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THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN TÜRKİYE

TÜRKİYE'DE ENERJİ TÜKETİMİ VE EKONOMİK BÜYÜME ARASINDAKİ İLİŞKİ

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ABSTRACT

The interplay between energy resource distribution and usage is pivotal for sustainable economic growth and development. Addressing global warming and climate change is essential, necessitating a shift towards renewable energy sources and reducing reliance on harmful energy types. Central to this endeavor is producing within the bounds of global steps and measures, fostering a sustainable relationship between humanity and resources, and achieving economic growth without depleting our natural endowments. The industrial sector's reliance on fossil fuels primarily contributes to rising carbon emissions, causing environmental degradation and climate change. This study scrutinizes the dynamics between energy consumption and economic growth in Türkiye from 1980 to 2020. Utilizing the Granger Causality Test, Johansen Cointegration Test, and Vector Error Correction Model, a causal link between energy consumption and economic growth was identified. Based on these findings, policy recommendations have been proposed to guide sustainable energy use and economic expansion.

Keywords: *Energy Consumption, Economic Growth, Causality Relationship*

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ÖZ

İktisadi büyüme ve kalkınma için temel unsur olarak öne çıkan enerji kullanımında enerji kaynaklarının dağılımı, iktisadi büyüme ve kalkınmanın sürdürülebilirliği açısından önem arz etmektedir. Bu bağlamda yenilenebilir enerji kaynaklarının arttırılması, doğal yaşama zarar veren enerji kaynaklarının kullanımının en aza indirgenmesi ile küresel ısınma ve iklim değişikliği gibi problemlerin önüne geçilmesi gerekmektedir. Dünya genelinde atılan adımlar ve alınan tedbirler çerçevesinde üretim yapılması ve insan ile kaynak arasındaki ilişkinin doğru tesis edilmesi, iktisadi büyümenin kaynaklar pahasına değil kaynakları koruyarak gerçekleşmesi en önemli mesele olarak karşımıza çıkmaktadır. Özellikle sanayinin enerji talebinin karşılanmasında kullanılan fosil yakıtlar neticesinde artan karbon emisyonu geri dönüşümsüz çevre sorunlarını yaratmakta ve iklim değişikliğine yol açmaktadır. Bu çalışmada Türkiye'de 1980-2020 yılları arasında enerji tüketimi ile iktisadi büyüme ilişkisi incelenmiştir. Analizde Granger Nedensellik Testi, Johansen Eşbütünleşme Testi ve Hata Düzeltme Modeline Bağlı Granger Nedensellik testi ile nedensellik ilişkisi araştırılmış ve analiz sonucunda enerji tüketimi ile iktisadi büyüme arasında uzun dönemde büyümeden enerji tüketimine doğru tek yönlü bir nedensellik saptanmıştır. Çalışma sonucunda elde edilen bulgular doğrultusunda Türkiye'de enerji kullanımı ve iktisadi büyüme ilişkisine ilişkin politika önerileri oluşturulmuştur.

Anahtar Kelimeler: *Enerji Tüketimi, Ekonomik Büyüme, Nedensellik İlişkisi*

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Genişletilmiş Özet

İktisadi büyümenin gerçekleşmesi ve kalkınmanın sürdürülebilir kılınması için enerji kullanımında kaynakların dağılımı büyük bir öneme sahiptir. Kömür, petrol ve doğal gaz gibi fosil yakıtlara olan bağımlılık ciddi çevresel sorunlar yaratmaktadır. Dünya genelinde atılan adımlar ve alınan tedbirler çerçevesinde üretim yapılması ve insan ile kaynak arasındaki ilişkinin doğru tesis edilmesi, iktisadi büyümenin kaynaklar pahasına değil kaynakları koruyarak gerçekleşmesi en önemli mesele olarak karşımıza çıkmaktadır. Bu nedenle biyoyakıt, rüzgar, güneş, jeotermal ve hidroelektrik gibi karbondioksit salınımı yapmayan yenilenebilir enerji kaynaklarının kullanımının yaygınlaştırılması kaynakları koruyarak büyüme sağlanması açısından büyük önem arz etmektedir. Bu konuda ilk uluslararası düzenleme olarak 2005 yılında yürürlüğe giren Kyoto Protokülü ile katılımcı ülkeler için emisyon azaltım hedefleri belirlenerek aralarında sera gazı emisyonunun azaltılması, alternatif enerji kaynaklarına yatırım yapılması, biyoyakıt kullanımının arttırılması gibi bir dizi çevre dostu politikaların geliştirilmesi amaçlanmıştır. Kyoto Protokolü sonrası, 2015 yılında düzenlenen Paris Anlaşması ile benzer hedefler ortaya konulmuştur. Bu protokollere rağmen karbondioksit seviyesi 2021 yılında 36,6 Gt gibi rekor bir düzeye yükselmiştir. Buna jeopolitik gerilimler de eklenince 2022 yılında ortaya çıkan enerji krizi, küresel enerji piyasalarının kırılganlığını ve temiz enerjiye güvenli bir geçişe olan acil ihtiyacı ortaya çıkarmıştır.

2022 yılı Dünya Enerji Görünümü Raporu, farklı makroekonomik ve coğrafi varsayımlara dayanan çeşitli senaryolar ortaya koymaktadır. Farklılıklar hükümetlerin politika tercihlerine, yatırım kararlarına ve tüketicilerin enerji ihtiyaçlarına bağlı olarak ortaya çıkmaktadır. Her senaryonun küresel enerji krizine tepkisi, farklı varsayımlar nedeniyle değişiklik göstermektedir. Açıklanan Taahhütler Senaryosu, hükümetlerin hedeflerine ulaşacağını varsayarken; 2050 Yılına Kadar Net Sıfır Emisyon Senaryosu, küresel sıcaklıkları 2030 yılına kadar 1,5 derecede sabitleyecek önlemleri içermektedir. Açıklanmış Politikalar Senaryosu ise mevcut politikalar, küresel enerji talebinin neredeyse tamamının 2030 yılına kadar arttığını göstermektedir. Özellikle nüfus artış hızının yüksek ve sanayileşmenin yoğun olduğu gelişmekte olan ülkelerin artan enerji ihtiyacı üretim kapasitesi ve kalkınma üzerinde önemli etkilere sahiptir. Bu nedenle enerji tüketimi ve ekonomik büyüme arasındaki ilişkinin incelenmesi özellikle de muhtemel çevresel etkilerle birlikte değerlendirilmesi gerekmektedir. Literatürde enerji tüketimi ile ekonomik büyüme arasındaki ilişkiyi çeşitli yöntemler, zaman dilimleri ve ülke örnekleri kullanarak inceleyen birçok çalışma bulunmaktadır. Enerji tüketimi ile ekonomik büyüme arasında pozitif bir ilişki olduğu konusunda fikir birliği mevcut olsa da nedenselliğin büyüklüğü ve yönü ülkelere ve kullanılan yöntemlere göre farklılıklar göstermektedir.

Bu çalışmada Türkiye'de 1980-2020 yılları arasında enerji tüketimi ile ekonomik büyüme arasındaki ilişki Granger nedensellik testi aracılığıyla incelenmiştir. Çalışmada enerji tüketimi ve Gayri Safi Yurtiçi Hasıla değişkenleri kullanmış ve veriler için Ekonomik Kalkınma ve İşbirliği Örgütü (OECD)'nün veri tabanı kullanılmıştır. İlgili serilerin durağanlığı Genişletilmiş Dickey Fuller (ADF) ve Phillips-Perron (PP) birim kök testiyle kontrol edilmiş, uzun dönemli ilişki ise Johansen eşbütünleşme testi ile incelenmiştir. Ayrıca uzun dönemli ilişkinin yönünü belirlemek amacıyla Vektor Hata Düzeltme Modeline (VECM) dayalı Granger nedensellik testi kullanılmıştır. Çalışmada elde edilen bulgulara göre değişkenler arasında kısa dönemli bir ilişkinin olmadığı görülmüştür. Ancak Johansen eşbütünleşme testi, enerji tüketimi ile ekonomik büyüme arasında uzun dönemli ilişkinin olduğunu göstermiştir. VECM ile yapılan analizler uzun dönemde ekonomik büyümenin enerji tüketimine neden olduğunu ortaya koymuştur. Bir diğer deyişle, ekonomik büyümeden enerji tüketimine doğru tek yönlü bir nedensellik tespit edilmiştir. Bu sonuçlar, Minh ve Van (2022), Demirgil ve Birol (2020), Lee ve Chang (2008) çalışmalarındaki bulguları desteklemektedir.

Türkiye'de ekonomik büyüme ile enerji tüketimi arasındaki dinamikleri daha iyi anlamak için analiz bulgularının ülkeye özgü faktörlerle birlikte değerlendirilmesi gerekmektedir. Türkiye'nin 2000'den 2020'ye kadar olan enerji görünümü incelendiğinde; petrol, toplam enerji arzının %29'unu oluşturarak en önemli enerji kaynağı olurken, %28 ile kömür ve %27 ile doğal gaz kullanılmaktadır. Enerji tüketiminde ise 2020 yılında en büyük payı %32,3 ile sanayi sektörü alırken, onu %24 ile ulaştırma ve %22,8 ile konut sektörü izlemiştir. Toplam enerji üretiminin toplam enerji arzına oranının %33,2'den %29,8'e düşmesi, enerjide dışa bağımlılığın arttığına işaret etmektedir. Bu bağımlılık, enerji talebini karşılamak için ham petrol ve doğalgaz gibi enerji kaynaklarını ithal etme ihtiyacından kaynaklanmaktadır. Birçok sektörde ithal enerji kullanıldığı için ithalattaki değişimlerin ekonomi üzerinde önemli etkileri bulunmaktadır. Türkiye enerji ticaretinde jeopolitik öneme sahiptir. Enerji ithalatının sürdürülebilirliğine yönelik politikaların geliştirilmesi gerekmektedir. Bu kapsamda, birçok doğalgaz ve petrol borusu projesi hayata geçirilmiştir. Birincil enerjinin bileşimi ve tüketim kalıpları, Türkiye'nin düşük karbonlu enerjiye geçişi açısından hayati önem taşımaktadır. Enerji arzında, özellikle elektrik üretiminde, yenilenebilir enerji kaynaklarının payının artırılması önemli bir öncelik olmalıdır. Sonuç olarak, Türkiye'nin enerji ihtiyacının artması; enerji kaynaklarının sürdürülebilirliği ve yenilenebilir enerjiye yatırım yapılması konularını oldukça önemli hale getirmektedir. Çalışma sonucunda tespit edilen Türkiye'de ekonomik büyüme ile enerji tüketimi arasındaki uzun dönemli nedensellik ilişkisi göz önüne alındığında, artan enerji talebini karşılamak için enerji kaynaklarının çeşitlendirilmesi, enerji verimliliğinin arttırılması ve yenilenebilir enerjinin teşvik edilmesi dışa bağımlılığın azaltılmasına yönelik politikaların oluşturulması gereği belirmektedir. Şüphesiz ekonomik büyümeyle ilişkili çevresel maliyetlerin dikkate alınması ve bu etkilerin en aza indirilmesine yönelik önlemlere yer verilmesi hususu önem arz etmektedir.

Introduction

The increasing need for energy significantly impacts the production capacity and development potential of especially developing countries with rapid population growth and industrialization. Therefore, examining the association between energy and growth is crucial (Chaudhry, Safdar, and Farooq, 2012, p. 372). However, the global reliance on fossil fuels has severe environmental consequences. The burning of coal, oil, and natural gas produces carbon dioxide, which contributes significantly to climate change. To mitigate these effects, it is essential to expand the use of renewable energy sources which do not emit carbon dioxide, such as biofuel, wind, solar, geothermal, and hydroelectric power (Güllü and Baygaç, 2017, p. 19).

The Kyoto Protocol which stands out as the first international act came into force in 2005. Protocol aimed to support environmentally friendly policies by setting emission reduction targets for participating countries. These policies included reducing greenhouse gas emissions by 5%, investing in alternative energy sources, and increasing the use of biofuels (Öztürk and Küsmez, 2019, p. 318). In the following period The Paris Agreement was signed on 12 December 2015. The results intended by Kyoto Protocol and Paris Agreement could not be achieved. The fact that neither of them contained any sanctions was effective in this result.

Despite these efforts, CO_2 emissions reached a record high of 36.6 Gt in 2021. Projections suggest that emissions will decrease to 32 Gt by 2050, assuming current measures are maintained, which would still result in a 2.5 °C increase in global temperatures by 2100. The energy crisis in 2022, exacerbated by geopolitical tensions, highlighted the vulnerability of the global energy market and the urgent need for a secure transition to clean energy. Rising fossil fuel prices and increasing emissions underscore the necessity for new policies to ensure energy security and environmental sustainability (World Energy Outlook, 2022, p. 30, 83).

The World Energy Outlook Report 2022 presents several scenarios based on different macroeconomic and geographic assumptions. The differences appear depending on policy choices of governments, investment decisions, consumers energy needs. Each scenario's response to global energy crisis is different because of different assumptions. The Announced Pledges Scenario assumes governments meet their targets, while the Net Zero Emissions by 2050 Scenario includes measures to stabilize global temperatures at 1.5 degrees by 2030. According to the Stated Policies Scenario, current policies indicate that almost all of the global energy demand increases until 2030, approximately 1% annually, will be met by renewable energy sources (World Energy Outlook, 2022, p. 29).

In this study the relationship between energy consumption and economic growth will be investigated in Türkiye for 1980-2020 period. Based on the findings, evaluations will be made on Türkiye and needs will be revealed. The study consists of four parts. In the first part of the study, we will provide information about the Energy Outlook in Türkiye through various tables and figures. In the second part, we will present a literature review on the subject. In the third section, we will provide information about the data set, variables and methodology used in the study and show the analysis results. In the conclusion part we will discuss the results of the study.

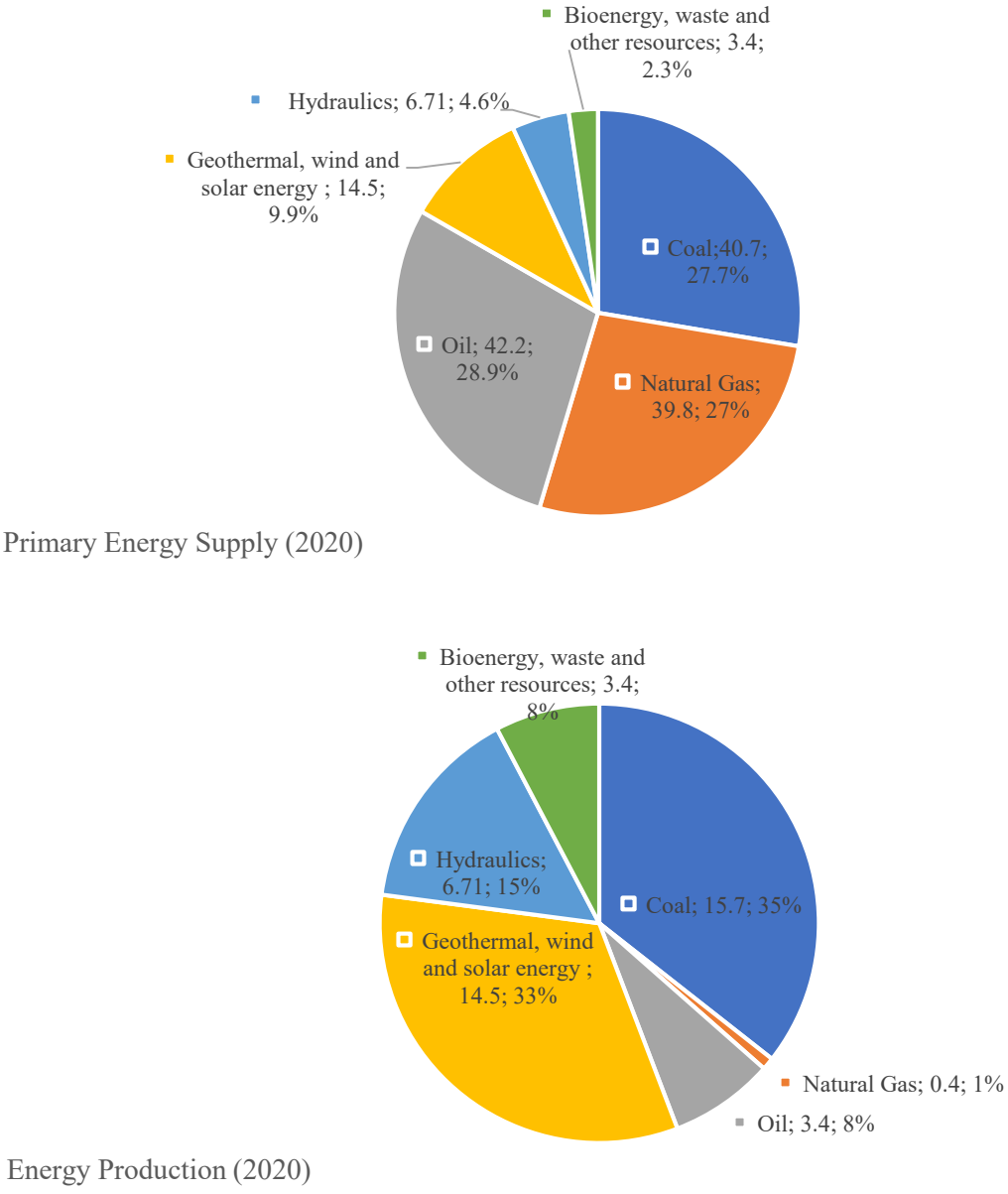
1. Energy Outlook in Türkiye

According to the Ministry of Energy and Natural Resources, Türkiye's total energy supply in 2020 was 147.17 million tons of oil equivalent (TOE). When we look at the source distribution of the supply, oil comes first with 42.19 million TOE and a share of 28.9% of the total supply. After oil, coal with 40.72 million TOE and 27.67% share. Natural gas comes with 39.81 million TOE and a share of 27.05%. After oil, coal, and natural gas; geothermal, wind, and solar energy with 14.5 million TOE and 9.85% share;

hydraulics with 6.71 million TOE and 4.56% share. Bioenergy, waste, and other resources include 3.4 million TOE and a percentage of 2.31% (Shura Energy Transition Center, 2022, p. 75-76; Yılmaz and Türkyılmaz, 2022, p. 8).

Figure 1 shows the amount and share of resources in Türkiye's primary energy supply and production.

Figure 1: *Amount and Shares of Resources in Türkiye's Primary Energy Supply and Energy Production in 2020 (Million TOE)*



Source: *Türkiye Energy Outlook, 2022*

Türkiye's crude oil production (in million TOE) and natural gas production (in cubic meters) between 2000 and 2020 are shown in Table 1.

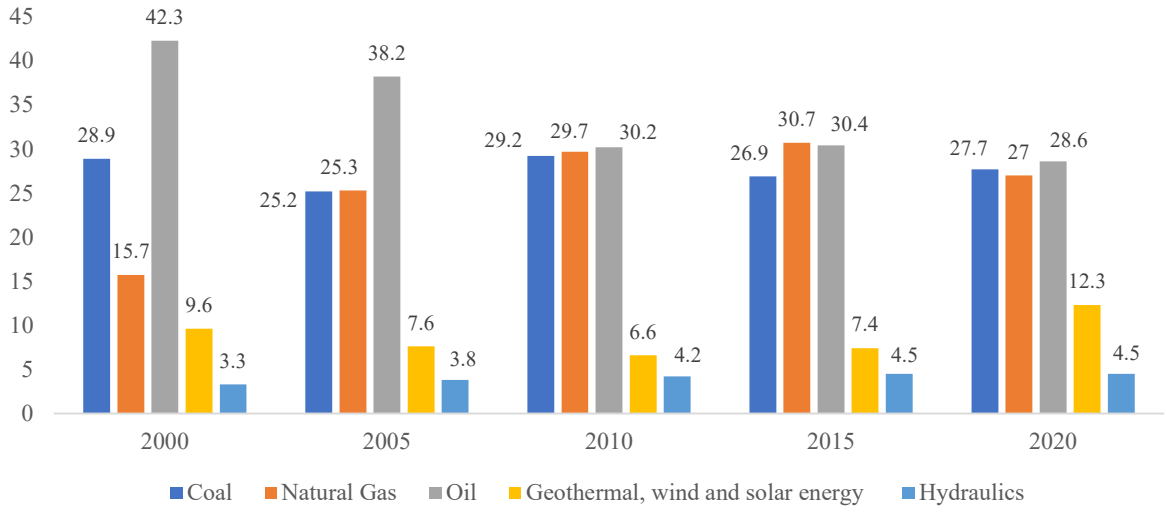
Table 1: *Crude Oil and Natural Gas Production in Türkiye (2000-2020)*

Years	Crude Oil Production (millions of TOE)	Natural Gas (Cubic Meter)
2000	2 749 105	639 222 969
2001	2 551 467	311 562 545
2002	2 441 534	378 402 738
2003	2 375 044	560 633 511
2004	2 275 530	707 008 763
2005	2 281 131	896 424 950
2006	2 175 668	906 587 974
2007	2 134 175	893 055 000
2008	2 160 067	1014 530 570
2009	2 401 799	729 414 369
2010	2 496 113	725 993 340
2011	2 367 251	793 397 572
2012	2 337 551	664 353 885
2013	2 398 454	561 544 788
2014	2 455 893	502 108 992
2015	2 515 662	398 723 410
2016	2 571 928	381 596 942
2017	2 551 929	364 295 167
2018	2 850 828	435 518 023
2019	2 984 800	483 381 033
2020	3 202 924	457 826 359

Source: General Directorate of Mining and Petroleum Affairs, 2022

Figure 2 shows the proportion of resources in Türkiye's total energy supply between 2000-2020.

Figure 2: *Shares of Resources in Türkiye's Total Energy Supply (2000-2020, %)*



Source: Türkiye Energy Outlook, 2022

Table 2 shows Türkiye's total energy supply, production, imports, exports, and total primary energy production ratio to meet the entire energy supply between 2000-2020. The table shows that Türkiye's total energy production increased by 66.9% between 2000 and 2020, from 26.4 million TOE to 44.07

million TOE. In the same period, the total energy supply increased by 86%, from 79.4 million TOE to 147.2 million TOE. Looking at the increase in imports and exports, total energy imports increased by 107.4%, and total energy exports increased by 450% between 2000 and 2020 (Türkiye Energy Outlook, 2022, p. 10-11).

Table 2: *2000-2020 Türkiye Total Primary Energy Supply, Production, Imports, Exports (Million TOE) and Production/Consumption Supply Changes (%)*

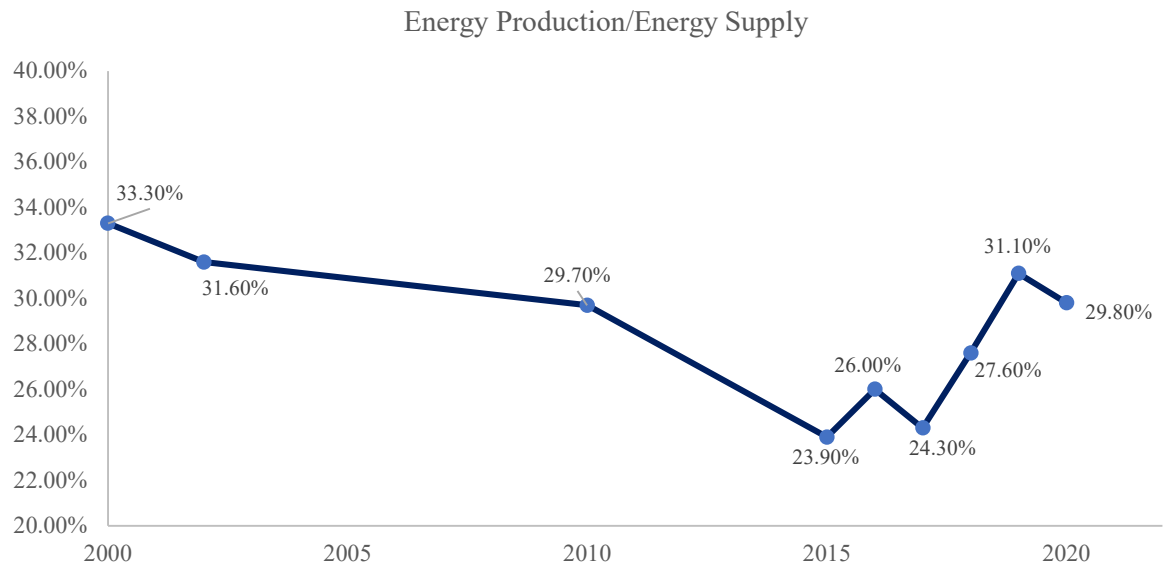
	2000	2002	2010	2015	2020	2000-2020 Change
Total Energy Supply	79,4	77,1	105,9	129,2	147,2	86%
Total Energy Production	26,4	24,4	31,5	30,9	44,07	66,90%
Total Energy Imports	55,1	57,2	84,6	112,8	114,29	107,40%
Total Energy Exports	1,6	3,2	7,9	8,1	8,8	450%
Energy Production/Energy Supply	33,20%	31,60%	29,70%	23,90%	29,80%	Difference: -3,4
Foreign Dependency in Energy Supply	66,80%	68,40%	70,30%	76,10%	70,20%	Difference: -3,4

Source: Türkiye Energy Outlook, 2022

Between 2000 and 2020, total energy production to total energy supply decreased from 33.2% to 29.8%. During this period, it is seen that Türkiye's foreign dependency in total energy supply increased. While foreign dependency on total energy supply was 66.8% in 2000, 70.3% in 2010, and 76.1% in 2015. It decreased to 70.2% in 2020, especially with the increase in solar, wind, and geothermal energy in the last five years (Yılmaz and Türkyılmaz, 2022, p. 10).

Figure 3 shows Türkiye's total primary energy production to energy supply ratio in the 2000-2020 period, while Figure 4 shows Türkiye's total energy foreign trade in the same period.

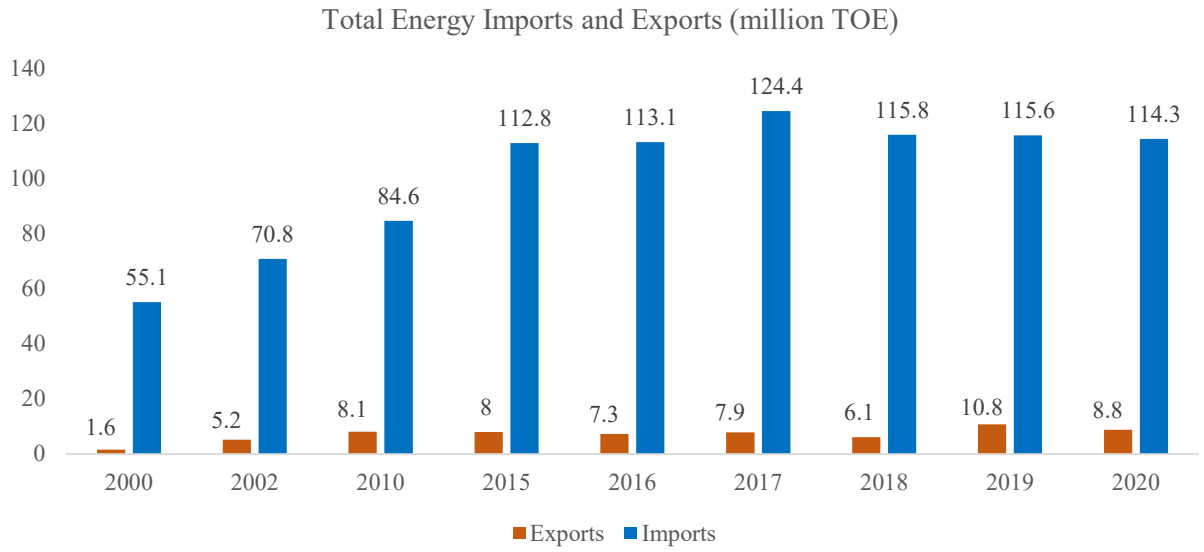
Figure 3: *The Ratio of Türkiye's Primary Energy Production to Energy Supply (2000-2020)*



Source: Türkiye Energy Outlook, 2022

Türkiye has many different energy resources, but it needs more energy resources. These are coal, natural gas, oil, and many renewable energy sources. Türkiye can't meet its energy needs with the resources it has. Türkiye is especially insufficient regarding oil and natural gas reserves, so it meets its oil and natural gas needs thanks to foreign countries (Çalışkan, 2009, p. 306).

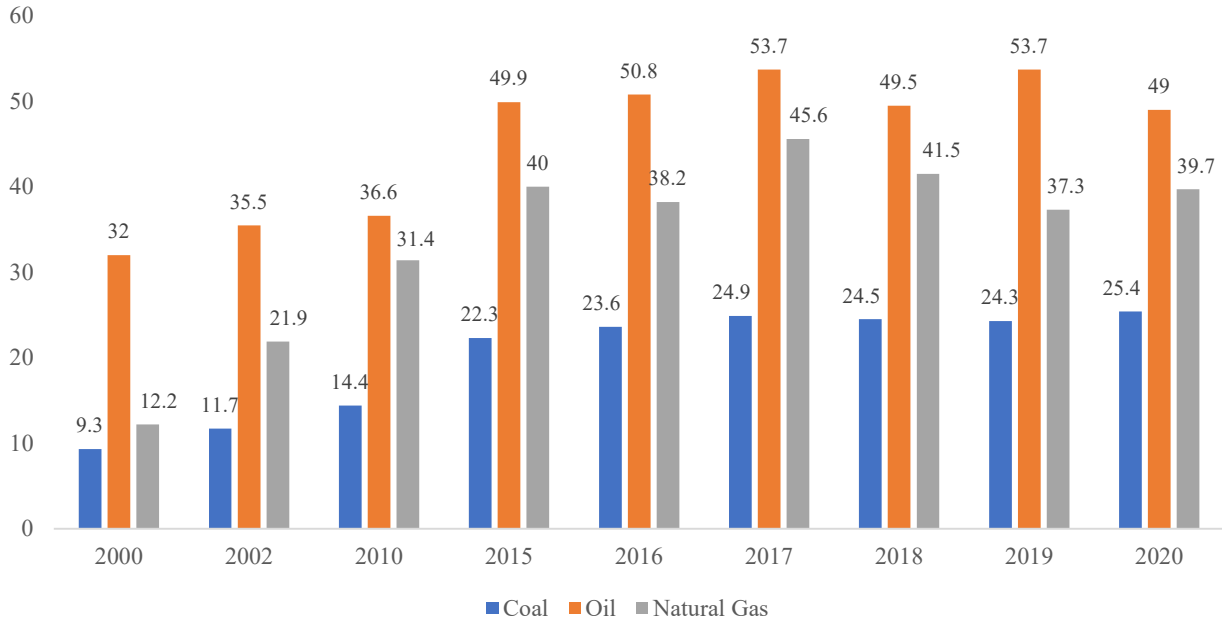
Figure 4: *Türkiye's Total Energy Foreign Trade (2000-2020, million TOE)*



Source: Türkiye Energy Outlook, 2022

The share of Türkiye's energy imports by resources is shown in Figure 5.

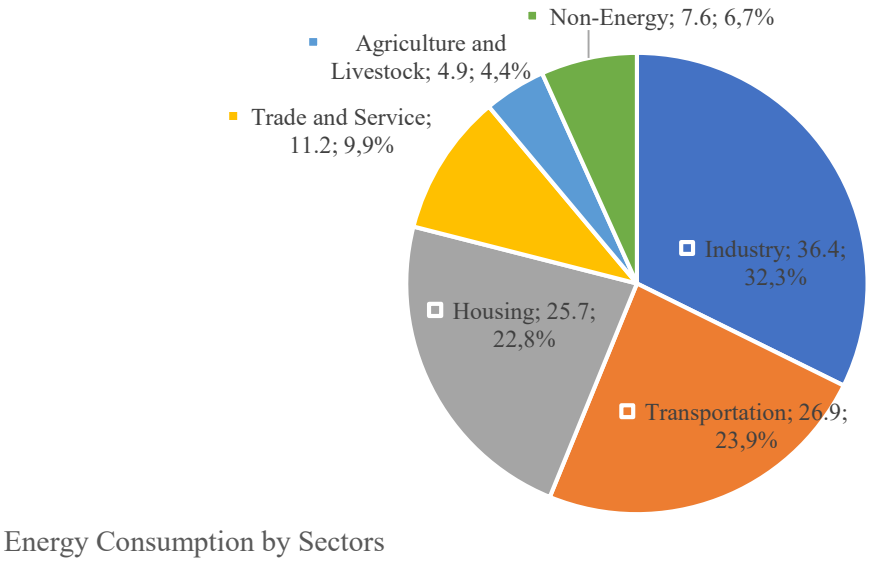
Figure 5: *The Share of Türkiye's Energy Imports by Resources (2000-2020, million TOE)*



Source: Türkiye Energy Outlook, 2022

Crude oil and natural gas show the energy items with the largest share in energy imports between 2000-2020. When we look at coal imports, it showed a significant increase, especially between 2010-2015, and maintained its share after 2015. The shares of energy consumption in Türkiye by sector are shown in Figure 6.

Figure 6: *The Shares of Energy Consumption by Sectors in Türkiye (2020, million TOE)*



Source: Türkiye Energy Outlook, 2022

When we look at the shares of primary energy consumption by sectors in 2020, the industry sector ranks first with 36.4 million TOE and a share of 32.27%. Then, the transportation sector comes in second place with 26.9 million TOE and a 23.9% share. When the development in consumption in the 2000s is examined, it is seen that while the share of the industry decreased, the share of the transportation sector grew rapidly, and its share increased. The housing sector follows the transportation sector with 25.7 million TOE and a share of 22.78%. In the same period, there was also a significant increase in the share of housing. Following these three sectors, the trade and service sector comes with 11.2 million TOE and a 9.94% share, and the agriculture and livestock sector comes with 4.9 million TOE and a 4.4% share, respectively. Finally, non-energy consumption is seen with 7.5 million TOE and a share of 6.71%.

The composition of the primary energy supply and the share and development of energy consumption provide clues for the low-carbon energy transition. Increasing the share of renewable resources in energy supply stands out as a priority area, and in this context, increasing the share in electricity production, which is the central area of the use of renewable energy, is essential. The composition of consumption sheds light on priorities, especially regarding energy efficiency. In this context, practices such as monitoring the development of industry, which constitutes the majority of consumption, and monitoring of housing and services, which increase their weight in consumption, are essential. On the other hand, the weight and growing share of the transportation sector in consumption also directs the developments within the scope of energy transition.

Since we emphasize electricity production, examining Türkiye's installed capacity in electricity production is also useful. Table 3 shows the composition of Türkiye's total installed power by resources between 2000-2020.

When the development of the installed power in the share of resources is examined, it is seen that there has been a decrease in the established power based on petroleum products in recent years. At the same time, there has been an increase in all those depending on other resources, including wind, solar and geothermal resources.

Table 3: *Türkiye's Total Installed Power by Resources (2000-2020)*

Years	Coal		Petroleum Products		Natural gas		Fossil		Waste		Hydraulic		Wind + Geothermal + Solar		Renewable		Total
	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW	Share (%)	MW
2000	7399	27,1	3725	13,7	4905	18	16029	58,8	24	0,1	11175	41	36	0,1	11235	41,2	27264
2001	7446	26,3	4302	15,2	4851	17,1	16600	58,6	24	0,1	11673	41,2	36	0,1	11733	41,4	28332
2002	7439	23,4	4855	15,2	7247	22,8	19541	61,4	28	0,1	12241	38,4	36	0,1	12305	38,6	31846
2003	8704	24,5	5381	15,1	8862	24,9	22947	64,5	28	0,1	12579	35,3	34	0,1	12640	35,5	35587
2004	8750	23,8	5236	14,2	10131	27,5	24117	65,5	28	0,1	12645	34,3	34	0,1	12707	34,5	36824
2005	9588	24,7	5303	13,7	10976	28,3	25867	66,6	35	0,1	12906	33,2	35	0,1	12977	33,4	38844
2006	10688	26,3	5249	12,9	11462	28,3	27379	67,5	41	0,1	13063	32,2	82	0,2	13186	32,5	40565
2007	10668	26,1	4913	12	11647	28,5	27229	66,7	41	0,1	13395	32,8	169	0,4	13607	33,3	40836
2008	10662	25,5	6217	14,9	10657	25,5	27535	65,8	60	0,1	13829	33i1	394	0,9	14282	34,2	41817
2009	11006	24,6	6421	14,3	11826	26,4	29253	65,4	87	0,2	14553	32,5	869	1,9	15509	34,6	44761
2010	12403	25	6466	13,1	13302	26,9	32171	65	107	0,2	15831	32	1414	2,9	17353	35	49524
2011	13028	24,6	7634	14,4	13144	24,8	33805	63,9	126	0,2	17137	32,4	1843	3,5	19106	36,1	52911
2012	13174	23,1	7568	13,3	14116	24,7	34858	61,1	169	0,3	19609	34,4	2423	4,2	22201	38,9	57059
2013	13218	20,7	8024	12,5	17171	26,8	38413	60	235	0,4	22289	34,8	3071	4,8	25595	40	64008
2014	15400	22,2	7379	10,6	18724	26,9	41503	59,7	299	0,4	23643	34	4075	5,9	28017	40,3	69520
2015	16104	21,7	6901	9,3	18528	25	41533	56	370	0,5	26868	36,2	5376	7,3	32614	44	74147
2016	17938	22,9	6414	8,2	19564	24,9	43915	55,9	496	0,6	26681	34	7405	9,4	34582	44,1	78498
2017	19349	22,7	3737	4,4	23206	27,2	46292	54,3	634	0,7	27273	32	11001	12,9	38908	45,7	85200
2018	19557	22,1	715	0,8	25675	29	45947	51,9	955	1,1	28291	32	13333	15,1	42579	48,1	88526
2019	20284	22,2	312	0,3	25904	28,4	46500	50,9	1163	1,3	28503	31,2	15101	16,5	44767	49,1	91267
2020	20323	21,2	312	0,3	25675	26,8	46309	48,3	1485	1,5	30984	32,3	17113	17,8	49582	51,7	95891

Source: Türkiye Energy Outlook, 2022

2. Literature Review

In literature many studies have examined the relationship between energy consumption and economic growth using various methods, time periods, and country samples. We categorize these studies as developed economies, emerging and developing economies, cross-regional and country-specific studies. We examine studies on Türkiye in a separate category.

Selected studies on developed economies are summarized below:

Ayhan, Kartal, Kılıç Depren, and Depren (2023) applied a non-linear regression model to analyze the impact of economic policy uncertainty and political stability on CO_2 emissions in G7 countries from 1997 to 2021. The findings indicated that economic policy uncertainty reduces CO_2 emissions in the USA, Italy, and Japan, while political stability has mixed effects across G7 countries. Energy consumption and economic growth were both found to increase CO2 emissions.

Mete (2021) used the dynamic ordinary least squares mean group method. This study analyzed the relationship between energy and growth in G7 countries (1993-2018). Results showed significant effects of GDP per capita, greenhouse gas emissions, and trade openness on energy consumption.

Selected studies on emerging market economies and developing countries are as follows:

Gyimah et al. (2022) explored the effects of renewable energy in Ghana from 1990 to 2015, finding a feedback effect between renewable energy usage and economic growth, highlighting the importance of encouraging renewable energy for growth.

Minh and Van (2022) examined Vietnam from 1995 to 2019 using Granger causality and ARDL tests. This study observed a unidirectional causality between renewable energy consumption and economic growth in the long run.

Emek and Polat (2022) investigated the relationship between non-renewable and renewable energy consumption, globalization, and economic growth in 15 emerging market economies (1990-2018). The study found bidirectional causality between both types of energy consumption and growth, as well as between globalization and growth.

Selected cross-regional studies are summarized below:

Bhattacharya et al. (2016) used data from 1991 to 2012 and examined the influence of renewable energy consumption on the economic growth of major energy-consuming countries. Results indicated a positive impact on economic growth in 57% of the countries, stressing the need for collaborative renewable energy investments.

Using panel cointegration tests, a study by Ergün and Atay Polat (2015) examined the relationship among carbon dioxide emissions, electricity, and growth in 30 OECD countries from 1980 to 2010. The study revealed a cointegration relationship among carbon dioxide emissions, GDP, and electricity consumption. The results suggest a non-linear relationship between carbon dioxide emissions and economic growth, supporting the Environmental Kuznets Curve (EKC) hypothesis. Additionally, through Vector Error Correction Model (VECM) analysis, it was observed that there exists a one-way causality relationship between GDP and carbon dioxide emissions and a two-way causality between GDP and electricity consumption.

Belke, Dobnik, and Dreger (2011) explored the long-run association between energy consumption (including energy prices) and real GDP across 25 OECD countries spanning 1981-2007. Utilizing Principal Component Analysis (PCA), the study revealed the inelasticity of energy consumption concerning prices and demonstrated a two-way causality between energy consumption and economic growth.

Apergis and Payne (2010) investigated the connection between renewable energy and economic growth across 20 OECD countries using data from 1985 to 2005. Employing panel cointegration and error correction models, the study indicated a positive and statistically significant relationship between real GDP and renewable energy use, gross fixed capital, and labor force. Granger causality findings indicate a two-way causality between energy usage and growth in the short and long run.

Selected country-specific studies are as follows:

Önder and Ağır (2023) stated the connection between energy use and growth in BRIC countries. The study conducted using annual data in the 1990-2020 period with dynamic panel analysis showed that a 1% rise in energy consumption increased economic growth by 1.46%.

In a study by Kuşkaya (2023) analyzing quarterly data from 1990 to 2020 in the USA, the impact of renewable energy production on economic growth was examined using quantile regression. The results indicated a positive influence of renewable energy production on economic growth.

Korkmaz and Yılgör (2011) assessed the connection between economic growth and energy consumption for 26 countries using CADF and CIPS cointegration tests. Focusing on 1980-2004, the research uncovered an association between economic growth and energy consumption in the long run.

Lee and Chang (2008) explored the causality between energy use and real GDP from 1971 to 2002 for 16 Asian countries, employing heterogeneous panel cointegration and panel ECMs. The results revealed a long-run positive cointegration between energy consumption and growth, with heterogeneity considered. However, this relationship was not observed in the short run, and a one-way long-run causality from energy usage to economic growth was identified. The study also divided the 16 Asian countries into APEC and ASEAN groups, conducting the same tests.

Selected studies conducted specifically for Türkiye are provided below:

Aydın (2010) analyzed the impact of primary energy consumption resources on economic growth. The author addressed this relationship with two separate analyses and used quarterly data between 1996 and 2004 in the first analysis; in the second analysis, the period 1980-2004 was examined with annual data. Using the Ordinary Least Squares (OLS) method, it was concluded that energy use positively affects growth.

Demirgil and Birol (2020) addressed the impact of renewable energy use on growth in Türkiye between 1980 and 2018. The ARDL bounds test indicated cointegration between variables, and it was concluded that a 1% increase in renewable energy consumption led to a 0.91% increase in economic growth in the long run. The Toda-Yamamoto causality test demonstrated a one-way causality relationship from energy consumption to growth.

Altıntaş (2013) scrutinized the interrelation among Türkiye's carbon dioxide emissions, per capita income, primary energy consumption, and investments from 1970 to 2008, utilizing cointegration and causality tests. The findings indicated that energy consumption, growth, and investments are Granger causes of carbon dioxide emissions in the long run.

Öztürk and Acaravcı (2010) investigated the long-run causality between carbon emissions, economic growth, energy use, and employment rate in Türkiye with the ARDL bounds test. The study, covering the years 1968-2005, reveals that per capita carbon emissions and per capita energy consumption are not the Granger cause of GDP per capita. Still, the employment rate is the Granger cause of per capita GDP in the short run. Additionally, the findings obtained for Türkiye do not support the Environmental Kuznets Curve (EKC) hypothesis.

In their study, Balcılar, Uzuner, Nwani, and Bekun (2023) applied the ARDL bounds test based on goal (7.8.11) from the United Nations Development Goals. The study discussed public-private partnerships, trade, economic growth, and foreign direct investment variables. The findings reveal a bond between public-private partnerships and other variables in the long run. It is also emphasized that encouraging renewable energy resource usage has an essential place in sustainable development.

Using structural break models, Erdoğan and Gürbüz (2014) investigated the association between energy and growth from 1970 to 2009. The study considered the Zivot-Andrews unit root test with structural breaks and the Gregory-Hansen cointegration test. Despite applying the Granger causality analysis, no causality was identified between energy use and economic growth.

In conclusion, while there is consensus on the positive relationship between energy consumption and economic growth, the magnitude and direction of causality vary across countries and methodologies. Future research should aim to standardize methodologies and consider country-specific factors to better understand these dynamics.

3. Analysis of the Relationship Between Energy Consumption and Economic Growth in Türkiye

3.1. Data and Methodology

In this research, the relationship between energy consumption (EN)-(gwat) and Gross Domestic Product (GDP)-(million $) in Türkiye for 1980-2020 period has been investigated by the data taken from the

database of the Organization for Economic Development and Cooperation (OECD). The stationarity of the relevant series has been checked by the Augmented Dickey-Fuller (ADF) Test. The causality relationship between the variables has been tested with the Granger causality test, and the Johansen cointegration test has investigated the long-run relationship. The Granger Causality Test based on the Vector Error Correction Model has been used to determine the direction of the long-term relationship. EViews 10.0 software has been used in the analysis.

3.2. Findings

The stationarity of energy consumption and economic growth series have been checked with the Augmented Dickey-Fuller (ADF) Unit Root Test developed by Dickey and Fuller (1979). When we apply ADF and PP Unit Root Tests, we observe that EN and GDP contain unit root in levels. When we take the first difference of the series, we observed that series are stationary. If the ADF test statistic is larger than the MacKinnon critical value, it indicates the series are stationary. We reject the null hypothesis because the p-value is less than 0.05. That is, the EN and GDP are integrated of order 1 or I(1) (Table 4). Incase problems such as randomness, covariance of error terms, nonparametric addition has been made by Phillips-Perron (PP) unit root test developed by Phillips and Perron (1988). Also in PP test, since t-statistic values of both series are larger than test critical values, it is seen that the first differences of both series are stationary.

Table 4: *ADF Unit Root Test Results*

	Variables	t-statistic	Prob
Constant and Trend	EN	-0.028657	0.9944
	GDP	-1.850296	0.6612
	DEN	-6.273695	0.0000
	DGDP	-5.305491	0.0005

Phillips-Perron Unit Root Test Results

	Variables	t-statistic	Prob
Constant and Trend	EN	1.624979	1.0000
	GDP	-2.055263	0.5541
	DEN	-7.821135	0.0000
	DGDP	-5.305491	0.0005

McKinnon Critical Value (at 5% significance level) is -3.52. Since the calculated statistical values and the MacKinnon critical value are negative, they are interpreted as absolute values.

To determine the lag length needed to establish the Vector Autoregression (VAR) model to be created for causality and cointegration analyses, AIC (Akaike Information Criterion), SC (Schwarz Criterion), and HQ (Hannan-Quinn Criterion) information criteria have been investigated and the lag length has been determined as 3 according to AIC and HQ results (Table 5).

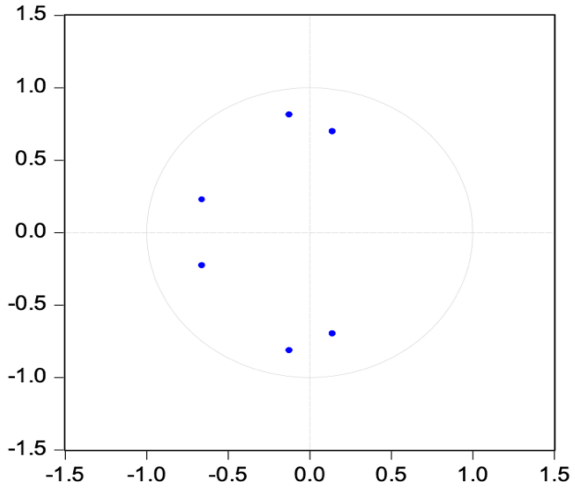
Table 5: *VAR Lag Order*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	98.84459	NA	1.35e-05	-5.533977	-5.445100*	-5.503296
1	103.8951	9.235284	1.28e-05	-5.594008	-5.327377	-5.501967
2	110.8436	11.91156	1.08e-05	-5.762489	-5.318103	-5.609087
3	117.7289	11.01662*	9.24e-06*	-5.927368*	-5.305229	-5.712605*
4	118.6194	1.322920	1.12e-05	-5.749678	-4.949785	-5.473555

"" indicates lag order selected by the criterion.*

The characteristic roots of the 3-lag VAR model have been shown in Figure 7. Since all AR roots are within the unit circle, the stationarity has also been confirmed in the 3-lag VAR model. In other words, since all the eigenvalues lie inside the unit circle, VAR satisfies the stability condition.

Figure 7: *Inverse Roots of AR Characteristic Polynomial*



Roots of Characteristic Polynomial

Root	Modulus
-0.337721 - 0.578293i	0.669685
-0.337721 + 0.578293i	0.669685
-0.208902 - 0.592623i	0.628364
-0.208902 + 0.592623i	0.628364

No root lies outside the unit circle.
VAR satisfies the stability condition.

The causality test developed by Granger (1969) has been used to examine the causality relationship between variables. In the Granger causality test, the coefficients of the lagged values of the independent variable are tested to be equal to zero. The null hypothesis is expressed as H_0: There is no causal relationship between the variables, and the alternative hypothesis is expressed as H_1: There is a causal relationship between the variables. According to the test results the probability value is bigger than 0.05, the null hypothesis is not rejected, and it is accepted that there is no causal relationship between the variables (Table 6).

Table 6: *Granger Causality Test Results*

Dependent Variable: EN		
Excluded	**Chi-sq**	**Prob**
GDP	3.103668	0.3759
Dependent Variable: GDP		
Excluded	**Chi-sq**	**Prob**
EN	1.960643	0.5806

Since p-value is greater than 0.01, 0.05 and 0.10, we fail to reject null hypothesis at 1%, 5% and 10% significance levels.

The long-run relationship has been explored by Johansen Cointegration test by Johansen (1991). For trace values (Trace Statistics), the main hypothesis is r=0, meaning there is no cointegration, and the alternative hypothesis is r≤1, meaning there is at least one cointegration. As seen in Table 7, since the value calculated at the 5% significance level is greater than the critical value, the null hypothesis is rejected, and it is accepted that there are 2 cointegrated vectors in the analysis. Since the calculated value for Maximum Trace Values (Maximum Eigen Statistics) is greater than the critical value at 5% significance level, the null hypothesis is rejected, and its alternative is accepted. In other words, there are 2 cointegrated vectors according to the maximum trace values. Accordingly, it has been revealed that there is a long-term relationship between energy consumption and economic growth (Table 7).

Table 7: *Johansen Cointegration Test Results*

Trace Test	**Cointegrated Vector**	**Eigenvalue**	**Trace statistic**	**Critical Value (0.05)**	**Prob**
	r=0	0.465674	38.48586	20.26184	0.0001
	r≤ 1	0.376774	16.54961	9.164546	0.0017
Maximum Eigenvalue Test	**Cointegrated Vector**	**Eigenvalue**	**Max-Eigen statistic**	**Critical Value (0.05)**	**Prob**
	r=0	0.465674	21.93625	15.89210	0.0049
	r≤ 1	0.376774	16.54961	9.164546	0.0017

For the validity of Granger causality test, the series must not be cointegrated. If the series are cointegrated, the Granger causality test based on the Error Correction model is performed instead of the standard Granger causality test. In cointegrated variables, deviations occur in the long-term balance over time. The error correction model equation includes the first differences of the variables as well as the one-period lagged errors of the cointegration regression. One of the advantages of using the error correction model is that it reveals short- and long-term causalities and enables the imbalance between variables to be determined and corrected (Enders, 1995, p. 365–366). During the difference operation applied to the series to ensure stationarity, long-term information is lost, so these imbalances are eliminated by using the error correction model. To detect the direction of the long-term relationship, the Granger causality test based on the VECM which is developed by Engle-Granger (1987) has been used. The response of the model to deviations from the long-term equilibrium is tested with the error correction mechanism by using equation 1.1 and 1.2.

$$\Delta Y_t = \alpha_1 + \sum_{i=1}^{m} \beta_{1i} \Delta X_{t-i} + \sum_{i=1}^{n} \lambda_{1i} \Delta Y_{t-i} + \gamma_1 \, ECT_{t-1} + \varepsilon_{1t} \qquad (1.1)$$

$$\Delta Y_t = \alpha_2 + \sum_{i=1}^{m} \beta_{2i} \Delta X_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta Y_{t-i} + \gamma_2 \, ECT_{t-1} + \varepsilon_{2t} \qquad (1.2)$$

Table 8: *Granger Test Results Based on Vector Error Correction Model*

Dependent Variable: EN		
Excluded	**Chi-sq**	**Prob**
GDP	11.72101	0.0084
Dependent Variable: GDP		
Excluded	**Chi-sq**	**Prob**
EN	1.873749	0.5990

Since p-value is less than 0.01, 0.05 and 0.10, we reject null hypothesis at 1%, 5% and 10% significance levels for EN equation. Since p-value greater than 0.01, 0.05 and 0.10, we fail to reject null hypothesis at 1%, 5% and 10% significance levels for GDP equation.

As a result of the analysis, a one-way causality from economic growth to energy consumption has been determined (Table 8). A unidirectional relationship was found between economic growth and energy consumption, and this result supports the findings in the studies of Minh and Van (2022), Demirgil and Birol (2020), Lee and Chang (2008). Due to the increase in growth over the years, Türkiye's energy need is also increasing. Issues such as the sustainability of energy sources and the need to invest in renewable energy comes forward. In this context, the transformation needed to produce clean and renewable energy must be planned, financed and realized.

The 2002-2021 period has been a special period for Türkiye both in energy investments and in the financing of these investments. Energy investments have increased with the development of the market mechanism, the increasing role of the private sector and institutionalization (Shura Energy Transition Center, 2022, p. 88). Türkiye's green growth targets are expected to increase R&D and innovation activities and investments in the field of renewable and clean energy. Measures, policies and targets to ensure green transformation are also included in the Medium-Term Program and Economic Reform Program. Action steps for achieving green transformation have been determined in the Green Agreement Action Plan (TUBİTAK, 2023, p. 23).

4. Conclusion

In this study the relationship between energy consumption and economic growth in Türkiye between 1980 and 2020 was investigated using the Granger causality test. Results indicated no short-term causality between the variables. However, the Johansen cointegration test identified two cointegrated vectors, indicating a long-term relationship between energy consumption and economic growth. Further analysis with the Vector Error Correction Model (VECM) revealed that in the long run, economic growth drives energy consumption.

To contextualize these findings, we reviewed Türkiye's energy outlook from 2000 to 2020. Throughout this period, oil was the dominant energy source, accounting for 29% of the total energy supply, followed closely by coal at 28% and natural gas at 27%. Notably, the ratio of total energy production to total energy supply decreased from 33.2% to 29.8%, highlighting an increase in foreign energy dependency. This dependency is due to the need to import crude oil and natural gas to satisfy energy demands.

In 2020, the industrial sector accounted for the largest share of energy consumption at 32.3%, followed by transportation at 24% and housing at 22.8%. The composition and consumption patterns of primary energy are vital for Türkiye's transition to low-carbon energy. A key priority is increasing the share of renewable energy sources in the energy supply, especially in electricity production.

Türkiye meets a large part of its energy needs through energy imports. Since imported energy is used in many sectors, changes in imports will have significant effects on the economy. Türkiye has geopolitical importance in energy trade. It is necessary to develop policies for the sustainability of energy imports. In this context, many natural gas and oil pipe projects have been implemented. In order to reduce foreign dependency, it is important to diversify Türkiye's energy resources, increase energy efficiency and encourage renewable energy production. Given the long-term causality between economic growth and energy consumption in Türkiye, it is imperative to diversify energy resources and reduce foreign dependency to meet rising energy demands. Also it is essential to consider the environmental costs associated with economic growth and implement policies to minimize these impacts.

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References

Altıntaş, H. (2013). "Türkiye'de Birincil Enerji Tüketimi, Karbondioksit Emisyonu ve Ekonomik Büyüme İlişkisi: Eşbütünleşme ve Nedensellik Analizi" [Elektronik Sürüm]. *Eskişehir Osmangazi University Journal of Economics and Administrative Sciences,* 8(1): 263-294 (Access Date: 23.10.2023)

Apergis, N. & Payne, J. E. (2010). "Renewable Energy Consumption and Economic Growth: Evidence from a Panel of OECD countries" [Elektronik Sürüm]. *Energy Policy*, 38(1): 656-660 (Access Date: 18.10.2023)

Aydın, F. (2010). "Enerji Tüketimi ve Ekonomik Büyüme" [Elektronik Sürüm]. *Erciyes University Journal of Faculty of Economics and Administrative Sciences,* 35: 317-340 (Access Date: 18.10.2023)

Ayhan, F., Kartal, M.T., Kılıç Depren, S. & Depren, Ö. (2023). "Asymmetric Effect of Economic Policy Uncertainty, Political Stability, Energy Consumption, and Economic Growth on CO_2 Emissions: Evidence from G-7 countries" [Elektronik Sürüm]. *Environmental Science and Pollution Research*, 30: 47422-47437. (Access Date: 05.11.2023)

Balcılar, M., Uzuner, G., Nwani, C. & Bekun, F.V. (2023). "Boosting Energy Efficiency in Turkey: The Role of Public–Private Partnership Investment" [Elektronik Sürüm]. *Sustainability,* 15(3): 2273 (Access Date: 03.11.2023)

Belke, A., Dobnik, F. & Dreger, C. (2011). "Energy Consumption and Economic Growth: New Insights into the Cointegration Relationship" [Elektronik Sürüm]. *Energy Economics*, 33(5): 782-789 (Access Date: 21.10.2023)

Bhattacharya, M., Paramati, S.R., Ozturk, I. & Bhattacharya, S. (2016). "The Effect of Renewable Energy Consumption on Economic Growth: Evidence from Top 38 Countries" [Elektronik Sürüm]. *Applied Energy*, 162: 733-741 (Access Date: 28.10.2023)

Chaudhry, I. S., Safdar, N. & Farooq, F. (2012). "Energy Consumption and Economic Growth: Empirical Evidence from Pakistan". *Pakistan Journal of Social Sciences*, 32(2): 371-382.

Çalışkan, Ş. (2009). "Türkiye'nin Enerjide Dışa Bağımlılık ve Enerji Arz Güvenliği Sorunu". *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, 25: 297-310.

Demirgil, B. & Birol, Y. E. (2020). "Yenilenebilir Enerji Tüketimi ve Ekonomik Büyüme İlişkisi: Türkiye İçin Bir Toda-Yamamoto Nedensellik Analizi" [Elektronik Sürüm]. *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 21(1): 68-83 (Access Date: 27.10.2023)

Dickey, D.A. & Fuller, W.A. (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root". *Journal of the American Statistical Association*, 7: 427-431.

Emek, Ö.F. & Atay Polat, M. (2022). "Enerji Tüketimi, Küreselleşme ve Ekonomik Büyüme Arasındaki İlişki: Seçilmiş Yükselen Piyasa Ekonomileri İçin Bir Nedensellik Analizi" [Elektronik Sürüm]. *Journal of Economic Policy Research,* 9(2): 331-351 (Access Date: 04.11.2023)

Enders, W. (1995). *Applied Econometric Time Series*, John Wiley&Sons, Inc., New York.

Engle, R.F. & Granger C.W.J. (1987). "Cointegration and Error Correction: Representation, Estimation, and Testing". *Econometrica*, 55: 251–276.

Erdoğan, S. & Gürbüz, S. (2014). "Türkiye'de Enerji Tüketimi ve Ekonomik Büyüme İlişkisi: Yapısal Kırılmalı Zaman Serisi Analizi" [Elektronik Sürüm]. *Selcuk University Journal of Institute of Social Sciences,* 32: 79-87 (Access Date: 25.10.2023)

Ergün, S. & Atay Polat, M. (2015). "OECD Ülkelerinde CO2 Emisyonu, Elektrik Tüketimi ve Büyüme İlişkisi" [Elektronik Sürüm]. *Erciyes University Journal of Faculty of Economics and Administrative Sciences,* 45: 115-141 (Access Date: 25.10.2023)

General Directorate of Mining and Petroleum Affairs (2022). Production Statistics. Access: https://www.mapeg.gov.tr (Access Date: 30.10.2023)

Granger, C.W.J. (1969). "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods". *Econometrica,* 37(3): 424-438.

Güllü, M. & Baygaç, H.N. (2017). "Biyoyakıt Üretimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisi: Amerika, Brezilya ve Almanya Örnekleri". *Akademik Bakış Dergisi*, 14: 18-34.

Gyimah, J., Yao, X., Tachega, M.A., Hayford, I.S. & Opoku-Mensah, E. (2022). "Renewable energy consumption and economic growth: New evidence from Ghana" [Elektronik Sürüm]. *Energy*, 248: 123559 (Access Date: 02.11.2023)

Johansen, S. (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models". *Econometrica*, 59: 1551-1580.

Korkmaz, S. & Yılgör, M. (2011). "Enerji Tüketimi-İktisadi Büyüme İlişkisi" [Elektronik Sürüm]. *Kocaeli University Journal of Social Sciences,* 22: 111-125 (Access Date: 20.10.2023)

Kuşkaya, S. (2023). "Yenilenebilir Enerji ve Ekonomik Büyüme İlişkisinin Kantil Regresyon ile Modellenmesi: ABD Örneği" [Elektronik Sürüm]. *İstanbul Gelişim Üniversitesi Sosyal Bilimler Dergisi,* 10(1): 234-245 (Access Date: 01.10.2023)

Lee, Chien-Chiang & Chang, Chun-Ping (2008). "Energy Consumption and Economic Growth In Asian Economies: A More Comprehensive Analysis Using Panel Data" [Elektronik Sürüm]. *Resource and Energy Economics,* 30(1): 50-65 (Access Date: 17.10.2023)

Mete, E. (2021). "Enerji Tüketimi ve Ekonomik Büyüme İlişkisi: G7 Ülkeleri Örneği" [Elektronik Sürüm]. *Atatürk University Journal of Economics and Administrative Sciences*, 35(4): 1481-1495 (Access Date: 07.11.2023)

Minh, T. B. & Van, H. B. (2022). "Evaluating the Relationship between Renewable Energy Consumption and Economic Growth in Vietnam, 1995–2019" [Elektronik Sürüm]. *Energy Reports*, 9: 609-617 (Access Date: 30.10.2023)

Önder, F. & Ağır, H. (2023). "Panel Econometric Analysis of the Relationship between Energy Consumption and Economic Growth: The Case of the Bric Countries" [Elektronik Sürüm]. *Türk Tarım ve Doğa Bilimleri Dergisi*, 10(4): 922–932 (Access Date: 03.11.2023)

Öztürk, İ. & Acaravcı, A. (2010). "CO2 Emissions, Energy Consumption and Economic Growth in Turkey" [Elektronik Sürüm]. *Renewable and Sustainable Energy Reviews*, 14(9): 3220-3225 (Access Date: 20.10.2023)

Öztürk, S. & Küsmez, T. (2019). "Elektrik Tüketimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisi (1995-2014)". *Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 12 (2): 316-327.

Phillips, P. C. B. & Perron, P. (1988). "Testing for a Unit Root in Time Series Regression". *Biometrika*, 75(2): 335–346.

Shura Energy Transition Center (2022). Yeşil Yeni Düzen Bağlamında Türkiye'de Enerji Dönüşümünün Finansmanı Raporu. Shura Enerji Dönüşüm Merkezi. Access: shura.org.tr (Access Date: 26.07.2023)

TUBİTAK (2023). Yeşil Büyüme Teknoloji Yol Haritası

Türkiye Energy Outlook (July 2022). TMMOB (MMO/731). Ankara: Makine Mühendisleri Odası.

World Energy Outlook (October 2022). International Energy Agency. Access: www.iea.org (Access Date: 30.07.2023)

Yılmaz, Ş. & Türkyılmaz, O. (2022). "Dünyada ve Türkiye'de Birincil Enerji Arzı". Türkiye'nin Enerji Görünümü 2022 (5-20). TMMOB.