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# A novel perspective on environmental quality: Exploring load capacity factors through FDI inflows across diverse sectors - Empirical evidence from Türkiye

# Çevre kalitesine yeni bir bakış açısı: Farklı sektörlere gelen DYY'lerin yük kapasitesi faktörleri yoluyla incelenmesi - Türkiye'den ampirik kanıt

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**ABSTRACT:** Climate change represents a severe threat not only to natural habitats but also to humankind in recent decades. Considering this, the underlying reasons for climate change have been extensively studied in the literature. It has been found that there is a positive relationship between economic activities and environmental degradation. As an essential component of economic activities, the effect of foreign direct investment (FDI) on environmental quality is a subject that has recently attracted researchers' attention. The existing studies focus on the impact of overall FDI inflows on environmental destruction; there are no studies considering the effect of FDI inflows in specific sectors on environmental quality. Within this context, the purpose of this study is to fill the gap and contribute to the literature by examining the effect of FDI flows into the primary, manufacturing, and service sectors on environmental degradation. This will be achieved by employing the Autoregressive Distributed Lag (ARDL) model over the period 1992-2018 in Türkiye. The outcomes of the study indicate that FDI flows in the service sector have a positive effect on environmental quality in both the short and long run in Türkiye. On the other hand, FDI in the manufacturing sector contributes to environmental degradation in both terms. Similarly, FDI flows into the primary sector have a reverse effect on environmental quality, but a significant effect in the short run has not been observed. Furthermore, this study also examines if there is a U-shaped relationship between income and the load capacity factor, termed the Load Capacity Curve (LCC) hypothesis. The results demonstrate that the validity of the LCC hypothesis is confirmed in Türkiye.
**Keywords:** Sectoral FDI inflows, Load capacity factor, Load capacity curve

**ÖZ:** İklim değişikliği, son on yıllarda sadece doğal habitatlar için değil, insanlık için de ciddi bir tehdit oluşturmaktadır. Bu durum göz önüne alındığında, iklim değişikliğinin altında yatan nedenler literatürde kapsamlı bir şekilde incelenmiştir. Ekonomik faaliyetler ile çevresel bozulma arasında pozitif bir ilişki olduğu bulunmuştur. Ekonomik faaliyetlerin önemli bir bileşeni olarak, doğrudan yabancı yatırımın (DYY) çevre kalitesi üzerindeki etkisi son zamanlarda araştırmacıların ilgisini çekmektedir. Mevcut çalışmalar genel DYY girişlerinin çevresel tahribat üzerindeki etkisine odaklanmakta olup, sektörel bazda DYY girişlerinin çevre kalitesi üzerindeki etkisini inceleyen bir çalışma bulunmamaktadır. Bu bağlamda, bu çalışmanın amacı söz konusu boşluğu doldurarak birincil, imalat ve hizmet sektörlerine gelen DYY akışlarının çevresel bozulma üzerindeki etkisini Türkiye için 1992-2018 dönemi boyunca Otoregresif Dağıtılmış Gecikme (ARDL) modelinin uygulayarak incelemektir. Çalışmanın sonuçları, Türkiye'de hizmet sektörüne yapılan DYY akışlarının hem kısa hem de uzun vadede çevre kalitesi üzerinde olumlu bir etki yarattığını göstermektedir. Öte yandan, imalat sektörüne yapılan DYY ise her iki dönemde de çevresel bozulmayı hızlandırdığı sonucuna ulaşılmıştır. Benzer şekilde, birincil sektöre yapılan DYY akışlarının çevre kalitesi üzerinde negatif etki yarattığı, ancak kısa dönemde anlamlı bir etkisinin olmadığı bulunmuştur. Ayrıca, bu çalışma gelir ile yük kapasitesi faktörü (LCF) arasındaki U şeklinde bir ilişki olup olmadığını, yük kapasitesi eğrisi (LCC) hipotezi çerçevesinde incelemiştir. Sonuçlar, LCC hipotezinin Türkiye'de geçerliliğini doğrulamaktadır.
**Anahtar Kelimeler:** Sektörel DYY girişleri, Yük kapasitesi faktörü, Yük kapasitesi eğrisi

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## GENİŞLETİLMİŞ ÖZET

**Literatür taraması**

Mevcut literatürki çalışmalar, doğrudan yabancı yatırım (DYY) ve çevresel bozulma arasındaki ilişkiyi bir bütün olarak ele almış (Muhammad vd., 2021; Nadeem vd., 2020; Kisswani ve Zaitouni, 2021), sektörel boyutta DYY ile çevre arasındaki ilişkiyi incelememişlerdir. Farklı sektörlere gelen DYY girişlerinin çevre üzerindeki etkilerini incelemek, bölünme hatası problemini ele almaya yardımcı olur ki söz konusu bölünme hatası bileşen yanılgısının (terkip hatasının) zıttıdır. Ekonomide, bileşen hatası, bir birey ya da firma için geçerli olanın tüm ekonomi için de geçerli olduğunu varsaymaktadır. Bölünme hatası ise bütün için geçerli olanın, onun bireysel parçaları ya da şirketleri için de geçerli olduğunu öne sürmektedir. Bu nedenle, toplam DYY akışlarının çevre üzerindeki etkisini değerlendiren çalışmalar, bölünme hatası sorunuyla karşılaşabilmektedir, çünkü DYY'yi çeken her bir sektör çevre üzerinde farklı etkiler yaratabilmektedir. Bu sebeple mevcut çalışma, DYY ve çevresel bozulma arasındaki ilişkiyi bölünme hatası çerçevesinde inceleyen ilk çalışmadır. Bu bağlamda, mevcut çalışma, birincil, imalat ve hizmet sektörlerine yönelik DYY girişlerinin çevre kalitesi üzerinde farklı etkiler yaratıp yaratmadığını değerlendirerek literatürdeki bu boşluğu doldurmayı amaçlamaktadır.

Literatürde toplam DYY girişlerinin çevre üzerindeki etkisini inceleyen bir çok çalışma mevcuttur (Cil, 2023). Ancak, bu çalışmaların bazılarının elde ettiği bulgular PHH'yi desteklerken ( Rahman vd., 2019; Sabir vd., 2020) bazıları ise PLH'yi desteklemektedir (Zubair vd., 2020, Repkine ve Min, 2020). Ayrıca, bazı çalışmalar ise DYY ile çevresel kalite arasında anlamlı bir bağlantı olduğuna dair bir kanıt bulamamıştır (Shaari vd., 2014; Haug ve Ucal, 2019). Bu sebeple literatürde DYY ile çevre arasındaki ilişkiyi analiz eden çalışmalar arasında fikir birliği bulunmamaktadır.

**Yöntem**

Mevcut çalışmada, sektörel DYY'nin çevresel bozulma üzerindeki etkisi incelenmek üzere ARDL tekniğini kullanılmıştır. Pesaran vd. (2001) tarafından geliştirilen ARDL Sınır testi, Engle-Granger ve Johansen testleri gibi geleneksel tekniklere kıyasla belirgin avantajlar sunmaktadır. Bu avantajlardan biri, değişkenlerin entegrasyon sırasına esneklik tanımasıdır. Ayrıca, ARDL tekniği bağımsız değişkenlerin farklı gecikme uzunluklarına sahip olmasına olanak tanırken, bu esneklik diğer yöntemlerde mevcut değildir (Kisswani ve Zaitouni, 2021). ARDL tekniği, tüm değişkenleri içsel olarak ele alarak potansiyel içsellik sorununu da çözmektedir (Kanas ve Kouretas, 2005; Jailani ve Masih, 2015; Nadeem vd., 2020). Ayrıca, hem kısa hem de uzun vadeli perspektifleri dikkate alarak değişkenler arasındaki ilişkileri incelememize olanak tanımaktadır. Son olarak, Pesaran ve Shin (1999), bu yaklaşımın özellikle küçük örneklem boyutları için daha güvenilir sonuçlar verdiğini vurgulamaktadır.

**Bulgular ve tartışma**

Çalışmanın bulguları, Türkiye'deki farklı sektörlere gelen DYY'nin çevresel kalite üzerindeki etkilerinin farklı olduğunu göstermektedir. Daha spesifik olarak, birincil sektöre gelen DYY akışları, kısa vadede anlamlı bir etki göstermemektedir. Bu sektöre gelen DYY'nin diğer sektörlere kıyasla nispeten az olması, çevresel kalite üzerindeki etkisinin kısa vadede gözlemlenememesine neden olabilmektedir. Uzun vadede ise bu sektördeki DYY'nin çevresel kalite üzerinde olumsuz bir etkisi görülmektedir. Tarım sektörü, pestisit ve gübre kullanımından dolayı toprak ve su kirliliğine yol açabilir. Ayrıca, madencilik ve hammadde çıkarımı, geniş alanların temizlenmesiyle gerçekleşen ormansızlaşma nedeniyle çevresel tahribata katkıda bulunmaktadır. Benzer şekilde, imalat sektörüne gelen DYY de her iki dönemde çevresel kalite üzerinde olumsuz etkiler sergilemektedir. Bu olumsuz etkiler, kirletici uygulamaların diğer sektörlere göre ağırlıklı olarak imalat DYY'siyle ilişkili olmasından kaynaklanmaktadır. Bu durum, büyük ölçüde sektördeki sanayi süreçlerinden ve emisyonlardan kaynaklanan yüksek seviyelerde hava ve su kirliliğine atfedilmektedir. Birincil ve imalat sektörlerine gelen DYY'nin aksine, hizmet sektörüne gelen DYY akışları, her iki dönemde de çevresel koşullar üzerinde olumlu bir etki göstermektedir. Bu olumlu etkinin, otelcilik, restoranlar ve iletişim gibi alt sektörlerden kaynaklanabileceği düşünülmektedir; bu alt sektörler, kirletici olmayan uygulamalarla karakterize edilmektedir. Ayrıca, bu iyileştirme etkisi, teknolojik yenilikleri finanse eden yeşil finansın özellikle yeni teknolojilerin benimsenmesini teşvik ederek çevresel bozulmayı azaltmasıyla da bağlantılı olabilmektedir. Bu sonuçlara dayanarak, birincil ve imalat sektörlerinde PHH'nin, hizmet sektöründe ise PLH'nin desteklendiği sonucuna varılmaktadır.

Araştırma ayrıca LLC hipotezini de değerlendirmektedir. Mevcut literatürde, bu hipotezi değerlendirmek için genellikle GSYH ve karesini kullanılmaktadır. Ancak, Narayan ve Narayan (2010), regresyonlara kübik veya dördüncü dereceden modeller eklemenin çoklu bağlantı sorunlarına yol açabileceğini iddia etmektedir. Bu sorunu aşmak için, Narayan ve Narayan'ın (2010) yaklaşımını takip ederek kısa ve uzun vadelerde GSYH katsayılarının büyüklükleri karşılaştırılmıştır. Bulgularımız, uzun vadede GSYH katsayısının kısa vadeye göre daha büyük olduğunu göstermekte olup, Türkiye'de LLC hipotezinin varlığını desteklemektedir.

**Sonuç ve öneriler**

Çalışma bazı önemli politika önerileri sunmaktadır. Elde edilen sonuçlar, yalnızca hizmet sektörüne gelen DYY akışlarının çevresel kalite üzerinde olumlu bir etki yarattığını vurgulamaktadır. Çevresel bozulmayı azaltmak için bu sektöre DYY çekilmesi önerilmektedir. Ayrıca, birincil ve imalat sektörlerine gelen DYY akışlarının neden olduğu çevresel zararlarla başa çıkmak için sıkı çevre yasaları ve düzenlemelerinin uygulanması önerilmektedir. Bu sektörlere gelen DYY'nin benimseyeceği çevre dostu teknolojilerin teşvik edilmesi, tüm sektörlerde kritik bir proaktif önlem olabilmektedir.

Gelecekteki bu konuda yapılması planlanan çalışmalar için de öneri sunulmaktadır. Gelecek çalışmalar bu üç ana sektörlerin alt sektörleri ile çevresel kalite arasındaki ilişkiyi analiz edebilirler. Çünkü her alt sektör, aynı sektör altında sınıflandırılsalar bile, çevresel kalite üzerinde farklı etkiler yaratabilmektedir.

**Introduction**

Climate change, a growing concern among researchers due to environmental degradation, poses a significant threat to both human and global ecosystems (Kirikkaleli et al., 2022). Consequently, significant research efforts have been dedicated to identifying the factors driving the disruptive impacts of climate change. It has been widely acknowledged that economic activities are closely linked to climate change (Khan and Ozturk, 2020; Pata and Isik, 2021). As countries, particularly developing ones, pursue higher economic growth rates, increased energy consumption becomes necessary to attain elevated GDP levels. Despite widespread recognition and increasing use of sustainable energy sources, the proportion of energy consumption from renewables remains insufficient to mitigate the detrimental effects of climate change. The highest recorded rate was 18.13% in 1998, followed by 17.54% in 2015 globally (WDI, 2023), indicating a substantial gap in achieving sufficient renewable energy consumption to combat climate change.

The literature extensively suggests a duality in the link between environment and economic growth. Rapid growth rate often contributes significantly to environmental degradation, making it challenging for a country to achieve both simultaneously. Given the myriad factors influencing economic growth, it is essential to clarify which drivers of the rate of economic growth contribute to environmental deterioration. Studies investigate environmental degradation through the hypothesis of the Environmental Kuznets Curve (EKC), which scrutinizes the link between environmental deterioration and income per capita. The EKC hypothesis proposes that initially, with the rise in income, there is a concurrent increase in environmental deterioration. However, once a specific threshold is surpassed, this degradation starts to decrease (Dinda, 2004).

FDI is among the factors that drive economic growth, prompting countries, especially developing ones, to compete in attracting FDI. The perceived benefits of foreign direct investment (FDI) include capital inflows, the transfer of advanced technologies, managerial expertise, organizational capabilities, and access to international networks. (Carkovic and Levine, 2005; Ozturk, 2007). Global FDI inflows have experienced a remarkable surge, increasing by 818% during the period 1990-2021, soaring to 2.2 trillion US dollars. This significant rise has piqued the curiosity of researchers, resulting in comprehensive investigations into the connection between FDI and economic growth (e.g., Alfaro et al., 2004; Durham, 2004; Iamsiraroj and Ulubaşoğlu, 2015). However, until recent decades, the consideration of the link between FDI inflows and the environment in the host country has been largely neglected (Koçak and Şarkgüneşi, 2018). Last but not least, the connection between environmental destruction and FDI flows to different sectors has been largely disregarded until now. This study showcases the first analysis of the impact of FDI flows in various sectors (namely, the primary, manufacturing, and service sectors) on environmental quality. We approach this question by employing the autoregressive distributed lags (ARDL) method over the period between 1992 and 2018 in Türkiye.

The selection of a variable to represent and assess environmental degradation has remained a subject of ongoing discussion in the literature. Various measurements, such as the ecological footprint (EF), sulfur dioxide emissions (SO2), and carbon emissions (CO2), serve as proxies for environmental degradation in different studies (e.g., Shahbaz et al., 2018 and Gokceli, 2022). The EF is a comprehensive measurement that encompasses the consumption of renewable resources, energy consumption, and built-up area usage, expressed in standardized units of biologically productive area (in Gha) as described by Schaefer et al. (2006). However, the EF predominantly represents the demand side of nature and falls short in capturing the supply side, making it an insufficient measure that necessitates the identification of a more accurate representation of environmental quality (Xu et al. 2022). Conversely, biocapacity is used as a proxy for environmental quality to account for the supply side, but neglects the demand side. The load capacity factor (LCF) considers both dimensions of demand and supply. It is computed as the ratio of biocapacity (which signifies the supply dimension) to the environmental footprint (demand aspect). By considering both the demand and supply side, the LCF measures an ability of a country to restore its population based on their current lifestyles (Siche et al. 2010). Because of this, it constitutes a more precise tool for environmental assessment. In comparison to other measurements such as CO2 and EF, the LCF is a more comprehensive measurement, providing a broader and more detailed analysis

(Pata and Isik, 2021; Hakkak et al., 2023; Xu et al., 2022). This approach enhances the understanding of environmental sustainability, contributing to literature in scope and depth.

Türkiye is particularly suited for an analysis of the environmental impact of FDI for several reasons. Türkiye, as a participant in the Paris Agreement aimed at restricting the global temperature rise to below 2 degrees Celsius compared to pre-industrial levels, is taking steps to address climate change. It is creating a long-term plan to adapt to and reduce greenhouse gas emissions. For instance, according to its First Nationally Determined Contribution (NDC), Türkiye has specified a purpose of reducing greenhouse gas (GHG) emissions by 41% by 2030. This shows Türkiye's specific goals and actions toward mitigating GHG emissions. Furthermore, Türkiye is also aiming to achieve net-zero emissions by 2053. This long-term target indicates Türkiye's ambition to transition to a carbon-neutral economy. Regarding FDI inflows, Türkiye has appealed to a huge amount of FDI after the 2000s, specifically since 2003 when it implemented legal reforms granting the same unrestricted mobility and equal rights to foreign capital as those enjoyed by local investors (Atici and Gursoy, 2012). For instance, the value of FDI attracted to Türkiye was 982 million dollars in 2000. It reached its highest level at 22,047 million dollars in 2007. Despite experiencing a significant decline during the financial crisis in 2009, Türkiye attracted 12,573 million dollars of FDI inflows again in 2018 (UNCTAD, 2023). Overall, these factors make Türkiye an interesting country to investigate the influence of FDI inflows into distinct sectors on environmental deterioration.

This research marks a pioneering effort to assess the influence of inward FDI on environmental deterioration at a sectoral level. Furthermore, it innovatively explores the indicated relationship utilizing the LCF, a measurement that offers a more thorough evaluation compared to previously utilized metrics for assessing environmental deterioration. Additionally, this study is the first to scrutinize the LLC hypothesis in the context of the interaction among sectoral FDI inflows and environmental quality. Also, it delves into the examination of the fallacy of division, presenting a unique contribution to the literature on the interconnection between environmental deterioration and FDI. Moreover, this research represents one of the initial inquiries into the stated link specifically for the context of Türkiye.

The organization of this study is structured as follows: The first section presents a literature review that provides a comprehensive empirical analysis of existing research. The subsequent section on Data and Econometric Analysis describes the dataset and elaborates on the econometric methodology employed. The Results section discusses the empirical findings and offers a concise interpretation. Finally, the concluding section provides key policy implications along with final remarks.

## Literature review

The current body of literature exploring the link between overall FDI and environmental destruction falls short in terms of sector-specific analysis. Examining how FDI inflows into various sectors affect the environment addresses the possible issue of the fallacy of division, which contrasts with the fallacy of composition. In economics, the fallacy of composition assumes that what's true for an individual or firm applies to the entire economy, while the fallacy of division asserts that what applies to the whole also applies to its individual parts or companies. Consequently, studies evaluating the impact of aggregate FDI flows on the environment may encounter the fallacy of division problem because individual sectors attracting FDI can have distinct effects on the environment. This study is the first to investigate the presence of the fallacy of division in the literature on the link between FDI and environmental destruction. Within this context, this research seeks to bridge this gap by assessing if FDI inflows into the primary, manufacturing, and services sectors have various effects on the environmental quality.

### *Theoretical framework*

In the literature concerning the link between environmental quality and FDI, studies frequently incorporate additional independent variables to assess environmental degradation. In this study, we utilized common control variables as employed in existing literature, offering explanations for their potential relevance to environmental considerations.

***Exploring the sectoral fdi-environment connection***

In the literature, FDI and environmental degradation are frequently discussed based on two main hypotheses: the pollution halo hypothesis (PLH) and the pollution haven hypothesis (PHH) (Kisswani and Zaitouni, 2021). The PHH posits that developing countries undergo environmental deterioration as foreign affiliates from developed countries move their polluting industries to benefit from less stringent environmental policies, along with cheaper labor and abundant resources in developing countries (Lee, 2013; Solarin et al., 2017). This leads to increased emissions and poor quality of the environment owing to the transfer of non-renewable energy-intensive technologies. Conversely, the PLH claims that FDI can contribute to enhancing environmental conditions in developing nations through introducing cleaner and energy-efficient technologies, resulting in reduced pollution emissions (Nadeem et al., 2020; Zakarya et al., 2015). The improvement of environmental conditions may occur when multinational corporations (MNCs) establish agreements with environmentally responsible firms in the host country. Furthermore, in line with the PLH, multinational companies participating in FDI are expected to disseminate their eco-friendly technologies to local companies in the host country when implementing a universal environmental standard (Zakarya et al., 2015)

Based on the PHH and PLH, the research analyzes FDI inflows in different sectors to determine their effects on environmental quality. Considering various subsectors within each main sector (primary, manufacturing, and services), it becomes evident that each sector may have a distinct impact on environmental quality. Specifically, pollution production is primarily associated with the primary and manufacturing sectors due to subsectors like mining, quarrying, petroleum, chemical, rubber, and plastic products, which are closely linked to higher pollution production. In contrast, when examining the components of the service sector, its impact on environmental degradation may appear to be positive. Notably, the subsector of financial activities, including green finance, is expected to have a positive effect on environmental quality by funding projects and investments that drive efficient advancements in machinery and the adoption of new technologies, thereby reducing environmental destruction.

***Exploring the gdp-environment connection***

The connection between income and the environment is typically examined by referencing the EKC hypothesis in the literature. The EKC claims that economic activities are linked to pollutant emissions, which initially increase environmental deterioration in a country. However, beyond a certain point, this negative effect is assumed to turn positive due to several factors: wealthier nations tend to abandon environmentally damaging practices, shift to cleaner and more efficient technology, and even relocate pollutant production to developing countries through FDI (Kanlı and Küçükefe, 2023). These reasons give the EKC an inverted U-shaped form.

To explore the connection between environmental degradation and income, we prefer to apply the LCF rather than specific pollutant emissions, such as carbon dioxide or sulfuric acid, for the reasons mentioned previously. Therefore, the relevant curve is referred to as the Load Capacity Curve (LCC) instead of the EKC, and its validity is demonstrated in a U-shaped curve. It should be kept in mind that an increase in LCC is related to a better environmental quality.

To be able to assess the validity of the LCC hypothesis, we refer to its definition as explained by Pata and Tanriover (2023). This hypothesis posits that the LCF experiences a decline during the initial phases of economic growth, attributed to the rise of economies of scale (demand-oriented factors increase). However, as economic development progresses, the LCF enhances due to shifts in structure and technology, resulting in higher biocapacity and lower Ecological Footprint (EF). It is crucial to mention that the calculation of LCF involves dividing biocapacity by EF.

The inclusion of both income and its square in the model is a common way to check the validity of the LCC hypothesis in the literature. If the squared GDP coefficient is negative, as opposed to the positive coefficient for GDP, it indicates the soundness of the EKC. For LCC, the coefficient of its squared term is expected to be positive, whereas the coefficient of GDP is anticipated to enter the regression with a negative sign. . Nevertheless, Narayan and Narayan (2010) point out that incorporating cubic or quadric models introduces multicollinearity concerns. To address this issue and enable an examination of the

LCC hypothesis, a comparison of income coefficients in the short and long terms is employed. Specifically, the LCC hypothesis holds when the short-run income coefficient is smaller than the long-run coefficient, while it is rejected if this condition is not met. In this context, we follow the method used by Narayan and Narayan (2010) and will compare the coefficient magnitudes after reporting the long-run results.

***Exploring the renewable energy consumption-environment connection***

As discovered by Bruns and Gross (2013), a strong correlation among different types of energy sources prompted us to include only renewable energy consumption in the model, excluding other types of energy consumption. The connection between renewable energy and environmental conditions is a frequently discussed topic in the literature, with three possible findings. It is widely accepted that a rise in renewable energy is related to an improvement in environmental conditions (Apergis et al., 2010; Bilgili et al., 2016; Jebli et al., 2016; Liu and Bae, 2018). This is because consuming energy produced by renewable sources leads to reduced pollutant emissions, thereby enhancing the quality of the environment (see Sharif et al., 2019; Pata, 2021). On the other hand, an insignificant relationship may result, often due to the relatively small share of energy consumption from renewables in the total energy supply (see Apergis et al., 2010; Al-Mulali, 2015). Finally, some studies suggest that renewable energy consumption is related to a slight increase in pollution levels, although it is significantly less polluting compared to energy generated from fossil fuels (see Bölük and Mert, 2014).

***Nexus between urbanization and environment***

Urbanization pertains to the movement of individuals from the countryside to city environments. Worldwide, urbanization is on the rise due to several reasons. Urban areas offer economic opportunities, improved education, better infrastructure, and superior healthcare. However, this trend also sparks a debate about its environmental impact. In the literature, there is a broad consensus that urbanization leads to elevated energy consumption, higher transportation demands, and greater infrastructure needs, leading to higher pollution levels and a degraded environment (see Doğan and Turkekul, 2015; Behera and Dash, 2017). On the other hand, clustering populations in compact cities may also reduce environmental destruction by minimizing the need for road infrastructure, shortening service distances, and optimizing urban resource usage (see Chen et al., 2008). Hence, opinions vary regarding the influence of urbanization on the environment.

***Review of research on fdi and environmental interactions***

Various studies have analyzed the linkage between FDI inflows and environmental deterioration, employing different measurements and various proxies for environmental degradation across different countries or country groups in the literature (Cil, 2023). However, these studies have yielded conflicting results, with no consensus on validating the PHH or PLH. Some research, such as Sabir et al. (2020) and Rahman et al. (2019), provides support for the PHH, while others, like Zubair et al. (2020), Repkine and Min (2020), and Mert and Bölük (2016), align with the PLH. Furthermore, certain studies, including Shaari et al. (2014) and Haug and Ucal (2019), have detected no evidence of a significant connection between inward FDI and environmental quality. Below, a range of studies is presented to highlight the inconclusive findings in this area.

Table 1 provides a succinct overview of studies examining the correlation between environment and FDI, encompassing authorship, study duration, sample countries, represented variables, methodology, and principal findings. Existing studies predominantly focus on the connection between environmental destruction and overall FDI in the host country. Therefore, our study's primary contribution to the literature is exploring this relationship at the sectoral level.

**Table 1:** Summary of research findings

| Author(s) | Time period and Country(ies) | Methodology | Environment Variables | Results | |
|---|---|---|---|---|---|
| | | | | **PHH** | **PLH** |
| **Hitam and Borhan (2012)** | Malaysia | cointegration test (Johansen-Juselius) | $CO_2$ | Confirmed. | |
| **Kim and Adilov (2012)** | 164 developed and developing countries, 1961-2004 | OLS | $CO_2$ | Supported for developing countries. | Supported for developed countries. |
| **Lee (2013)** | 19 countries from G20, 1971-2009 | Error correction models using fixed effects models | $CO_2$ | Validated. | |
| **Omri et al. (2014)** | Caribbean and Latin America, Sub-Saharan Africa, North Africa, Europe and North Asia, Middle East, 1990-2011 | GMM | $CO_2$ | Corroborated for the Middle East, the Caribbean and Latin America, Sub-Saharan Africa. | |
| **Chang (2015)** | 65 developing and developed countries, 1984-2005 | The model of Caner and Hansen's threshold | $CO_2$ | Substantiated for countries above a corruption threshold. | Verified for low-corruption countries. |
| **Seker et al. (2015)** | Türkiye, 1974-2015 | ARDL | $CO_2$ | Supported. | |
| **Mert and Bölük (2016)** | Kyoto countries, 1970-2010 | ARDL-PMG | $CO_2$ | | Validated. |
| **Jiang et al. (2018)** | Cities of China (150), 2014 | Spatial econometric models | air quality index | Confirmed. | |
| **Solarin and Al-Mulali (2018)** | Developing and developed countries (20), 1982-2013 | Augmented Mean Group | Ecological footprint, $CO_2$, carbon footprint | Verified for developing countries. | Substantiated for developed countries. |

| | | | | | |
|---|---|---|---|---|---|
| **Sung et al. (2018)** | Subsectors of the manufacturing sector in China, 2002-2015 | System GMM | $CO_2$ | | Suggested |
| **Haug and Ucal (2019)** | Türkiye, 1974-2014 | ARDL | $CO_2$ | No evidence. | No evidence. |
| **To et al. (2019)** | Emerging countries in Asia, 1980-2016 | FMOLS, DOLS | $CO_2$ | Confirmed. | |
| **Caglar (2020)** | Green category countries (classified by the Climate Change Performance Index), 1970-2014 | ARDL | $CO_2$ | Corroborated for Morocco and India. | |
| **Muhammad et al. (2021)** | BRICS, 1991-2018 | System GMM and Dynamic fixed effect model, | $CO_2$ | Suggested for developing countries. | Verified for developing countries. |
| **Nadeem et al. (2020)** | Pakistan, 1970-2014 | ARDL | GHG, $CO_2$, $SO_2$, $CO_2$ emissions from solid fuels, | No evidence. | No evidence. |
| **Sabir et al. (2020)** | South Asian countries, 1984-2019 | ARDL | $CO_2$ | Validated. | |
| **Faheem et al. (2022)** | Malaysia, 1970-2018 | ARDL | $CO_2$ | Confirmed. | |
| **Kisswani and Zaitouni (2021)** | Thailand, Malaysia, Singapore, and the Philippines. 1971-2014 | VECM, ARDL. | $CO_2$ | Supported for the Philippines. | Validated for Malaysia and Singapore. |
| **Pavlovic et al. (2021)** | Balkan countries, 1998-2019 | Pearson correlation | $CO_2$ | | Substantiated. |
| **Pradhan et al. (2022)** | BRICS, 1992-2014 | FMOLS and DOLS | $CO_2$ | | Suggested. |
| **Christoforidis and Latrakilidis (2022)** | Central and Eastern Europe, 1995-2014 | ARDL | $CO_2$ | Approved in the early phase of growth. | Confirmed in the late stage. |
| **Gökçeli (2022)** | Türkiye, 1990-2017 | ARDL | EF | | Verified. |
| **Shahbaz et al. (2018)** | France, 1955-2016 | ARDL | $CO_2$ | Confirmed. | |

**Data and method of econometric analysis**

The research utilizes annual time-series data spanning from 1992 to 2018 to analyze the influence of inward FDI into various sectors, including the manufacturing, primary, and services sectors, on environmental degradation in Türkiye, utilizing the ARDL technique. Environmental quality is represented by the LCF, which has been clarified before as a better measurement for environmental assessment. The calculation of the LCF involves dividing the biocapacity, which signifies the supply side, by the EF, which symbolizes the demand side (Xu et al., 2022). An LCF value less than 1 indicates an unsustainable ecosystem, whereas a value greater than 1 reflects ecological sustainability (Siche et al., 2010). The sustainability threshold is set at one. Both datasets (EF and biocapacity) are gained from the Global Footprint Network.

This study is among those that do not require ethics committee approval due to the usage of secondary data sources. Data on FDI inflows into various sectors are collected from the OECD's International Direct Investment Statistics Yearbook (2002) for the period covering the early 1990s to 2001. For the subsequent years until 2019, data is extracted from the Yearbooks (2003, 2004, 2012, 2013, 2014, 2019). FDI inflows are used in their natural logarithm form. This study incorporates additional determinants of environmental quality as control variables, including the ratio of renewable energy consumption to total final energy consumption and urbanization, calculated as the urban population percentage divided by the total population. The existence of the LCC hypothesis is assessed using GDP (constant 2015 US$) in its logarithm form. All data regarding the control regressors are gained from the World Bank Indicator.
Based on the specified time series employed in this research, the model to assess the impact of sectoral FDI on environmental deterioration is formulated as follows:

$$lnLCFt = \alpha 0 + \beta 1lnSFDIt + \beta 2lnRECt + \beta 3lnURt + \beta 4lnGDPt + \varepsilon t \quad (1)$$

where ln(LCF) represents the natural logarithm of the LCF serving as an indicator of environmental quality. Ln(SFDI) refers to the natural logarithms of FDI flows into the primary, manufacturing, and service sectors, respectively. Ln(REC), ln(UR), and ln(GDP), correspond to renewable energy consumption, urbanization, and GDP, respectively. The parameter coefficients of the relevant variables are denoted as β1 to β4i, where i = 1, 2, 3, 4 represent the coefficients of the regression estimated. The symbol of ε stands for the error term.

The descriptive statistics of the data utilized in this paper are presented in Table 2. The minimum values for the manufacturing and service sectors are nearly identical to the maximum value observed in the primary sector, suggesting consistently higher FDI flows into both the manufacturing and service sectors in comparison to the primary sector. Furthermore, FDI in the service sector appears to exhibit a higher value than in the manufacturing sector. The table furnishes additional details for each series.

**Table 2:** Summary statistics

| Variables | Obs | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| **LCF** | 27 | 0.5534 | 0.1184 | 0.3799 | 0.7687 |
| **PFDI** | 27 | 7.8291 | 0.6957 | 6.3010 | 8.8129 |
| **MFDI** | 27 | 9.0507 | 0.4003 | 8.4857 | 9.6497 |
| **SFDI** | 27 | 9.2737 | 0.6139 | 8.3344 | 10.1703 |
| **REC** | 27 | 12.4912 | 0.6139 | 8.2116 | 15.5440 |
| **UR** | 27 | 67.8334 | 4.5701 | 60.518 | 75.143 |
| **LnGDP** | 27 | 26.9857 | 0.3654 | 26.4451 | 27.6196 |

In our paper, we adopt the ARDL technique to delve into the influence of inward FDI in the three sectors on environmental degradation. The ARDL Bound test developed by Pesaran et al. (2001) offers distinct advantages over conventional techniques like the Engle-Granger and Johansen tests. One notable advantage is its flexibility regarding the integration order of variables. This method can be employed regardless of whether the variables are stationary at level (0) or the first differences I (1), or a mixed order. On the contrary, traditional cointegration methods necessitate all variables to possess first-order integration (Kisswani and Zaitouni, 2021).

Moreover, the ARDL technique allows the independent variables to have varying lag lengths, whereas this flexibility is not available in other methods (ibid). Additionally, the ARDL technique addresses the potential endogeneity issue by considering all variables as endogenous (Kanas and Kouretas, 2005; Jailani and Masih, 2015; Nadeem et al., 2020). More clearly, the ARDL method, as outlined by Pesaran and Shin (1999), resolves endogeneity problems by including suitable lags of all variables, effectively addressing both serial correlation and endogeneity issues. Furthermore, it enables us to investigate links among the variables, considering both short and long-term perspectives. Lastly, Pesaran and Shin (1999) highlight that this approach yields more reliable results, especially for small sample sizes.

Fully Modified OLS (FMOLS), Dynamic OLS (DOLS), or Canonical Cointegration OLS could be preferred as alternatives to the ARDL method. Like ARDL, these three methods also account for the endogeneity problem. However, unlike ARDL, they do not provide short-term analysis results. Another alternative, the VAR method, is not preferred because, while ARDL allows different lag structures for different variables, VAR assumes that all variables have the same number of lags. This flexibility in ARDL enhances the adaptability of the model.

The specific equations of the ARDL method given below are used in the model.

$$\Delta ln\text{LCF}_t = \delta + \sum_{i=1}^{k} \gamma_0 ln\text{LCF}_{t-I} + \sum_{i=0}^{k} \gamma_1 lnS\text{FDI}_{t-i} + \sum_{i=0}^{k} \gamma_2 ln\text{REC}_{t-i} + \sum_{i=0}^{k} \gamma_3 ln\text{UR}_{t-i} + \sum_{i=0}^{k} \gamma_4 ln\text{GDP}_{t-i} + \varepsilon_t \quad (2)$$

where k stands for the optimum number of lags and γ denotes coefficients of the regressors. The lag order is decided using the Akaike Information Criteria (AIC). Finally, ε represents the error terms in the model. To analyse if there is cointegration among the series, the ARDL Bound test is conducted using the equation outlined below:

$$\Delta ln\text{LCF}_t = \delta + \sum_{i=1}^{k} \gamma_0 \Delta ln\text{LCF}_{t-I} + \sum_{i=0}^{k} \gamma_1 \Delta lnS\text{FDI}_{t-i} + \sum_{i=0}^{k} \gamma_2 \Delta ln\text{REC}_{t-i} + \sum_{i=0}^{k} \gamma_3 \Delta ln\text{UR}_{t-i} + \sum_{i=0}^{k} \gamma_4 \Delta ln\text{GDP}_{t-i} + \gamma_6 \text{lnLCF}_{t-i} + \gamma_7 \text{lnSFDI}_{t-i} + \gamma_8 \text{lnREC}_{t-i} + \gamma_9 \text{lnUR}_{t-i} + \gamma_{10} \text{lnGDP}_{t-i} + \varepsilon_t \quad (3)$$

where Δ refers to the first difference of the variables. The examination of the long term link among the variables is founded on the following hypothesis:

Hn: $\gamma 6 = \gamma 7 = \gamma 8 = \gamma 9 = \gamma 10 = \gamma 11 = 0$ Ha: At least one of the $\gamma \neq 0$

The null hypothesis suggests the absence of cointegration among the variables, whereas the alternative one proposes the presence of cointegration. The ARDL Bound test provides a range of critical values, both upper and lower, for the F test, which are essential for determining the presence of cointegration among the variables being analyzed. If the F value surpasses the upper bound, leading to rejection of the null hypothesis, which indicates a long-term link among the regressors. Conversely, if the calculated F value does not exceed the lower bound, we refrain from rejecting the null hypothesis, indicating an absence of cointegration. In the scenario where the calculated F value lies among the lower and upper bounds, the determination of the long-run relationship's validity remains inconclusive.

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**Analysis of findings**

To apply the ARDL model, it is essential to confirm that the variables do not have a unit root at I(0) or I(1) or exhibit a mixed order but are not integrated higher than the first difference I(1).Within this context, the Dickey-Fuller unit root test (ADF) introduced by Dickey and Fuller (1979) was applied to make sure that the time series meet the requirements of the ARDL method.

**Table 3:** Findings of unit root tests

| Variables | ADF Test | | | |
|---|---|---|---|---|
| | **t-statistics at I(0)** | **Significance level** | **t-statistics at I(1)** | **Significance level** |
| **lnLCF** | 2.224 | (0.9917) | -4.961*** | (0.002) |
| **lnPFDI** | -2.291 | (0.424) | -4.828*** | (0.003) |
| **lnMFDI** | -3.415 | (0.072) * | -5.298*** | (0.001) |
| **lnSFDI** | -2.419 | (0.362) | -5.128*** | (0.002) |
| **lnUR** | 0.033 | (0.994) | -4.758*** | (0.007) |
| **lnREC** | -2.177 | (0.481) | -4.326** | (0.013) |
| **lnGDP** | -0.026 | (0.558) | -5.272*** | (0.001) |

**Note:** The ADF test has been applied by employing intercept and trend. P values are presented within parentheses. (***) signifies 1% level, (**) signifies 5% level, and (*) signifies 10% level

The findings of the ADF unit root test are displayed in Table 3. It indicates that all the time series are nonstationary, except for the FDI flows into the manufacturing sector (lnMFDI), which is stationary at the 10% significance level. On the other hand, all variables turn into stationary after their first difference at a 1% significance level, showing mixed order of cointegration and facilitating the application of the ARDL technique.

In addition to the ADF test, the Lee-Strazicich LM unit root test, introduced by Lee and Strazicich (2003), is applied to assess the cointegration of the series, considering two structural breaks. The Lee-Strazicich LM unit root test's ability to identify two structural breaks offers advantages over the Augmented Dickey-Fuller (ADF) test. It provides an improved fit, enhancing model accuracy and yielding more reliable conclusions. This is particularly valuable because conventional unit root tests, assuming only one structural break, might lead to misleading results.

**Table 4:** Findings of the lee-strazicich lm unit root test

| At level I (0) | | | | | | |
|---|---|---|---|---|---|---|
| Variables | **Minimum test statistic (λ)** | **Model** | **Break Points** | **Test critical values** | | |
| | | | | **1%** | **5%** | **10%** |
| **lnLCF** | -5.6378 | C | 2001 2013 | -6.6910 | -6.1520 | -5.7980 |
| **lnPFDI** | -6.3265*** | C | 2001 2009 | -6.9320 | -6.1750 | -5.8250 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **lnMFDI** | -6.2875** | C | 2005 2010 | -6.9780 | -6.2880 | -5.9980 |
| **lnSFDI** | -7.5677*** | C | 2004 2012 | -6.6910 | -6.1520 | -5.7980 |
| **lnUR** | -6.7058*** | C | 2000 2009 | -6.932000 | -6.175000 | -5.825000 |
| **lnREC** | -5.5599 | C | 2003 2014 | -6.6910 | -6.1520 | -5.7980 |
| **lnGDP** | -10.706 | C | 2006 2009 | -6.8210 | -6.1660 | -5.8320 |
| **At First Difference I (1)** | | | | | | |
| **lnLCF** | -8.1339*** | C | 1999 2007 | -7.1960 | -6.3120 | -5.8930 |
| **lnREC** | -6.0233 | C | 1996 2008 | -7.0040 | -6.1850 | -5.8280 |

**Note:** Model C enables a simultaneous break in the intercept and slope. (*) signifies 10% level, (**) signifies 5% level, and (***) signifies 1% level.

The findings of the structural break test are reported in Table 4. As observed, it is noted that lnLCF and lnREC exhibit a unit root, whereas the remaining variables are cointegrated at their level. However, lnLCF and lnREC attain stationarity in their first-difference form. The combination of cointegration orders (level and first difference) indicates the need for applying the ARDL bound test to examine the existence of the long-term connection among the time series.

One of the structural break years in Load Capacity Factor (LCF) was 2001, which was marked by an economic crisis. Due to this crisis, industrial production declined, leading to a decrease in energy consumption. As a result, environmental pollution also decreased in that year. In contrast, 2013 was a year when renewable energy investments increased significantly due to the acceleration of Renewable Energy Law (YEKDEM) incentives. This policy shift contributed to the structural break observed in 2013.

The initial analysis phase entails specifying the optimal number of lags, determined using Akaike's Information Criterion. After lag selection, the outcomes of the ARDL bound test are shown in Table 4. With F-statistics exceeding the upper bound level, the null hypothesis of no long-run relationship is not accepted, stating an established long-term connection among the variables. Before applying the ARDL technique, a few diagnostic tests are conducted to ensure the model's compliance with prerequisites, including error term normality, absence of autocorrelation and heteroscedasticity, time series stability, and model adequacy.

**Table 5.** Findings of bound test and some diagnostics tests

| Tests | F-statistics values | Critical values (reported for ARDL Bounds at 5% level) and P-values (presented for others) |
|---|---|---|
| ARDL Bounds | 3.5908** | 2.56 - 3.49 |
| Normality test (Jarque-Bera ) | 0.9216 | 0.6308 |
| Autocorrelation test (Breusch-Godfrey LM Test) | 0.2558 | 0.7804 |
| Heteroskedasticity Test | 1.1648 | 0.4115 |
| RAMSEY | 1.8769 | 0.2039 |

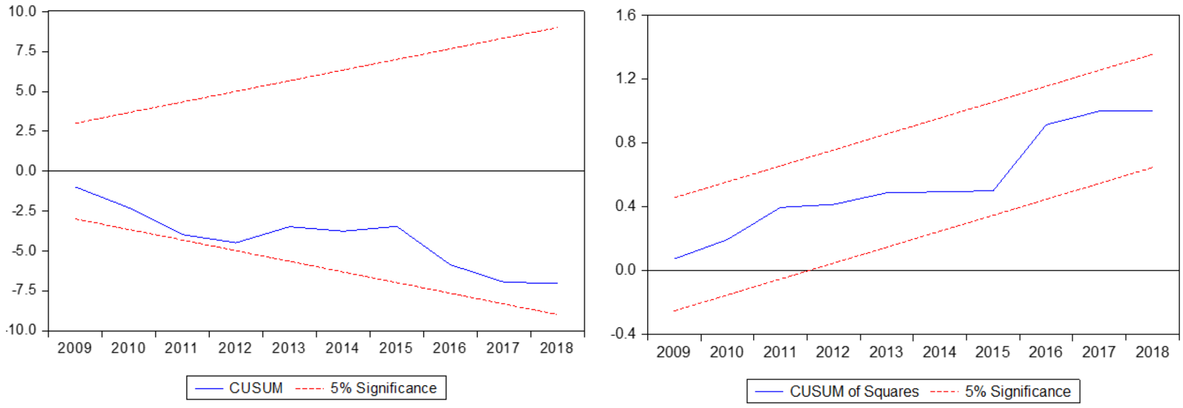
**Note:** (*) signifies 10% level, (**) signifies 5% level, and (***) signifies 1% level.

The findings from the diagnostic tests are detailed in Table 5. The Jarque-Bera normality test is conducted, revealing that the null hypothesis of error terms being normally distributed is not rejected. This confirms the normal distribution of the error terms. Another crucial requirement is the fulfillment of the absence of serial correlation, verified through the Breusch-Godfrey Serial Correlation LM Test.

The findings indicate the absence of serial autocorrelation within the residuals. Moreover, the Breusch-Pagan-Godfrey test, an essential assessment for heteroscedasticity, is applied. The results of this test support the absence of heteroscedasticity within the model.

To assess the stability of the model, CUSUM and CUSUMS plots, presented in Figures 1 and 2, are employed to identify potential structural shifts within the time series data. The results suggest that the variables adhere to a normal distribution and show no structural breaks at the 5% significance level. The final assessment involves conducting the RAMSEY test to verify the proper specification of the regression. The findings indicate that the null hypothesis, suggesting the absence of omitted variables in the model, is not rejected. This supports the accurate specification of the model for data analysis. As a result, all diagnostic tests for the model have been successfully cleared, affirming that the outcomes estimated through the ARDL approach are likely to be accurate and reliable.

**Figure 1:** CUSUM Stability and CUSUMS stability tests




Initially, the calculated coefficients of the short run are presented in Table 6. As shown, the error correction term (ECT) indicates how quickly deviations from the long-run equilibrium get corrected in the short run. Its coefficient should be significantly negative, yet not less than -2, to validate the existence of a long-term equilibrium connection among time series. As noted by Alam and Quazi (2003), when the ECT coefficient falls between 0 and -1, it tends to cause lnLCF to monotonically converge to the long-run equilibrium. In our study, the ECT coefficient is -1.49. If the coefficient falls within the range of -1 to -2, it suggests that the error correction process narrows fluctuations around the long-term equilibrium, rather than directly and smoothly converging to the long-term equilibrium as pointed out by the study of Alam and Quazi (2003).

The coefficient of FDI in the service sector is positive and significant in the short run, showing that a 1% increase in FDI flows into the service sector is related to approximately a 1.5% increase in the quality of the environment. The improvement effect of lnSFDI on environmental quality may be attributed to the subsectors of the sector, including financial activities, hotels and restaurants, communications, etc., which are considered free from pollutant activities. Moreover, the improvement effect could be attributed to financial activities through green finance. Despite the lack of unanimity on defining green finance, Höhne et al. (2012) define it as financial resources directed toward projects and initiatives that advance environmentally responsible investments and support the adoption of low-carbon technologies, leading to the reduction or prevention of GHGs. When looking at the implementation of green finance in Türkiye, there has been a noticeable increase in recent years. As of 2023, the total volume of green and sustainable bonds issued by banks and companies reached approximately $5 billion. Additionally, the total amount of loans allocated to green finance reached around $30 billion in the same year. In this context, this reduction effect of environmental pollution can be attributed to the funding of technological innovations, which drives efficient advancements in machinery and the adoption of new technologies. These innovations directly lead to increased energy efficiency, reduced energy consumption, and, consequently, an enhancement in environmental quality.

Conversely, the coefficient of inward FDI in the manufacturing sector is negative and significant, demonstrating that a 1% increase in FDI is linked to around a 0.84% increase in environmental destruction. This finding is also consistent with our expectation because polluting practices are mostly related to more manufacturing FDI compared to the other two sectors. This is largely due to the sector's higher levels of air and water pollution resulting from industrial processes and emissions. FDI in the primary sector enters the regression insignificantly, showing that any significant impact of FDI in the primary sector is not observed in the short run. The possible reason for the insignificant effect could be that the share of FDI inflows into this sector is relatively low, so its effect on environmental quality may not be observed in the short term.

To test the EKC and LLC hypotheses, GDP is included in the model and demonstrates a negative effect on the environment. As mentioned earlier, both GDP and its squared term are used to assess the EKC or LLC. Due to multicollinearity concerns stemming from incorporating GDP and its squared term, we opt to adhere to the method outlined by Narayan and Narayan (2010) and will compare coefficient magnitudes after presenting the long-run results. Currently, we are examining the short-run effect of lnGDP on the environment, and the findings demonstrate that higher GDP is related to a reduction in the quality of the environment in Türkiye.

We also controlled other variables commonly used as determinants of the environmental quality in the literature. The urbanization coefficient shows a significantly negative impact, indicating that increased urbanization is linked to a worse environmental condition. This adverse impact arises from higher population density in cities, leading to increased energy consumption and transportation needs, contributing to pollution. This aligns with Solarin and Al-Mulali's (2018) findings, which also highlight the detrimental effect of urbanization in Türkiye. Another control variable applied in this study is the consumption of renewable energy. lnREC demonstrates a positive and significant effect on environmental degradation. The improvement can be attributed to the reduced pollutant emissions resulting from energy consumption produced by renewable sources, which enhances environmental quality. This finding is also parallel to the conclusions of Muhammad et al. (2021).

**Table 6:** ARDL Short run results, ARDL (3,2,1,0,1)

| Variables | Coefficients | Std. Error | t-Statistics | Prob. |
|---|---|---|---|---|
| lnLCF (-1) | 0.7119*** | 0.2126 | 3.3486 | 0.0074 |
| lnLCF (-2) | 0.2095** | 0.0811 | 2.5866 | 0.0271 |
| lnPFDI | 0.0443 | 0.1099 | 0.4037 | 0.6949 |
| lnMFDI | -0.8496** | 0.2798 | -3.0362 | 0.0125 |
| lnSFDI | 1.4738*** | 0.1981 | 7.4408 | 0.0000 |
| lnGDP | -1.2369*** | 0.1583 | -7.8136 | 0.0000 |
| lnGDP (-1) | 0.6677*** | 0.1619 | 4.1236 | 0.0021 |
| lnUR | -1.9303* | 0.9121 | -2.1162 | 0.0604 |
| lnREC | 0.1099*** | 0.0321 | 3.4238 | 0.0065 |
| ECT | -1.4934*** | 0.2854 | -5.2327 | 0.0004 |

**Note:** The lag order is decided employing the Akaike Information Criteria (AIC). (*) signifies 10% level, (**) signifies 5% level, and (***) signifies 1% level.

The findings of the long-run ARDL are reported in Table 7. The coefficient of lnPFDI enters the regressions as negative and significant, indicating that a 1% increase in lnPFDI is associated with a 0.36% decrease in environmental quality in the long run. This result aligns with our expectations, as the agricultural sector may contribute to soil and water contamination through pesticide and fertilizer use.

Additionally, the mining and extraction subsectors are associated with clearing large areas of land, leading to deforestation, and disrupting habitats for diverse plant and animal species. lnMFDI maintains its anticipated long-term negative impact on the environment. When comparing the magnitudes of the coefficients in both sectors in absolute value, FDI in the manufacturing sector is twice as high (-0.619 and -0.367, respectively).

The positive effect of the service sector also persists in the long run, as in the short run. This positive effect is anticipated to be achieved through green finance and other environmentally friendly subsectors, such as hotels, restaurants, communications, and more, as previously explained. Based on these results, we can deduce that the PHH finds support in the primary and manufacturing sectors, whereas the PLH is substantiated in the service sector.

Regarding the control variables, urbanization has a similar effect as in the short run. In contrast to the short run, renewable energy consumption is insignificant in the long run, possibly due to the insufficient level of renewable energy consumption to significantly reduce environmental harm. This finding is supported by Solarin and Al-Mulali (2018). To test the LCC hypothesis, we compare the coefficients of GDP in the long and short term. As observed from Tables 5 and 6, the long-term coefficient is less than the short-term coefficient, signifying the presence of the LCC hypothesis in Türkiye. This situation also confirms the validity of the EKC (Environmental Kuznets Curve) hypothesis. In the short term, GDP negatively impacts environmental quality, but this effect diminishes over the long run. This suggests that as GDP grows, the relationship between income and environmental pollution follows an inverted U-shape, approaching a turning point. In other words, as GDP increases, environmental pollution initially rises but then begins to decline upon nearing a certain threshold. Beyond this turning point, economic growth starts to enhance environmental quality rather than degrade it.

**Table 7:** ARDL Findings estimated for the long run

| Variables | Coefficients | Std. Error | t-Statistics | Prob. |
|---|---|---|---|---|
| lnPFDI | -0.367087*** | 0.091730 | -4.001802 | 0.0025 |
| lnMFDI | -0.618888** | 0.277552 | -2.229807 | 0.0499 |
| lnSFDI | 0.556327*** | 0.171409 | 3.245610 | 0.0088 |
| lnREC | 0.042662 | 0.039226 | 1.087592 | 0.3023 |
| lnUR | -1.379195** | 0.471992 | -2.922072 | 0.0152 |
| lnGDP | -0.341868** | 0.127414 | -2.683117 | 0.0230 |
| Constant | 9.048311*** | 0.990603 | 9.134146 | 0.0000 |

**Note:** (*) signifies 10% level, (**) signifies 5% level, and (***) signifies 1% level.

**Conclusions**

Climate change is becoming increasingly evident through observable signs such as higher global temperatures, melting glaciers contributing to rising sea levels, unusual weather phenomena, and a reduction in biodiversity over the past few years. Academics have been actively working to identify the underlying causes of these occurrences. In academic studies, it is widely accepted that economic activities often lead to environmental damage, contributing to climate change (Khan and Ozturk, 2020; Pata and Isik, 2021).

On the other hand, countries worldwide seek economic growth to raise living standards and improve the quality of life. In recent years, FDI has gained significance as an essential part of economic activities to boost countries' growth rates. While the connection between FDI inflows and economic growth rates has been broadly examined, its impact on environmental quality has received less attention. Furthermore, there is no unanimous agreement in the existing body of literature regarding the impact of FDI on environmental deterioration. This inconclusive outcome may arise from the fact that FDI flows in different sectors, including the service, manufacturing, and primary sectors, have varying impacts on environmental destruction. To the best of our knowledge, existing studies have predominantly focused on the impact of aggregate FDI on environmental degradation. In light of this, the present study seeks to fill this gap by investigating the effects of FDI inflows into the primary, manufacturing, and service sectors on environmental quality. Employing the ARDL approach, the analysis covers the period from 1992 to 2018 in the case of Türkiye The outcomes of the study indicate that FDI flows into different sectors have a different impact on the quality of the environment in Türkiye. More specifically, FDI inflows into the primary sector show an insignificant impact in the short term. As the share of FDI inflows into this sector is relatively low compared to the other sectors, its effect on environmental quality may not be observed in the short term. FDI in this sector shows a negative impact on environmental quality in the long run. The agricultural sector can lead to soil and water contamination due to pesticide and fertilizer use. Furthermore, mining and extraction contribute to environmental destruction through deforestation caused by clearing large areas of land. Likewise, FDI inflows into the manufacturing sector exhibit negative impacts on environmental quality in both terms. The detrimental effects stem from the fact that polluting practices are primarily associated with manufacturing FDI compared to other sectors. This is mainly attributed to higher levels of air and water pollution stemming from industrial processes and emissions within the sector. Contrary to FDI inflows into the primary and manufacturing sectors, FDI inflows into the services sector positively impact environmental conditions in both terms. This positive influence can arise through subsectors like hotels, restaurants, and communications, which are characterized by pollutant-free practices. Additionally, the improvement effect could be linked to financial activities, particularly green finance, which funds technological innovations, promoting more efficient machinery and the adoption of new technologies, which, in turn, reduces environmental degradation. Based on these results, we can deduce that the PHH finds support in the primary and manufacturing sectors, whereas the PLH is affirmed in the service sector.

The research also assesses the LLC hypothesis. Within the prevailing body of research, GDP and its squared term are frequently employed to evaluate this hypothesis. However, Narayan and Narayan (2010) claim that including cubic or quadric models in regressions can lead to multicollinearity concerns. To deal with this problem, we follow Narayan and Narayan's (2010) approach, comparing the magnitude of GDP coefficients in the short and long runs. Our findings indicate that the coefficient of GDP in the long term is greater than that in the short term, supporting the existence of the LCC hypothesis in Türkiye.

The study provides some important policy implications. Our results highlight that only FDI flows into the service sector positively impact environmental quality. To reduce environmental deterioration, attracting FDI to this sector is recommended. Additionally, to address environmental damage from FDI inflows into the primary and manufacturing sectors, implementing stringent environmental laws and regulations is recommended. Encouraging environmentally friendly technologies embraced by incoming FDI can be a crucial proactive measure across all sectors.

When comparing proposed policies with those currently implemented in Türkiye, the country's environmental regulations are primarily based on the 1983 Environmental Law, which was established to protect the environment and ensure sustainability. This law has led to the introduction of various regulations, such as the Waste Management Regulation, Air Quality Management Regulation, and Environmental Impact Assessment (EIA) Regulation. The EIA process is strictly enforced, particularly for mining, industrial, and infrastructure projects, affecting both local and foreign companies. In 2011, Türkiye introduced the Renewable Energy Resources Support Mechanism (YEKDEM) to promote renewable energy production by offering government incentives to renewable energy facilities. Additionally, efforts to reduce carbon emissions, especially in the industrial sector, are being carried out through the Emission Trading System (ETS) studies. Moreover, in 2021, Türkiye became a party to the Paris Climate Agreement, committing to net zero carbon emissions by 2053. Overall, Türkiye's environmental regulations are well-structured and aligned with the proposed policies. However, introducing more specific regulations for FDI based on various sectors could further enhance environmental protection.

Another suggestion for future research is to examine the relationship between individual subsectors within the primary, manufacturing, and service sectors and environmental quality. This is important, as subsectors within the same broad category may exert heterogeneous effects on environmental outcomes.

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**Ethical approval**

This study is among the studies that do not require ethics committee approval due to the absence of direct human or animal subjects involved in the research, as it primarily utilizes secondary data sources

**Contribution rate of researchers**

1st author contributed 50%, 2nd author contributed 30%, and 3rd author contributed 20% to the study.

**Conflict of interest**

There is no potential conflict of interest in this study.

**Support information / Thanks**

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