert negative or statistically weaker effects on sales performance. These findings underline the prominent role of human capital and organizational attributes in shaping firm productivity and competitiveness, offering meaningful implications for policymakers and business strategists within emerging market contexts.

Keywords

Sales Performance, Firm Characteristics, Research and Development (R&D) Activities, Innovation, World Bank Enterprise Survey (WBES), Türkiye.

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Türk Firmalarının Satış Gelirlerinin Belirleyicileri: Ampirik Bir Analiz

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Öz

Bu çalışma, Türkiye'deki firmaların satış performansının belirleyicilerini incelemekte; analizlerde 2024 Dünya Bankası İşletme Anketi verileri kullanılmaktadır. 1.000 firmadan kesitsel bir veri grubu üzerinde (OLS) regresyon modeli uygulanarak, firma özelliklerinin ve yönetsel faktörlerin satış sonuçları üzerindeki etkileri araştırılmıştır. Ampirik bulgular, firma büyüklüğü, yöneticilerin eğitim düzeyi, yöneticilik deneyimi ve firma yaşı gibi faktörlerin satış performansı ile pozitif ve anlamlı bir ilişkiye sahip olduğunu ortaya koymaktadır. Buna karşılık, üst düzey yöneticinin kadın olması, firma satışlarıyla negatif yönde ilişkilendirilmiş olup, bu durum kadınların liderlik pozisyonlarında karşılaştığı yapısal ve kurumsal engellere işaret etmektedir. Ayrıca, Ar-Ge faaliyetleri, ürün inovasyonu, yabancı teknoloji kullanımı ve sertifikasyon gibi değişkenlerin satış performansı üzerinde negatif veya istatistiksel olarak daha zayıf etkiler gösterdiği gözlemlenmiştir. Bu bulgular, beşeri sermaye ve örgütsel özelliklerin firma verimliliği ve rekabet gücü üzerindeki belirleyici rolünü vurgulamakta olup gelişmekte olan piyasa bağlamlarında politika yapımcılar ve iş stratejistleri için önemli çıkarımlar sunmaktadır.

Anahtar Kelimeler

Satış Performansı, Firma Özellikleri, Ar-Ge Faaliyetleri, İnovasyon, Dünya Bankası İşletme Anketi (WBES), Türkiye.

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Telif Hakkı & Lisans	Yazarlar dergide yayınlanan çalışmalarının telif hakkına sahiptirler ve çalışmaları CC BY-NC 4.0 lisansı altında yayımlanmaktadır.

Introduction

In today's competitive economic landscape, generating sales revenue is a critical indicator of a firm's financial health, competitiveness, and growth potential. Understanding the factors that drive sales performance is vital for both strategic planning and policy development. Prior research has revealed that industry-level characteristics significantly influence sales growth (Fávero et al., 2018). Warsame (2023), using the World Bank Enterprise Survey, found that labor productivity and technology positively influence sales in Sub-Saharan African countries. The study also noted that profitability and market position are closely tied to sales revenue, which is shaped by both internal and external dynamics. It is recommended that firms enhance productivity through skilled labor.

In the Turkish context, Dalgıç and Fazlıoğlu (2021) explored the role of innovation in firm performance across manufacturing and service sectors. They found that R&D has a stronger effect on manufacturing firms, whereas service firms benefit more from innovative outputs. Sönmez and Amirzai (2024) explored firm-level sales performance using the World Bank Enterprise Survey and emphasized the role of firm size and age in Turkish manufacturing firms while giving limited attention to managerial and institutional characteristics. Similarly, Sönmez and Amirzai (2023) highlighted the importance of in-house R&D activities and using foreign technology in promoting the innovation activities of Turkish manufacturing firms.

Türkiye's emerging market status, diverse industrial base, and recent economic challenges create an ideal context to explore these dynamics. Utilizing 2024 World Bank Enterprise Survey data, this study addresses the research gap by examining how a broader range of firm-specific factors (e.g., age, size), managerial factors (e.g., experience, gender), and institutional factors (e.g., R&D, New product innovation, Use of foreign technology, international certification) influence sales revenue. This study aims to identify the key firm-specific, managerial, and institutional factors driving sales revenue in Turkish firms. The study offers actionable insights for Turkish firms to enhance performance, for policymakers to design targeted interventions, and for academia to advance knowledge on sales drivers.

This study is organized into five sections, each serving a distinct purpose. The first section is the introduction part, providing background and context. The second section reviews the literature. The third section describes the research methods and data sources. The fourth section presents the empirical analysis and findings on factors influencing sales revenue. The fifth section concludes by summarizing key findings and discussing their implications for Turkish firms.

1. Literature review

Sales growth studies are a popular research area that examines both firm and company growth. Firm growth can arise from new financing sources, such as debt and equity, while sales growth involves increases in assets, sales, equity, and liabilities. This research focuses on the determinants of sales growth. (Warsame, 2023) Growth in sales has been attributed to the company's industry-level attributes. The study reveals that industry-level characteristics account for a significant portion of the variance in real annual sales growth, representing 77.2% of the variance (Fávero et al., 2018).

The industry academic literature confirmed that there is a positive and significant relationship between the firm size and sales revenue growth, supporting the argument that larger firms benefit from economies of scale and enhanced market access (Ibhagui & Olokoyo, 2018; Olawale et al., 2017; Pervan & Višić, 2012). Also, as stated by Lun & Quaddus (2011), the bigger companies often encounter greater sales increases due to economies of scale and larger market accessibility. A study on French new ventures stated that firm size development facilitates the bond between growth purpose and sales growth, representing that as firms grow in magnitude, their sales revenue tends to rise (Cesinger et al., 2018). Their study, Widawati (2023), showed that firm size positively affects financial performance. These studies indicate a positive correlation between firm size and sales revenue, with larger firms often benefiting from economies of scale and greater market penetration. Sönmez and Amirzai (2024) explored firm-level sales performance using the World Bank Enterprise Survey and emphasized the role of firm size and age in Turkish manufacturing firms. However, some research suggests that there is a nonlinear relationship between business age and revenue creation, with younger firms undergoing substantial expansion, accompanied by stability or decline over time (Coad et al., 2013, 2018).

The literature emphasizes the significant impact of managerial expertise, particularly top managers' experience, on firm performance, including sales revenue (Bathula, 2008; Davis et al., 1997; Hamori & Koyuncu, 2015). Navigating risks and uncertainties enables top-experienced managers to make informed decisions (Peni, 2014). Accordingly, Venkat's (2005) study examines Emirates' strategic incorporation of sales, revenue management,

and organized planning; developing management experience; positioning objectives; developing decision-making; and improving sales revenue and effectiveness. Mixed results on managerial experience's impact on firm performance, with a Fortune 500 study suggesting broader managerial skills are crucial for revenue generation (Cedillos et al., 2020). Having a revenue manager on personnel was not sufficient; their qualifications and experience were worthy factors in establishing the accomplishment of revenue management employment (Abad et al., 2019). Peake (2014) is considering his recommendations. Although experience is essential, it is not the single factor of sales revenue, and other aspects must be studied, paving the way to add more variables to study to cover the main determinants of sales revenue of Turkish firms.

The study explores the influence of the educational composition of the staff, specifically the percentage of workers with secondary education qualifications, on firm performance (Warsame, 2023). Skilled labor has been seen as important in firm production (Erden et al., 2014). Also, literature supports the idea that education has a strong influence on firms' revenue generation (Bartolj, 2023a; Bolander et al., 2014; Deli et al., 2024; Kampelmann et al., 2016). There is a strong relationship between educational diversity and firm performance, as studies conclude that education levels and disciplines of education mark the probability of expansion of total sales (Bartolj, 2023b). The paper emphasizes the importance of secondary education in meeting labor needs in organized sectors, driving sales growth, enhancing skills, and improving employment opportunities. (Jain et al., 2018), The importance of quality education, particularly secondary education, lies in fostering sales growth by improving workforce capabilities and market adaptability. (Matthews, 2013), These empirical studies show that education has a direct influence on sales revenue.

There are notable gender differences in firm size, but not always in terms of productivity and sales growth, according to existing data on the performance disparity between male and female businesses across various global areas (Allison et al., 2015; Bardasi et al., 2011). According to Lee et al. (2010), in their study, they stated that female managers reported higher profit growth between 1996 and 1999 despite lower business profits, indicating they perceive businesses as more successful despite smaller sales figures. Also, a study conducted in South Asia examined productivity gaps between female- and male-managed companies globally, revealing higher average labor productivity in firms with female top managers, leading to higher profitability performance (Martinez-Zarzoso, 2023). It suggests that female managers' superior behavior control may enhance sales growth, although specific metrics are not provided for the study (Piercy et al., 2003).

A study made in India using World Bank enterprise data found that 44.9 percent have adopted international quality certification, enhancing business processes. These results show significant differences in sales (Ali & Yusuf, 2021). Literature stated that International certification, like ISO standards, significantly boosts a firm's reputation, productivity, and foreign market access, thereby boosting sales growth. (Aji et al., 2023; Bukhari et al., 2024; Kang & Lee, 2022; Otsuki, 2011; Wayoro, 2024). Some other studies also stated that international certification leads to lower financial risk, and standard administration practices such as ISO 14001 hinder the sales growth of firms (Ye et al., 2020).

Recent research suggests a complex relationship between foreign-licensed technology adoption and sales growth, with some studies showing a positive correlation and others suggesting a non-universal impact. Although it has mixed results, according to Gaspar's (2022) study, in Philippine manufacturing companies' sales do not always rise when foreign-licensed technology is introduced, unless businesses that invest in personnel training perform better, indicating that absorptive capacity is essential for reaping the benefits of having foreign-licensed technology. Businesses that utilize technology licensed from outside benefit from productivity and sales growth. (Rigo, 2021). Nabin et al. (2013) revealed that there is a significant positive correlation between foreign-licensed technology and economic growth in Asian economies, suggesting that licensing can boost production efficiency and sales.

Methodology

This study aims to identify the key firm-specific, managerial, and institutional factors driving sales, using Sales revenue as the dependent variable, as the natural logarithm of total sales, to account for potential skewness and improve interpretability, by employing a linear regression model. To this end, the following empirical model was specified:

Equation of the Model

$$\begin{aligned} \text{Log}(\text{Sales})_i = & \beta_0 + \beta_1 \cdot \text{Size}_i + \beta_2 \cdot \text{Age}_i + \beta_3 \cdot \text{Experience}_i + \beta_4 \\ & \text{R\&D}_i + \beta_5 \cdot \text{Education}_i + \beta_6 \cdot \text{New Product Innovation}_i + \beta_7 \cdot \text{Gender}_i + \beta_8 \cdot \text{International Certification} \\ & + \beta_9 \cdot \text{Foreign Technology}_i + \varepsilon_i \end{aligned}$$

In Equation (1), the dependent variable is the natural logarithm of total sales revenue for firm i . The independent variables include the number of full-time employees (size), firm age in years (age), cumulative managerial experience (experience), engagement in research and development activities (R&D), the percentage of employees with at least secondary education (education), gender of top management (gender of the top manager), possession of quality certification (international certification), utilization of foreign technology (foreign technology), and the introduction of new products (new product innovation).

Each coefficient (β) in the model captures the direction and magnitude of the relationship between the respective explanatory variable and sales performance, while the error term (ε_i) accounts for unobserved factors affecting firm revenue. By analyzing these relationships, the model aims to identify the most influential factors driving firm-level sales outcomes in the Turkish context.

Data

The study's dataset was based on firm-level data from the 2024 World Bank Enterprise Survey (World Bank, 2024). This dataset includes essential information from 1,000 Turkish businesses. A wide range of business-related topics, including financial indicators and innovation goals, are covered in detail by the study's comprehensive data collection methods, which are all expressed in Turkish Lira (TRY). Since the 2024 dataset was the most current and comprehensive source available at the time of our inquiry, it was used. This allowed us to use up-to-date, reliable data to analyze the factors influencing company sales income in the context of Turkish firms.

Table 1: Variable description

Variable	Definition
Size	Number of employees in the firm (firm size).
Education	Average years of education of the firm's manager.
Experience	Years of experience as the firm's manager in the industry.
Gender	Dummy variable: 1 if the firm's top manager is male; 0 if female.
New product Innovation	Dummy variable: 1 if the firm introduced a new product in the Last 3 years, 0 otherwise.
Age	Number of years since the firm was established.
Foreign Technology	Dummy variable: 1 if the firm has foreign technology, 0 otherwise.
International certification	Dummy variable: 1 if the firm has an international certificate 0 otherwise.
R&D	Dummy variable: 1 if the firm invests in research & development 0 otherwise.
Annual Sales	Total annual sales.
Prepared by the author from WBES-2024.	

Results and Discussion

Table 2: Descriptive statistics of variables (N = 1,000)

Variable	Obs	Mean	Std. Dev.	Min	Max
International certification	1,000	0.527	0.500	0	1
Foreign Technology	1,000	0.788	0.409	0	1
New Product Innovation	1,000	0.083	0.276	0	1
R&D	1,000	0.041	0.198	0	1
Firm Age	1,000	17.099	11.199	0	76
Geder	1,000	0.065	0.247	0	1
Size	1,000	1.756	0.801	1	3
Education	1,000	57.832	29.951	0	100
Sales	1,000	1.95e+08	6.06e+08	360,000	1.61e+10
Experience	1,000	25.308	11.485	1	70

Table 2 presents the descriptive statistics for the dataset, offering insights into the characteristics of 1,000 Turkish firms. Approximately 52.7% of firms hold international certifications, indicating that just over half meet industry or quality standards. A significant 78.8% use foreign technology, reflecting a strong reliance on external technological advancements. However, only 8.3% have introduced new products in the past three years, and just 4.1% invest in research and development (R&D). These low figures suggest that many firms prioritize operational stability over innovation, possibly due to limited resources.

Firm age averages 17.1 years, ranging from newly established to 76 years old, showing a diverse range of experience levels. Gender diversity is limited, with only 6.5% of firms led by female top managers. Firm size, measured on a scale from 1 (small) to 3 (large), averages 1.76, indicating most firms are small to medium-sized. Education levels vary widely, with an average of 57.8% of managers or employees having formal education, ranging from 0% to 100%.

Sales show significant variation, averaging 195 million Turkish Lira (TRY) but ranging from 360,000 to 16.1 billion TRY, reflecting differences in market reach and firm scale. Managerial experience averages 25.3 years, with a range of 1 to 70 years, suggesting that experienced individuals lead most firms.

Table 3: Variance inflation factor (VIF) for variables

Variable	VIF	1/VIF
Experience	1.45	0.6879
Firm age	1.38	0.7269
Size	1.31	0.7661
International certification	1.26	0.7933
Foreign technology	1.13	0.8826
New product innovation	1.14	0.8755
R&D	1.16	0.8647
Gender	1.06	0.9423
Education	1.06	0.9477
Mean VIF = 1.22		

Table 3 shows that the Variance Inflation Factor (VIF) values for the independent variables in the regression model are below the threshold, indicating low multicollinearity concerns. The mean VIF of 1.22 confirms the model's stability and reliability, enhancing the robustness and interpretability of the regression estimates.

Table 4: Assumption tests for linear regression model

Assumption	Test	Statistic	p-value	Conclusion
Linearity	Visual check	–	–	Satisfied
Homoskedasticity	Breusch–Pagan	$\chi^2(I) = 2.41$	0.1208	Satisfied
Normality	Shapiro–Wilk	W = 0.9972	0.0771	Satisfied

Table 4 shows the diagnostic tests conducted to evaluate the assumptions of the linear regression model, indicating that the key conditions for valid inference are satisfied. The linearity assumption was verified through visual inspection of residuals, which showed no evidence of nonlinearity between the predictors and the dependent variable. The Breusch–Pagan test for homoskedasticity yielded a chi-square statistic of 2.41 with a p-value of 0.1208, suggesting that the variance of the residuals is constant and there is no *significant heteroskedasticity*. Additionally, the Shapiro–Wilk test for normality of residuals returned a W statistic of 0.9972 and a p-value of 0.0771, indicating that the residuals do not significantly deviate from a normal distribution. Collectively, these results support the appropriateness of the linear regression model assumptions, thereby reinforcing the reliability and validity of the model's estimates.

Table 5: Regression results for sales

Variable	Coefficient.	Std. Error	t-value	p-value
International Certification	-0.6628	0.0836	-7.93	0.000
Foreign Technology	-0.2772	0.0968	-2.86	0.004
New Product Innovation	-0.2929	0.1439	-2.03	0.042
R&D	0.3623	0.2015	1.80	0.073
Firm Age	0.0164	0.0039	4.21	0.000
Gender	-0.4138	0.1553	-2.67	0.008
Size	1.3717	0.0530	25.86	0.000
Education	0.0077	0.0013	6.07	0.000
Experience	0.0101	0.0039	2.58	0.010
Constant	14.7116	0.1788	82.28	0.000

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

R-squared = 0.6056

Adj R-squared = 0.6021.

Table 5 summarizes the result of a multiple linear regression model analysis used to explore the determinants of firm sales performance, determined as the natural logarithm of sales (log-sales), using a sample of 1,000 firms. The regression model is highly significant ($F(9, 990) = 168.93$, $p < 0.001$) and explains around 60.2% of the variation in sales performance (adjusted $R^2 = 0.6021$), indicating a strong model fit and explanatory power.

Among the firm-level variables, firm size was the most significant positive predictor with a coefficient of 1.372 ($p < 0.001$), proposing that larger firms benefit from economies of scale or improved market power that significantly increase sales. In line with previous studies (Ibhagui & Olokoyo, 2018; Olawale et al., 2017; Pervan & Višić, 2012). Firm Age also showed a positive and statistically significant effect ($\beta = 0.016$, $p < 0.001$), revealing that more established firms manage to achieve higher sales due to accumulated experience and market reputation.

Managerial-related variables, including education ($\beta = 0.008$, $p < 0.001$) and work experience ($\beta = 0.010$, $p = 0.010$), were positively associated with sales, reinforcing the critical role of skilled and experienced labor in driving firm performance. These findings are consistent with the literature emphasizing the value of knowledge and expertise within organizational settings (Warsame, 2023). Inverse to expectations, the gender variable, coded as a dummy for female top managers, was negatively related to sales performance ($\beta = -0.414$, $p = 0.008$). This finding may reflect underlying structural or contextual barriers that female-led firms face in the studied market, warranting further qualitative investigation to understand the socio-economic dynamics at play.

Regarding institutional-related variables, Foreign Technology Adoption ($\beta = -0.277$, $p = 0.004$) and New Product Introduction ($\beta = -0.293$, $p = 0.042$) were both negatively associated with sales. This counterintuitive result may indicate challenges such as excessive costs, market resistance, or implementation inefficiencies that diminish short-term sales outcomes. Additionally, the international certification status variable exhibited the strongest

negative impact on sales ($\beta = -0.663$, $p < 0.001$), potentially reflecting the burden of certification costs or stricter compliance requirements limiting sales capacity in the short run. Also, the effect of research and development (R&D) activities was positive but marginally insignificant at the 5% level ($\beta = 0.362$, $p = 0.073$), suggesting a potential beneficial influence that could be pronounced more with a larger sample or longitudinal data.

Overall, these findings highlight the nuanced relationships between firm size, age, human capital, managerial gender, innovation efforts, and certification on sales performance. The evidence suggests that while traditional firm and human capital characteristics bolster sales, the benefits of innovation and certification may be more complex, incurring short-term costs that offset gains. This underscores the need for supportive policies to facilitate the effective implementation of technology and certification standards, particularly for smaller or female-led firms in emerging economies.

Conclusion

This empirical investigation provides robust evidence on the determinants of firm sales performance within the Turkish business context, utilizing a comprehensive sample of 1,000 firms. The results demonstrate that firm size, educational attainment of employees, work experience, and firm age are statistically significant and positively associated with sales performance, highlighting the critical role of human capital accumulation and organizational longevity in driving firm outcomes. Conversely, variables such as the gender of the top manager, foreign technology adoption, new product introduction, and certification status exhibit either negative or statistically insignificant relationships with sales, indicating potential complexities in how these factors influence firm performance in emerging market settings.

The adjusted R-squared of 0.6021 underscores that the model explains a substantial proportion of variation in sales performance, affirming the overall model's explanatory power. However, the negative coefficient associated with female top management challenges conventional assumptions and suggests the need for further nuanced inquiry into gender dynamics in firm leadership within this regional context.

These findings carry important implications for both policy and managerial practice. Specifically, interventions aimed at enhancing employee education and experience, alongside supporting firm growth and maturity, may yield significant improvements in sales performance. Meanwhile, the ambiguous effects of innovation-related variables and managerial gender highlight areas for future research to unpack underlying mechanisms and contextual influences. In sum, this study contributes to the literature on firm performance by explaining the multifaceted factors that shape sales outcomes in emerging economies, thereby offering a foundation for targeted strategies to bolster firm competitiveness and sustainable growth.

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